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The Taxonomy of

Australian Freshwater Amphipoda

(Crustacea : Malacostraca)

by

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Volume 1: Text and References

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ABSTRACT

The aims of this study are the taxonomic description of new species, examination of the stygobiont amphipod fauna of Australia, the review of phylogenetic relationships among the Australian Crangonyctoidea, and generation of a key to all Australian freshwater amphipod species.

Characteristics of Amphipoda are summarised, the Australian families and their relative importance discussed, and current knowledge of Australian freshwater amphipods reviewed. New species and genera of the Paramelitidae, Neoniphargidae and Melitidae are described. The possible extent of future investigations into undescribed collections is discussed.

A number of populations of the morphologically cryptic paramelitid genus *Antipodeus* are examined using molecular genetics. This results in determining that the genus is multispecious, and that the observed minor anatomical differences and apparent cryptic morphology are not attributable to variation within a single species.

Family characteristics of the Neoniphargidae are reviewed. The character *rugosities*, introduced by Williams and Barnard (1988), is examined in detail using the scanning electron microscope. Not all characters are found to be unique, although rugosities are shown to be characteristic of the family. The family is redefined. The neoniphargid genus *Wesniphargus*, redescribed by Williams and Barnard (1988) from an incomplete specimen, is redefined to include those portions absent from the original specimen, and to include the male which had not been described previously. The genus *Nedsia*, family Melitidae, previously monospecific, is redefined and the definition expanded to include description of the male, not previously described, and to accommodate new species.

For each of the three families of Australian Crangonyctoidea, and for the Melitidae, distributions are detailed, and species lists compiled.

The occurrence and diversity of stygobiont freshwater Australian Amphipoda are reviewed and discussed. Contrary to predictions (Williams 1986) significant numbers of stygobiont amphipods are recorded, their diversity comparable with regions elsewhere. The distributions of stygobiont Amphipoda are described and a checklist of known stygobionts, as well as stygophiles, compiled.

Phylogenetic relationships among the Crangonyctoidea of Australia and *Paramelita* of South Africa are investigated using cladistic analysis (PAUP* version 4.0b4a, MULPARS and MacClade 3.07). Results of the analysis are detailed and the outcome of the investigation discussed. The systematics of the Paramelitidae are revised on the basis of these results. Neoniphargidae and Perthiidae are lowered in rank to sub-family status to become the Neonipharginae and Perthiinae, and the sub-family Paramelitinae established. Possible associations between the stygobiont characters habitat, eye loss and attenuation of the antenna are examined using the Concentrated Changes Test in MacClade 4. No associations are demonstrated.

A key to all Australian freshwater Amphipoda is provided, as well as a checklist of species.

This study has contributed significantly to knowledge of the freshwater amphipoda of Australia: nine new genera are established and forty three new species described within the Crangonyctoidea and Melitidae. Previously, eighteen genera and forty species of those families had been described. Many of the new taxa are stygobionts, and understanding of the diversity and abundance of these amphipods has contributed significantly to arguments in favour of groundwater conservation. Publication of the key to species will assist environmental surveys in the future. The cladistic study has provided better understanding of the systematics of Australian Crangonyctoidea. Nevertheless, while the number of described species has more than doubled, it is clear many taxa among collections are unresolved. Determination of these new taxa remains a challenge for future research.

Statement

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying.

John Hugh Bradbury

Date

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My daughter Melissa conducted SEM examinations and co-authored publication of the results of that study.

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Chapter 1

General Introduction

Preamble

That new, undescribed amphipods exist in Australian fresh waters is undoubted (Knott 1983, 1993; Williams 1986; Williams and Barnard 1988; Humphreys 1991, 1993 a, b; Humphreys and Adams 1991): museum collections of unidentified taxa abound; ecologists, too, are unable to satisfactorily categorise amphipod specimens (Wade pers. com., Doeg pers. com., Crowther pers. com., Humphreys pers. com.). Furthermore, recent studies of stygofauna include many specimens of amphipods: new taxa much more prevalent than previously expected (Williams 1986; Humphreys 1991; Knott 1983, 1985). In many instances the species display distinct cave morphologies, similar to those found among cave dwelling species elsewhere, indicating a long period of adaptation to stygian living (Holsinger 1996). Thus, large collections of Australian freshwater amphipods, consisting of undescribed material from a very wide range of sites amassed over a number of years, are held within museums and similar institutions. Recent initiatives in the study of environmental health, environmental impact, and in faunal surveys, provide additional material, freshly collected and in good condition.

The poor knowledge of this fauna has resulted in its frequent exclusion from environmental research, despite amphipods being sensitive indicators of water quality in both marine and freshwaterenvironmentas monitors of heavy metal poisoning (Plenet 1999), pollution (Crane *et al* 1999; Leight *et al* 1999; Blockwell *et al* 1999; Nebeker and Schuytema 1998; Thomas 1993) and fouling (Marzio *et al* 1999; Ingersoll *et al* 2000). For amphipod taxa to be useful in such environmental studies of Australian fresh waters taxonomic definition and description, and deposition of type species into accessible collections, are required.

1.1. Brief Summary Of Amphipoda

The Amphipoda are a significant order of malacostracan crustaceans comprising around six thousand described marine and freshwater species world-wide. There are four amphipod sub-orders, but the Gammaridea predominate among fresh water taxa: estimates of the total numbers vary between four thousand five hundred (Holsinger 1982) and five thousand seven hundred (Barnard and Karaman 1991). There are about one thousand (Holsinger 1982) to one thousand two hundred (Barnard and Karaman 1991) described freshwater species in two hundred and thirty five genera (Barnard and Karaman 1991).

Amphipoda have two principal traits which make them unusual. Whether marine or freshwater they have an affinity for cold water and, like other Peracarida, they brood their young (Barnard and Barnard 1983). Both these traits significantly influence distribution, habit, dispersal and evolution. Their recognised distribution is strongly antiboreal, although somewhat broader within subterranean waters. Brooding offspring leads to relatively low dispersal rates and high degrees of endemism and speciation: large species flocks occur in Lakes Baikal and Titicaca, in the running waters of Europe and North America, and in the marine forms found in the Okhotsk Sea and around southern Australia (Barnard and Barnard 1983).

Amphipods are an ancient group. They existed in the Paleozoic in the fully modern morphology, and although their origins are unknown, their line of descent proceeds through the Corophiidae (numerous, marine, characterised by a fleshy telson) (Barnard and Barnard 1983).

The Gammaridea, the dominant sub-order, already existed in the era of Pangaea, inhabiting fresh waters as sterno-branchiate crangonyctoids. This resulted in parallel evolution of Holarctic (Laurasian) and Gondwanan freshwater taxa after the break up of Pangea as free exchange through freshwater pathways was lost. There is no evidence in Southern Hemisphere seas of any pandemic marine dispersal that might otherwise account for these freshwater parallels (Barnard 1972a, b). In the Holarctic freshwater gammaroids succeeded crangonyctoids long after Pangea

dispersed, although this did not occur in Australia, where crangonyctoids still predominate (Barnard and Barnard 1983).

Australian gammaridean freshwater amphipods are common in both epigean and hypogean habitats of cooler regions: Tasmania; the south east mainland and mountains of the Great Dividing Range; the south east of South Australia; and also the south west of Western Australia (Williams and Barnard 1988). Nevertheless, despite their frequent occurrence and widespread distribution in southern regions, and in contrast to the state of knowledge of amphipods of Europe and North America (Barnard and Karaman 1991), the taxonomy and systematics of Australian freshwater amphipods has been largely neglected. Less than twenty-five publications represent the sum of taxonomic knowledge of Australian freshwater amphipods between Thomson's (1893) first record of a species from Tasmania, and Barnard and Williams' last paper (1995). Of the few reports available, most are isolated accounts describing only single collections. Why this is so is unclear. Perhaps the paucity of research on the group represents the fact that at species level amphipods are difficult to distinguish morphologically (Williams and Barnard 1988), and that many taxa are relatively small, making distinctions more difficult.

The predominant tendency toward a cool climate distribution of amphipods in Australia parallels that of other regions. Globally the group principally inhabits cool waters, is distinctly antitropical in distribution and is restricted to permanent water bodies (Barnard and Barnard 1983). There are few exceptions to this distributional pattern among known Australian amphipod fauna. Two examples, *Chillagoe thea* Barnard and Williams 1995, and *Brachina invasa* Barnard and Williams 1995, have been recorded from arid, inland regions, semi or wholly tropical. However, these are either hypogean species of marine origin (*Brachina invasa*: Melitidae) stranded by recession or have invaded during periods of marine inundation and subsequently adapted to non marine waters. Alternatively they are inhabitants of hypogean fresh waters which are relict species or species residing in refugia, insulated from the extremes of climate which would otherwise be experienced in the epigean environment of those arid regions (*Chillagoe thea*: Crangonyctoidea, Paramelitidae).

1.2: Amphipod Families In Australia

Eight amphipod families comprise the described Australian freshwater fauna. They are the Paracalliopiidae Barnard and Karaman 1982, Ceinidae Barnard 1972a, Corophiidae Dana 1849, Eusiridae Stebbing 1888, Melitidae Bousfield 1973, and (three) families within the Crangonyctoidea Bousfield 1977 (Williams and Barnard 1988). A ninth family, the Bogidiellidae, is recorded (Bradbury, unpublished), but the only species described to date is from an anchialine site on Barrow Island, Western Australia (Bradbury and Williams 1996a). The fresh water amphipods of the eight families include twenty three genera: the Crangonyctoidea - an ancient freshwater group with origins in the late Palaeocene (Barnard and Barnard 1983) - are the dominant freshwater amphipod fauna, comprising three families (Paramelitidae - Bousfield 1977; Neoniphargidae - Bousfield 1977; Perthiidae - Williams and Barnard; 1988) and fifteen genera (Williams and Barnard 1988; Barnard and Williams 1995). Among the five other families represented the Corophiidae include one monspecific genus (Taylor (2002) refers to undescribed corophiids from sites in South Australia), and Chapman (2002) re-describes *Paracorophium* from the Brisbane River as a new species *P. brisbanensis*); Ceinidae - two genera, four species; Eusiridae - two genera, three species; Paracalliopiidae - one genus, two species; Melitidae - three genera, three species. Although these families are relatively poorly represented, some among them are not uncommon. Included among the Ceinidae is one genus, *Austrochiltonia*, which is very widespread, occurring in lowland waters of many areas, often in large numbers (Williams 1962, Barnard and Williams 1995).

1.3: Importance

The Crangonyctoidea with three families, fifteen genera and thirty eight described species dominates the Australian freshwater amphipod fauna (Williams and Barnard 1988, Barnard and Williams 1995, Stock and Iliffe 1990). The superfamily is strongly represented in southern Africa, north America, and Australia and is of considerable biogeographical interest. Additionally, crangonyctoids are useful indicators of water quality, since they are fastidious inhabitants of pristine cool waters (Williams and Barnard 1988). Such waters are in many regions endangered,

despite their importance as sources of domestic water supplies. Amphipods are, therefore, potential tools useful to environmentalists engaged in the maintenance of waterways. Furthermore, degradation of water quality has occurred through the spread of human habitation and many anthropogenic influences such as water extraction, urban development and industrialisation, as well as agricultural activities and forestry. This has resulted in both physical and chemical habitat destruction (heavy metal poisoning (Plenet 1999), pollution (Crane *et al* 1999; Leight *et al* 1999; Blackwell *et al* 1999; Nebeker and Schuytema 1998) and fouling (Marzio 1999; Ingersoll *et al* 2000)). Amphipoda are themselves consequently endangered, and at least one Australian species (*Austrogammarus australis* Sayce) has become extinct within its type location since description in 1900 (Williams and Barnard 1988).

Contemporary freshwater Melitidae are taxa of marine origin, relicts of inundation and strandings, or invasion. They have been recorded from the Flinders Ranges, South Australia (*Brachina invasa* Barnard and Williams) and from North West Cape, Western Australia (*Nedsia douglasi* Barnard and Williams). Both described species are hypogean, probably stygobionts (Barnard and Williams 1995). That only two melitid taxa are recorded probably reflects inadequate sampling. Many regions of the continent which have been inundated by the sea have been sampled; a far greater diversity has been anticipated (Barnard and Williams 1995, Knott 1983, 1985).

Among other amphipod families found in Australia, the Paracalliopiidae (one genus, two species), and Eusiridae (two genera, three species) are narrowly distributed in fresh waters, somewhat akin to the Crangonyctoidea. The Ceinidae are more widespread than any other group; two cryptic, probably sympatric species (*Austrochiltonia subtenuis* and *A. australis*), occurring in Tasmania, Victoria, New South Wales and Western Australia (Williams 1962), and another two species (*A. dalhousiensis* and *Phreatochiltonia anophthalma*) extend the distribution of the family as far inland as the mound springs of northern South Australia (Zeidler 1991, 1997).

1.4. Current Knowledge Of Australian Amphipoda

The history of Australian fresh water amphipod taxonomy has been reviewed by Williams and Barnard (1988). The first record, by Thomson (1893), was of two Tasmanian crangonyctoids; from near Franklin, and from Mt Wellington. These were initially assigned to the genus *Niphargus* Schiodte, subsequently *Neoniphargus* Stebbing and to *Antipodeus* Williams and Barnard. From that time reports were spasmodic: collection and reporting of Australian freshwater amphipods has been, in the main, a disjointed and piecemeal record of casual rather than causal investigation. Following Thomson's first report in 1893 collections and descriptions were tabled by Stebbing 1899; Sayce 1899, 1901, 1902; Smith 1909; Chilton 1916, 1925; and Nicholls 1924, 1926a-d. Between 1926 and 1962 when Williams rediagnosed and redescribed *Austrochiltonia* Hurley and 1964 when Straskraba (1964, 1966) reviewed Western Australian Museum collections, no work was reported. Few descriptions have been published since: Knott (1975) one species, Williams and Barnard (1988) seven species, Barnard and Drummond (1992) one species, Barnard and Williams (1995) six species (ie four crangonyctoids and two melitids), Stock and Iliffe (1990) one species, and Zeidler (1991, 1997) two species. Useful volumes are among these, most notably the report of Williams and Barnard (1988) in which all known Australian crangonyctoid amphipods were reviewed, types examined, and genera and families rediagnosed. Reviewing type collections, Williams and Barnard (1988) discussed in detail the composition and relationships of the Crangonyctoidea, and re-assessed Australian material, working on type collections. They coincidentally established a new family (Perthiidae), four new genera and seven new species. In a later work Barnard and Williams (1995) described a further four species (in the same paper they also described the two first endemic freshwater Melitidae). They noted a significantly low species to genus ratio among Australian crangonyctoids, suggesting a history of species extinction, and reflecting, perhaps, the diverse nature of Australia's climatic history; a history of radical change and extremes (Williams and Barnard 1988, Barnard and Williams 1995). They recognised among the crangonyctoids three families, sixteen genera and thirty nine species. To these totals should be added the genus *Uronyctus* and the species *U. longicaudus* (Stock and Iliffe 1990).

1.5. Aims of this study

The work presented in this thesis contributes to knowledge of Australian freshwater amphipoda; in particular the two major taxa, the Crangonyctoidea families, and the Melitidae. The emphasis is upon the taxonomy of new genera and species, but also includes an investigation of those amphipoda which are stygobiotic, an analysis of relationships among Australian Crangonyctoidea, and the construction of a key to species.

Specifically, the main questions and objectives of the work are:

1. What undescribed taxa exist ?

The diversity of the Australian amphipod fauna has been seen to extend well beyond current knowledge. In the introduction to this thesis I therefore review descriptive works on the Australian Amphipoda and record reports of new, undescribed taxa. The study draws upon extensive material collected by researchers and museums as well as collections made in course of the investigation. This is included in Chapters 3 and 4.

2. How extensive is the Australian stygobitic amphipod fauna ?

Knowledge of Australian stygobiotic amphipoda has been limited, although research elsewhere indicates hypogean species dominate the amphipod fauna (Holsinger 1993, 1994b). However, growing interest in Australia in the preservation of karstic systems and associated fauna, as well as concerns for the conservation of underground waters in regions of increasing anthropogenic degradation, have led to recent accumulation of significant stygobiont amphipod collections which have been available to the study. This material forms the basis of Chapter 5.

4. What are the phylogenetic relationships among Australian Crangonyctoidea ?

Three families are said to exist among the Australian Crangonyctoidea. However, the relationships among the fauna have not been tested. In Chapter 6 cladistic analysis is used to investigate the relationships of Australian Crangonyctoidea.

5. What is the extent of the Australian freshwater amphipod fauna, and what is beyond the scope of this study ?

An assessment of the extent of the Australian freshwater amphipod fauna relative to the taxonomic achievements of this study is made in Chapter 8.

5. To construct a key to families, genera and species of Australian freshwater amphipoda.

Although some keys to the identification of amphipod taxa have been published, those keys are of little use where new species abound. In regions such as the Pilbara, detailed groundwater surveys have been undertaken as a result of recent environmental monitoring regulations. While Amphipoda comprise a major component of the stygobiotic fauna, ecologists and those involved in environmental impact studies have been largely unable to determine the identity of amphipod specimens taken in the course of their investigations. As a result, and in the absence of functional keys to the amphipod fauna, much data has been neglected by, or unavailable to, such studies. In Chapter 7 I have formulated a new key to the group.

Chapter 2

Materials and Methods

2.1 Materials

This study is based upon collections held by museums and similar organisations, private collections of scholars studying freshwater diversity and ecology, and on-going conservation studies such as surveys of World Heritage Areas and cave systems. In particular, the late Professor W. D. Williams amassed collections of amphipods from south-eastern Australia and from Tasmania in over three decades of freshwater research, and also accessed collections held by the Museum of Victoria, the Western Australian Museum and the Australian Museum, all of which were available to the study. Furthermore, Dr W. F. Humphreys of the Western Australian Museum requested examination of collections made in studies of cave systems and underground waters in association with mining survey work. National Parks and Wildlife, New South Wales, forwarded cave-dwelling specimens from a number of sites taken during faunal surveys, and many individual researchers forwarded specimens for examination and description to assist in their environmental assessments.

2.2 Sampling

Inadequacies evident among the collection were supported by additional sampling where possible. Sampling employed a number of methods. A fine mesh dip net was swept across the current downstream of disturbance in streams or through the disturbed area in still waters following dislodgement of bottom sediments or rocks, usually achieved by disturbing the substrate with the feet. Along rocky lake shores or in small streams and pools when amphipods were visible, individual specimens were drawn up using an aspirator. In waters where dense, fine sediment enabled

amphipods to remain hidden, or to quickly escape from view, such as in the bottom sediments of shallow alpine tarns and pools, or where dense weed beds provided refuge for the animals, sediment and weeds were collected and specimens individually extracted from this material spread into a shallow, white plastic tray.

2.3 Preservation.

Specimens were preserved in aqueous 70% ethanol/5% glycerin solution, or frozen in liquid nitrogen or dry ice.

2.4 Analysis of samples

Collections were first analysed to the lowest possible taxonomic level from available descriptions. Examination of specimens in the laboratory was with a 'Wild M5' dissecting microscope illuminated by a 'Schott' twin arm cold light, and with a Wild M20 compound microscope fitted with integral light source. Initial examination as well as dissection of specimens was conducted under the M5 microscope at 12 to 50 magnifications and using 'Dumont' or 'Inox' size 5 or 55 forceps. Specimens were identified initially to family, genus and species wherever possible using available keys and original descriptions (Barnard and Barnard 1983, Williams and Barnard 1988; Barnard and Williams 1995;). In the case of unidentifiable specimens, male and female animals were selected and illustrated, then dissected. The limbs and appendages of one side were removed, as well as all mouthparts, and mounted on slides in glycerin for illustration and description. Where new species were represented these specimens became types and along with the type series were ultimately registered and lodged in Museum collections following publication of the descriptions. Illustrations were made with the aid of a 'Wild' camera-lucida attached to the M20 compound microscope.

Scanning Electron Microscope

Where more detailed perspective of the ultrastructure of particular features of amphipod anatomy was required, material was examined using a Philips XL30 scanning electron microscope. Specimens were prepared using a method modified

from Felgenhauer (1987): fixation for 12-14 hrs in 4% paraformaldehyde/1.25% gluteraldehyde in phosphate buffered saline (PBS) + 4% sucrose, at pH 7.2; washed twice for 30 mins in PBS + 4% glucose; post-fixed in 1% OsO_4 for 2 hrs under refrigeration; dehydrated through successive alcohol (ethanol) baths (70, 90, 95, 100%) for two hours and two changes in each; followed by 1 hour in 100% ethanol; 20 mins in equal parts 100% alcohol and 100% acetone; 20 mins. in 100% acetone. Specimens were then dried to critical point by replacement of acetone with CO_2 and evaporation of the CO_2. The specimens were mounted on a microscope stub, sputter coated with gold-palladium, and examined at 10 kV with the Philips XL30 scanning electron microscope. Specimens were examined at approximately 300 to 10 000 magnification. Photographic results were recorded and stored digitally.

Allozyme electrophoresis

The taxonomic identity of populations of amphipods could not always be distinguished by considering morphologic features alone. Differentiation of these populations was assisted by allozyme electrophoresis. Electrophoretic techniques have been reviewed in detail by Richardson *et al* (1986) and employed in taxonomic studies of many crustacea (Horwitz *et al* 1990; Hebert and Wilson 2000; Stewart 1992; Humphreys and Adams 1991). To enable this work, fresh frozen collections had to be made. Fresh specimens were placed in cryo-tubes and preserved by freezing in liquid nitrogen in the field, or, where liquid nitrogen could not be carried, in dry ice. Where neither liquid nitrogen nor dry ice was available in the field, specimens were held live in water in zip-top plastic bags within an insulated flask (from 2 to 4 hours) until they could be frozen. In every case, specimens were transferred to, or held in, liquid nitrogen storage in the laboratory for up to three months, or were stored in an ultra-freezer at -90°C. Analyses were carried out using a cellulose acetate system and Helena Laboratories equipment*[1]. Power supply, baths, applicators, buffers, gels, enzymes and stains, followed the methodology of Richardson *et al* (1986), and Hebert and Beaton 1993. The electrophoretic mobility of isozymes was measured against a single standard chosen from among the group. Methods of data and statistical analysis followed

[1] Helena Laboratories, 1530 Lindberg Drive, Beaumont, Texas, U.S.A.

Richardson *et al* 1986. Tissue used in these examinations was dissected from the abdomen and limbs of the frozen specimen, the remainder of the specimen returned to storage in liquid nitrogen. Tissue samples were macerated directly into Helena sample wells. All frozen collections were examined by allozyme electrophoresis,. For the purposes of analysis specimens from each collecting site were treated as a single Operational Taxonomic Unit (OTU).

The number of specimens examined per sample ranged from two to eleven. No out-group was used as the intention of the study was to determine the existence of suspected cryptic species among populations of *Antipodeus*. Stewart *et al* (1994) homogenised whole animals in Tris buffer in their allozyme study of *Paramelita*, whereas France (1994) examined the results achieved from homogenising different parts of *Abyssochomene* sp. No genetic differences were found between homogenates of whole animal and abdomen alone. In the present study portions of abdomen and thoracic limbs of specimens were homogenised in Tris buffer. Only tissue from one side of each specimen was used, the remainder being retained frozen in case of the need for further analysis, and to assist in the identification of the specimen.

Genetic divergence between OTU s was calculated as a percentage of fixed differences (Richardson *et al* 1986), or as Nei's unbiased genetic distance (Nei 1978). Dendrograms representing the inter population genetic relationships amongst species were constructed from the genetic distance matrix by the phenetic technique of an unweighted pair group analysis (UPGMA) (Sneath and Sokal 1973; Richardson *et al* 1986).

2.5 Descriptions and nomenclature

Descriptions of new species are based on whole type specimens and their dissected parts. Wherever possible appendages of one side only were dissected and removed to slides for examination and description. Dissections were carried out in aqueous alcohol solution, parts removed to microscope slides and mounted as temporary preparations under cover slips in glycerin or aqueous glycerin solution, and stained with Rose Bengal. Following description specimens and dissected parts were

returned to 70% alcohol/5% glycerin solution in micro vials. Type specimens and series were lodged in museum collections, their allocated serial numbers recorded in the publication of descriptions.

Nomenclature follows Williams and Barnard 1988 and Barnard and Williams 1995, but with some amendments. For example, the term 'spine' is used loosely by these and several authors in referring to large, robust setae, whereas a spine is actually an outgrowth of cuticle (Oshel and Steele 1988; Oshel *et al* 1988). In this text, except where other authors are quoted, such setae are referred to as 'robust setae'. Distinctions made between different types of setae follow Oshel and Steele (1988), Oshel *et al* (1988). The notation **M**, with an appended number, indicates the position of an object as a fraction of the distance from the base to the apex of an appendage; **S** large spine; **s,** small spine. Abbreviations used in the figures are as follows: **A**, antenna; **Abd**, abdomen; **acc**, accessory; **C**, coxa; **d**, dorsal; **dact**, dactylus; **E**, epimeron; **fl**, flake; **flag**, flagellum; **g**, gill; **G**, gnathopod; **Hd**, head; **i**,- inner; **juv**, juvenile; **L**, left; **lac**, lacinia mobilis; **LL**, lower lip; **MD**, mandible; **med**, medial; **mol**, molar; **MP**, maxilliped; **MX**, maxilla; **o**, outer; **O**, oostegite; **opp**, opposite; **p**, palp; **P**, pereopod; **PC**, prebuccal complex; **pl**, plate; **Pp**, pleopod; **R**, right; **sp**, spine; **sq**, square view; **sr**, setae removed (sometimes marked by sockets); **st**, sternal gill; **T**, telson; **U**, uropod; **UL**, upper lip; **UR**, urosome; **1, 2, 3 ..7**, first, second, third ..seventh article, segment, somite or epimeron (as appropriate). Mandibular palp setae are described using the notation of Karaman (1969) and Barnard and Barnard (1983). Names applied to new taxa were composed in accordance with the International Code of Zoological Nomenclature (Ride *et al* 1985). Other abbreviations include: **AM**, Australian Museum; **WAM**, Western Australian Museum; **NP**, National Parks; **Coll**. Collector.

The CSIRO taxonomic description programme **DELTA** (DEscription Language for TAxonomy) (Dallwitz 1980, Dallwitz *et al* 1993) was used to assist in the development of character sets and to generate plain language descriptions, and keys. Adoption of this method of computerised analysis enabled not only the comparison of a large number of characters, and, although in some respects repetitive, contributed significantly to consistency of terminology and comparable individual descriptions when dealing with numbers of taxa.

2.6 Cladistic analyses

Phylogenetic relationships among genera of Australian Crangonyctoidea were examined cladistically. Analyses were performed using PAUP* version 4.0b4a (Swofford, 2000). Detailed methods of analysis are set out in Chapter 6.

Chapter 3

Super-Family Crangonyctoidea

Introduction

The major Australian families of freshwater amphipods are the Paramelitidae, Neoniphargidae and Perthiidae of the superfamily Crangonyctoidea, and the Melitidae. The superfamily Crangonyctoidea was erected by E. L. Bousfield in 1977. Williams and Barnard (1988) review in detail the crangonyctoid concept, defining essential characters of the superfamily as follows: 1. Calceoli are of linear form, not cup shaped, "Type 9" as defined by Lincoln and Hurley (1981). Calceoli are not always present. 2. The accessory flagellum of the first antenna is two or more articulate. 3. The outer ramus of the third uropod is usually two articulate, or, the third uropod is not magniranous. 4. Coxae 5-7 are smaller then coxa 4. 5. Basofacial spines (robust setae) are absent from the peduncle of the first uropod. 6. inner lobes of the lower lip are indistinct. 7. The palp of the maxilla is 2 articulate. 8. Setae other than E setae are present on the mandibular palp. 9. The first gnathopod is not dominant. Three groups of Australian Crangonyctoid amphipods were identified: Paramelitidae, Perthiidae and Neoniphargidae.

3.1 Family Paramelitidae Bousfield

Introduction

The family Paramelitidae was established by Bousfield (1977) to include 'pleisiomorphic crangonyctoideans of antiboreal continental fresh waters' and included the *'Gammarus'* (*Austrogammarus*) of Australia, *Uroctena*, *Hurleya*, *Paramelita* (South Africa) and *Falklandella* (Falkland Islands). The original familial diagnosis was subsequently emended by Bousfield (1982a, 1983) to include

also *Sternophysinx* (South Africa). Williams and Barnard (1988) reviewed the family, making few significant changes to the original diagnostic characters, but excluding *Falklandella* Schellenberg; *Sternophysinx* Holsinger and Straskraba; *Paracrangonyx* Stebbing (one of only two New Zealand freshwater genera, occasionally allied to the Australian taxa through similarities of the gnathopods, at other times assigned to the bogidiellids - where it clearly does not belong (Barnard and Barnard 1983)) This diagnosis by Williams and Barnard (1988) was "*essentially one which emends Bousfield's original and subsequent family diagnosis in order to expedite and accommodate our (re)description of Australian paramelitids*"; they recognised a possible need for a more formal diagnosis of the family at some time in the future, in the knowledge that several undescribed paramelitids existed, and thus the likely necessity of further emendation of the family.

Diagnosis

Williams and Barnard (1988) diagnose the family characters as: *Antennal sinus of head well developed or weak. Molar mandible well developed, triturative. Outer plate of maxilla 2 with one kind of seta apicolaterally. Outer plate of maxilliped of ordinary size. Rugosities absent on maxillipedal palp article three and gnathopods. Gnathopods of medium size, first not dominant, carpi of medium length, weakly or not lobate, propodi attached to carpi normally [(syn)axially], spines on palms not of bifid crangonyctid form. Domination of posterior lobes on coxae 5-7 variable. Oostegites broad. Sternal gills sausage shaped or absent. Urosomites separate.*

Further descriptive characters included: *at least primitive members with sternal gills; primitive members with mostly transverse setation on pleonites; calceoli when present of crangonyctoid form (type 9) (Lincoln and Hurley 1981); lateral bases of outer rami on pleopods with bifid spines bearing diverse branches.*

Composition of the Family

The family is represented in South Africa by the genus *Paramelita* Schellenberg, and in Australia by the genera: *Protocrangonyx* Nicholls, 1926a (1 species); *Uroctena* Nicholls, 1926c (5 species); *Hurleya* Straškraba, 1966 (1 species); *Giniphargus* Karaman and Barnard 1979 (1 species); *Austrogammarus* Barnard and Karaman, 1983 (7 species); *Austrocrangonyx* Barnard and Karaman, 1983 (2

species); *Antipodeus* Williams and Barnard, 1988 (6 species); *Toulrabia* Barnard and Williams, 1995 (1 species); *Chillagoe*, Barnard and Williams, 1995 (1 species).

Description Of New Genera And Species

In the course of this study four new genera of the family Paramelitidae were established: *Chydaekata* Bradbury 2000 (15 species); *Molina* Bradbury 2000 (1 species); *Pilbarus* Bradbury and Williams 1997 (1 species); *Totgammarus* Bradbury and Williams 1995 (1 species), and four new species of the genus *Austrogammarus* are also described, bringing the number of Australian Paramelitidae genera to 13, and of species to 47. These new taxa are described in the following section.

Of remaining Paramelitidae genera: *Austrocrangonyx*, *Hurleya*, *Uroctena*, *Giniphargus*, *Protocrangonyx*, *Toulrabia*, and *Chillagoe*, no new species were found among samples. Diagnoses and composition of these genera remain as set out by Williams and Barnard 1988, and Barnard and Williams 1995.

3.1.1 The genus *Austrogammarus* Barnard and Karaman

The genus *Austrogammarus*, established by Barnard and Karaman (1983), included two species previously assigned to *Gammarus*; *G. australis Sayce* 1901, and *G.haasei* Sayce 1902. These two species had already been recognised as not belonging in the genus *Gammarus* (Barnard 1972a, Williams 1974) well before establishment of *Austrogammarus*. Williams and Barnard (1988 p. 16), re-diagnosed *Austrogammarus*, and although not substantially amending the original diagnosis, expanded substantially upon it. At the time of their review, *Austrogammarus* consisted of seven species: *A. australis* (Sayce), *A. smithi* Williams and Barnard, *A. haasei* (Sayce), *A. saycei* Williams and Barnard, *A. spinatus* Williams and Barnard, *A. multispinatus* Williams and Barnard, *A. telsosetosus* Barnard and Williams. Williams and Barnard (1988) regarded *Austrogammarus* as the most primitive of Australian Paramelitidae. Four new species of the genus *Austrogammarus* are described here.

3.1.1.1 *Austrogammarus badgerhill* n.sp. Figs. 3.1-3.3.

Etymology. Named for the type locality.

Type locality.

Stream to the north of Badger Hill, Flinders Island.

Material examined.

Male 'a' 6mm., male 'b' 6mm.,male 'c', female 12mm. Coll. HBN.Hynes, station A352, 13 Oct.75. Ref.# T370.

Type specimen.

Holotype, Male 'a' 6mm.

Diagnosis.

Antennal sinus strong; first antenna long; second antenna sparsely setose, bearing calceoli on peduncle and flagellum. Mandibular palp article 3 bearing ABDE setae. Labium lacking inner lobes. Inner plate of first maxilla sub triangular, outer plate bearing 11 spine setae, left and right palps asymmetrical. Inner plate of second maxilla bearing oblique setal row. Coxae 1-3 bearing posterior robust setae. Gnathopods sexually dimorphic, palms almost transverse. Uropod 1 lacking basofacial seta. Uropod 3 variramous, the inner ramus reaching to M0.5 of the outer, outer ramus two articulate. Telson laterally tumid, cleft 75% , bearing apical setation.

Description of Holotype (male 'a').

Body: 6mm, cuticle smooth, with numerous dorsal setae on pleon restricted to a posterior band. *Gills*: coxal gills present on coxae 2-7, gill 7 reduced; sternal gills simple (sausage shaped), present on sternites 2-7, located antero-laterally on sternites 2-7. *Head*: eyes (? invisible after preservation). *Antenna 1*: very long, 0.8 x body, 2 x antenna 2, with few setae; peduncle 0.25x length of flagellum; primary flagellum 44 articulate; accessory flagellum short, 5 articulate, extending to M0.7 of article 7 of the primary flagellum. *Antenna 2*: slender, similar to antenna 1, with few short setae on peduncle and flagellum; flagellum shorter than 0.9 x peduncle, 15 articulate; bearing 3 calceoli on article 5 of the peduncle, and calceoli on articles 6, 8 and 10 of the flagellum. *Mandibles*: incisors asymmetrical, left with 6 teeth; right with 4 teeth; lacinia mobilis asymmetrical, left with 5 teeth, right bifid, strongly denticulate; left mandible with 6 serrate setae, 4 plumose intermediate setae, 9 brushy basal setae; right mandible with 4 serrate setae, 3 plumose intermediate setae, no brushy basal or hooked basal molarial setae, and 1 chisel

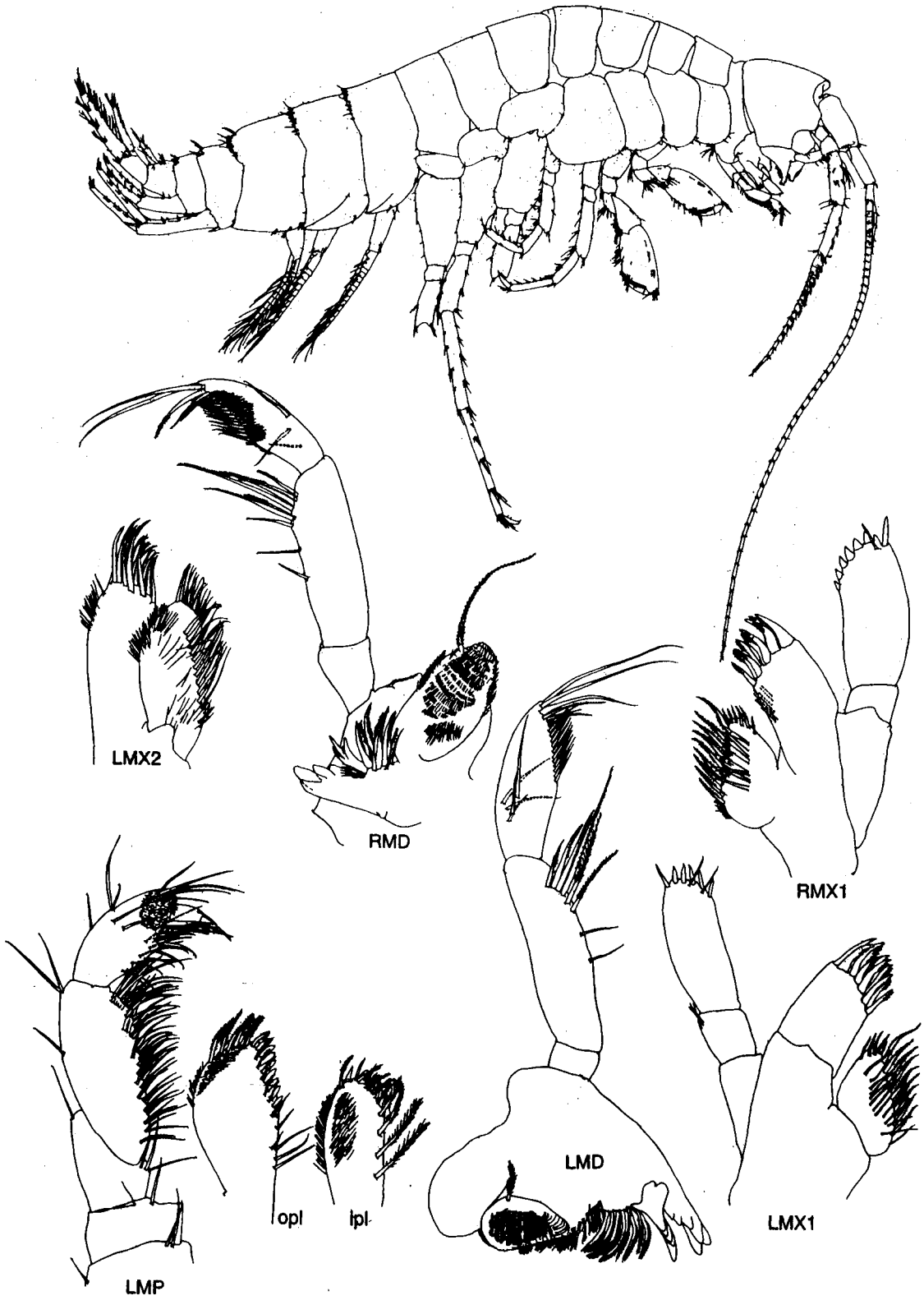

Fig. 3.1. *Austrogammarus badgerhill* n. sp. Male 'b' whole; male 'a' mouthparts.

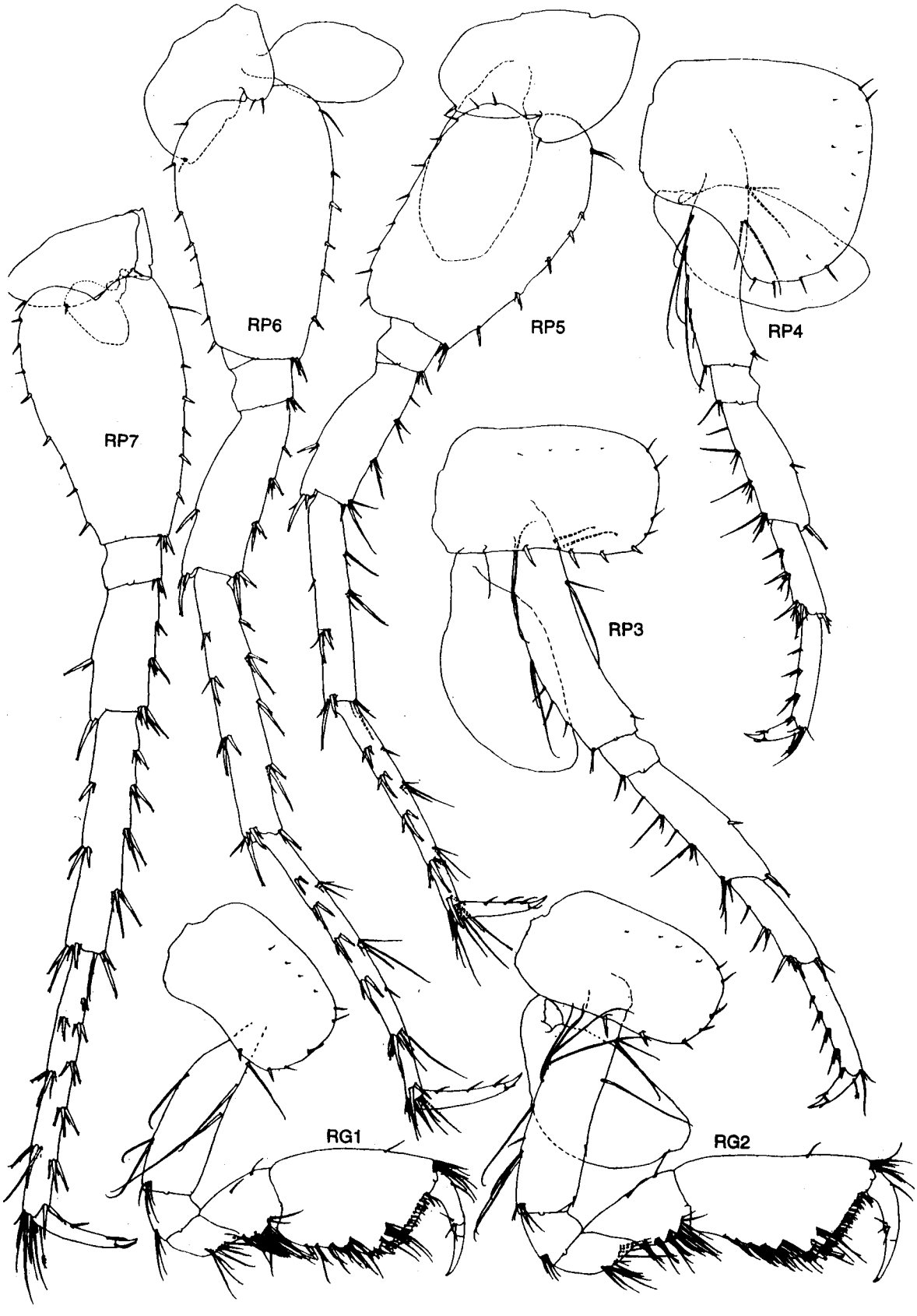

Fig. 3.2. *Austrogammarus badgerhill* n. sp. Male 'a' right legs.

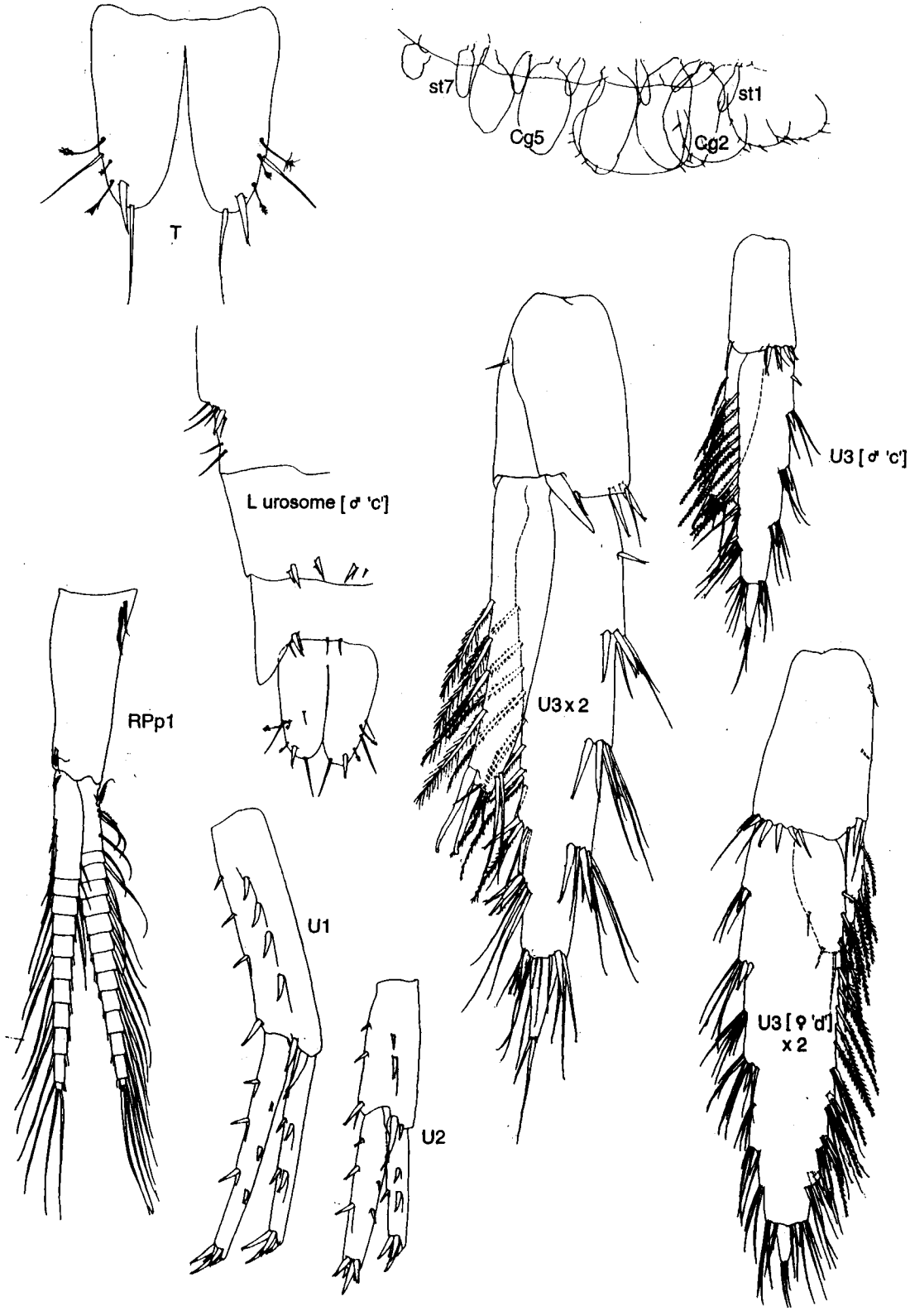

Fig. 3.3. *Austrogammarus badgerhill* n. sp. Male 'a' (except where marked) gills, pleopod 1, uropods 1-2, uropod 3 (x 2), telson (x 2); male 'c' left urosome, uropod 3; female 'd' uropod 3 (x 2).

seta; molars fully triturating, with long pappose seta on right, short on left; palps of three articles; left palp with 2 A, 3 B, 13 D, 5 E setae; right palp with 2 A, 1 B, 13 D, 5 E setae. *Maxilla 1*: inner plate subtriangular, with 9 plumose setae on medial margin, and 5 short plumose setae apically and disto laterally, basally and facially naked, without apico-medial plumose setae; outer plate with 11 setal teeth, 9 cuspidate, and 2 naked; left palp with 5 apico-medial and apical naked setae, 1 naked apico lateral seta, 2 distal ventro-facial setae, and 0 distal facial setae; right palp asymmetrical with left, apex with 6 articulated, and 0 fused broad based tooth setae, and 1 apicolateral seta. *Maxilla 2*: inner plate with slender medial setae, tending facial distally, forming an oblique row, facially setose (pubescent); outer plate bearing apical and sub-apical slender setae, with disto-lateral seta. *Gnathopods*: sexual dimorphism seen as enlargement of male gnathopods (particularly G2). Gnathopod 1: smaller than gnathopod 2; coxa one with 2 robust posterior setae, 4 ventral setae, and 0 anterior setae; merus without posterior scythe seta; carpus sub-triangular, short, shorter than 0.5 x propodus; propodus trapezoidal, palmar angle acute, palm without bifid robust setae along margin, and with simple setae along margin, with 3 lateral and 3 medial robust setae around the posteroventral corner, corner slightly out-turned; dactyl reaching to palmar corner, with single recumbent inner tooth spine, nail with accessory setules at the junction of the nail. Gnathopod 2: larger than gnathopod 1; coxa with 3 robust posterior setae, 4 ventral setae, and 0 anterior setae; merus without posterior scythe seta; carpus subtriangular, long, shorter than, 0.5 x propodus; propodus trapezoidal, palmar angle acute, palm with simple setae along margin, with 3 lateral robust setae around posteroventral corner, and 3 medial robust setae around posteroventral corner, corner subquadrate; dactyl reaching to palmar corner, with single recumbent inner tooth spine, with accessory setules at the junction of the nail. *Pereopods*: Pereopods 3-4 equal in length to gnathopod 2. Pereopod 3: coxa with 0 anterior setae, 4 ventral setae, and 4 robust posterior setae; propodus with more than one robust seta in posterior sets; pereopod three subequal in length to pereopod four, P3 smaller than P4, similar in form. Pereopod 4: coxa with moderate postdorsal emargination, with 2 anteroventral setae, 4 posteroventral setae, 0 robust posterior setae; merus moderately setose posteriorly; propodus with more than one robust seta in posterior sets. Pereopod 5: longer than P4; coxa short, posteriorly reduced with a single strong seta ventrally on both lobes; basis weakly expanded, with small

posteroventral lobe, posteroventral corner without elongate setae, anterior margin with medium length robust setae, posterior margin with medium length slender setae; merus to propodus with mixed short and long setae. Pereopod 6: longer than P5; coxa smaller than coxa 5; basis weakly expanded, without posteroventral lobe, posteroventral corner without elongate setae, anterior margin with short robust setae, posterior margin with short robust setae; merus to propodus with mixed short and long setae. Pereopod 7: coxa smaller than coxa 5; basis weakly expanded, without posteroventral lobe, posteroventral corner without elongate setae, anterior margin and posterior margins with short robust setae; P7 subequal in length to P6. *Pleonites 1-3*: transverse bands of dorsodistal setae a strong mix of both slender and robust setae, with transverse band of dorsodistal slender setae. *Epimera*: Epimeron 1 without anteroventral setae, without robust setae on the anteroventral margin, with 1 robust seta on the posteroventral margin, without slender setae on the ventral margin, without slender setae on the posterior margin, posterior margin sinuous, posteroventral corner acuminate, without spine or seta. Epimeron 2: with 2 robust setae on the anteroventral margin, without robust setae on the posteroventral margin, without slender setae on the ventral margin, with 4 slender setae on the posterior margin, posterior margin sinuous, posteroventral corner acuminate, without spine or seta. Epimeron 3: with 3 robust setae on the anteroventral margin, without robust setae on the posteroventral margin, without slender setae on the ventral margin, with 2 slender setae on the posterior margin, posterior margin straight, posteroventral corner acuminate, with small spine. *Pleopods*: biramous. Pleopod 1: peduncle with 2 retinaculae, 1 accessory retinaculum. Pleopod 2: peduncle with 2 retinaculae, 1 accessory retinaculum. Pleopod 3: peduncle with 2 retinaculae, 1 accessory retinaculum. *Urosomites*: Urosomite 1: with transverse band of dorsodistal slender setae, with 1 distolateral robust seta, without post-dorsal robust seta. Urosomite 2: with transverse band of post-dorsal slender setae, with 3 distolateral robust setae, without post-dorsal robust seta. Urosomite 3: with transverse band of post-dorsal slender setae, with 2 distolateral robust setae, without post-dorsal robust seta, bearing distoventral seta at the base of uropod one. *Uropods*: Uropod 1: peduncle 1 x length of inner ramus, with 4 dorsolateral, 2 apicolateral, 3 dorsomedial, and 1 apicomedial robust setae; medial ramus longer than lateral ramus; lateral ramus with 2 lateral, 3 medial, and 5 apical robust setae; medial ramus with 3 lateral, 3 medial, and 5 apical robust setae. Uropod 2: 0.7 x

length of uropod one, peduncle 0.8 x length of inner ramus, with 2 dorsolateral, 2 apicolateral, 2 dorsomedial, and 2 apicomedial robust setae; medial ramus longer than lateral ramus; lateral ramus with 2 lateral, 2 medial, and 5 apical robust setae; medial ramus with 2 lateral, 3 medial, and 5 apical robust setae. Uropod 3: extending beyond uropods 1-2 in intact specimen, 0.9 x the length of uropod 1; peduncle short, length 0.3 x outer ramus, 1x the length of urosomite three, with no robust or small dorsolateral setae, with 2 robust apicolateral setae, 1 small apicolateral seta , with no robust dorsomedial setae, 1 small dorsomedial seta , with no robust apicomedial setae, no small apicomedial setae, with 1 robust apicodorsal seta, 1 small apicodorsal seta; inner ramus shorter than, about 0.5x, outer ramus; outer ramus two articulate, proximal article setae arranged laterally and medially in transverse bands or arranged medially singly with, with 3 lateral transverse bands of mixed robust and small setae, with 3 medial bands of mixed robust and small setae, 6 medial small setae (plumose), 1 apicolateral robust seta, 4 apicolateral small setae, 2 apicomedial robust setae, and 6 apicomedial small setae; distal article short, narrow, sub triangular, with 0 lateral robust setae, 0 lateral slender simple setae, 0 medial robust setae, 0 medial slender simple setae, 0 medial slender plumose setae, 0 apical robust setae, 2 apical slender simple setae, 0 apical plumose setae; inner ramus with 0 lateral robust setae, 0 lateral slender setae, with 0 medial robust setae, 0 medial slender setae, and 4 medial plumose setae, inner ramus apical setae: 2 robust setae terminally hooked, plus slender as in following, with 2 apical robust setae, 7 apical slender setae, 0 apical plumose setae. *Telson*: subequal in length to urosomite three, deeply cleft, (80 %), as long as broad, lateral margins tapering, convex, apices rounded, dorsal setae absent, left lobe with 1 apical robust seta , right lobe with 1 apical robust seta , left lobe with 1 apical slender seta , right lobe with 2 apical slender setae, apical penicillate setae absent, and single penicillate setae, at M0.67 to M0.87 from the telson base.

Description of female 'd'.

Similar to male 'a' except: length 12mm; second antenna without calceoli; second gnathopod similar in size to the first gnathopod; coxae of pereopods 2-5 bearing large, ovate, peripherally setose oostegites; third uropod peduncle bearing a distomedial pair of moderate size robust setae and two small submarginal medial setae, the outer ramus bearing seven transverse lateral setal bands, more setose than male 'a', the inner ramus short,about 0.3x length of the proximal article of the

outer ramus, and bearing single lateral and apicolateral small setae, a medial row of three plumose setae and two slender setae with a single slender apical seta unlike the hooked paired robust setae of male 'a'.

Description of male 'c'.

Length 6mm. Similar to male 'a'.

Relationships

Austrogammarus badgerhill differs from all other austrogammarids in possessing three lateral robust setae on the palmar corner of the first gnathopod, and the basis of the fifth pereopod is only weakly expanded. This species differs from all others of the genus excepting *A. smithi* and *A. multispinatus* in bearing few peduncular setae on the second antenna, which are short unlike *A. australis*, *A. saycei*, *A. spinatus*, *A. robbins* and *A pegarah*, but not ventrally as in *A. australis* and *A. telsosetosus*; calceoli are present on the fifth peduncular article of the second antenna whereas they are absent in *A. smithi*, *A. australis* and *A. saycei*; like *A. smithi*, *A. australis*, *A. robbins* and *A pegarah* the posterior margin of the first coxa bears two robust setae; the lengths of gnathopodal carpi are less than propodi, unlike *A. australis* and *A. saycei*; the inner ramus of uropod three is about half the length of the outer ramus, similar only to *A. spinatus*; the telson is cleft 80%, less than other species, excepting *A. saycei*.

Distribution.

Stream to the north of Badger Hill, Flinders Island, approximately 148°E 40°S.

3.1.1.2 *Austrogammarus robbins* n.sp. Figs. 3.4-3.6.

Etymology. Named for the type locality.

Type locality.

Seepage, south of Robbins Rd., along Millwood Rd., north of Yarra Creek, King Island.

Material examined.

Male 'a' 6mm; male'b' 6.5mm, male'd' 7mm, female'c', female'e'. Coll. B. Knott, 8 Dec. 72. Ref.# T295.

Type specimen.

Holotype, Male 'a' 6mm.

Diagnosis.

Eyes medium, reniform. Antenna 1 very long. Antenna 2 slender, with few setae,bearing calceoli on peduncle article 5 and on the flagellum. Mandibular palp article three with ABDE setae. Labium lacking inner lobes. Maxillae medially setose; inner plate of maxilla 1 subtriangular, outer plate bearing 11 setal spines, all cuspidate; maxilla 2 inner plate with weakly oblique row of facial setae; coxae 1-3 bearing robust posterior setae; coxa 4 deeply excavate. Gnathopods 1-2 subequal in size, palmar angles almost transverse. Pereopods 5-7 long, second article broadly expanded, dactyls not multispinous. Basomedial setae on inner ramus of pleopods bifid. Pleonites bearing transverse distal band of setae, lacking robust lateral seta. Uropod 1 without basofacial armaments. Uropod 3 extending beyond uropods 1-2, outer ramus of two articles, the second small, inner ramus extending to M0.6 of outer. Telson as long as urosomite 3, deeply cleft, longer than broad, lobes laterally tumid, bearing slender dorsal setae.

Description of Holotype (male 'a').

Body: 6mm, cuticle smooth, with numerous dorsal setae on pleon restricted to a posterior band. *Gills*: coxal gills present on coxae 2-7; sternal gills simple (sausage shaped), present on sternites 2-7. *Head*: eyes present, medium in size, reniform. *Antenna 1*: very long, 0.6 x body, 3.7 x antenna 2, with few setae; peduncle 0.3 x length of flagellum; primary flagellum 53 articulate; accessory flagellum short, 6 articulate, extending to M0.8 of article 7 of the primary flagellum. *Antenna 2*: slender, similar to antenna 1, with moderate numbers of medium setae on peduncle and flagellum; flagellum as long as peduncle 19 articulate; bearing 4 calceoli on article 5 of the peduncle, and calceoli on articles 2 of the flagellum, 3 of the flagellum, 5 of the flagellum, 6 of the flagellum, 7 of the flagellum, 8 of the flagellum, 10 of the flagellum and 13 of the flagellum. *Mandibles*: incisors asymmetrical, left with 5 teeth; right with 4 teeth; lacinia mobilis asymmetrical, left with 4 teeth, right bifid, strongly denticulate; left mandible with 6 serrate setae, 4 plumose intermediate setae, 5 brushy basal setae; right mandible with 4 serrate setae, 4 plumose intermediate setae, 4 brushy basal setae; molars fully triturating, with long pappose seta on right, short on left; palps of three articles; left palp with 4 + 2 A setae, 3 B setae, 17 D setae, 4 E setae; right palp with 3 + 2 A setae, 5 B setae, 17 D setae, 4 E setae. *Maxilla 1*: inner plate subtriangular, with 12 plumose setae on medial margin, and 8 short plumose setae apically and disto laterally, basally and facially naked, without apico-medial plumose setae; outer plate with 11 setal teeth, 11

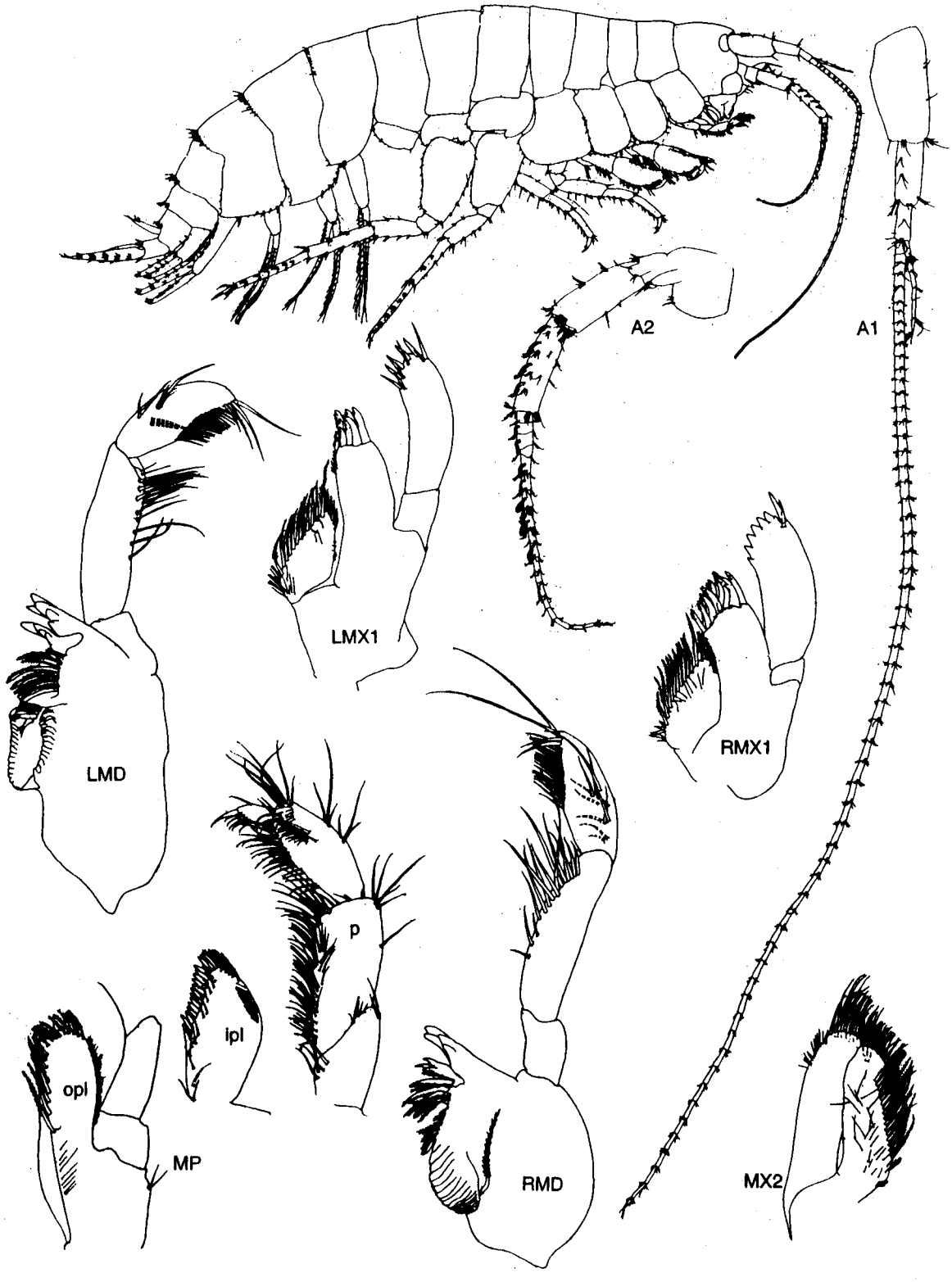

Fig. 3.4. *Austrogammarus robbins* n. sp. Male 'b' whole; male 'a' antennae 1-2, mouthparts.

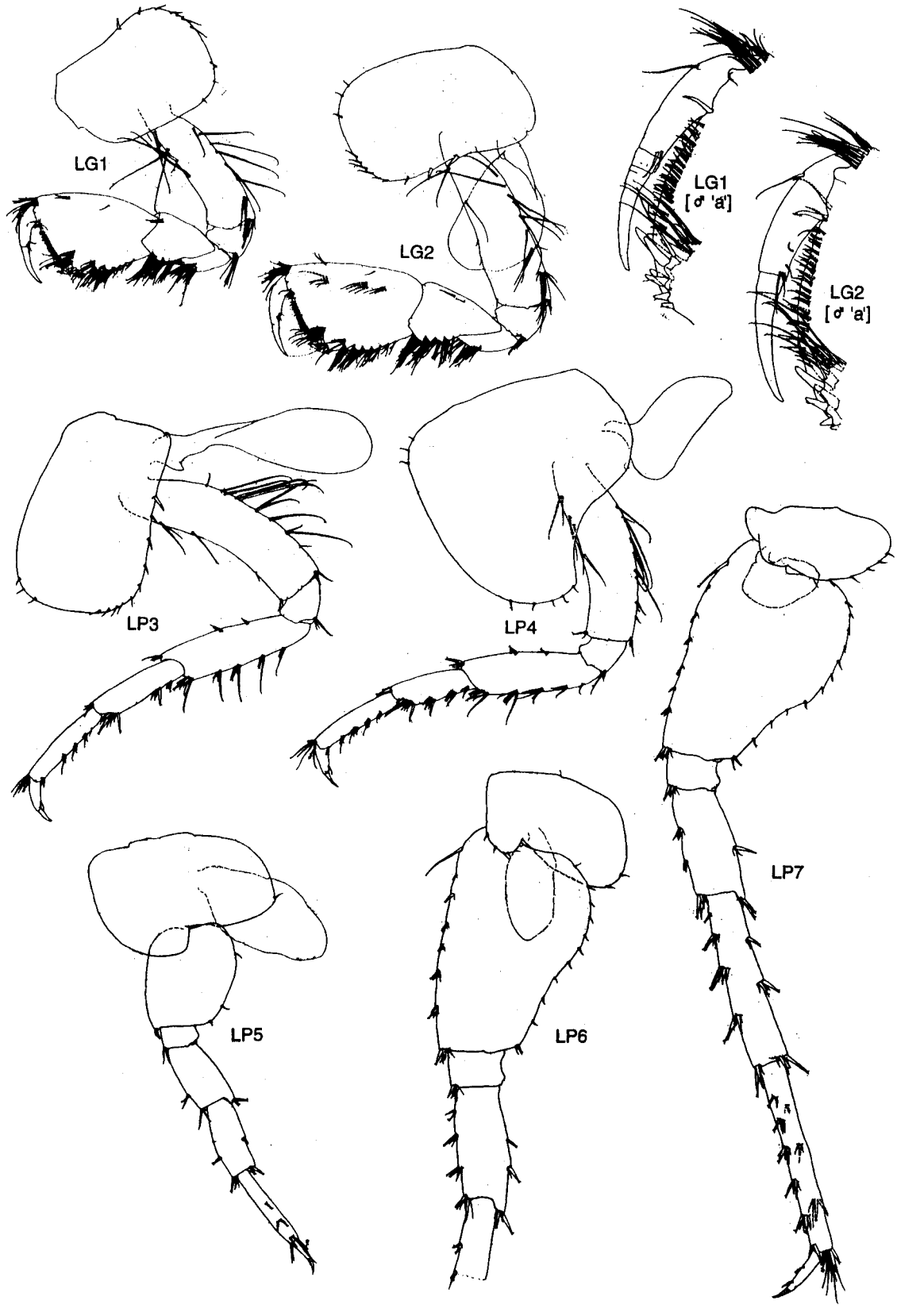

Fig. 3.5. *Austrogammarus robbins* n. sp. Male 'a' gnathopods 1-2 palms; male 'd' left legs.

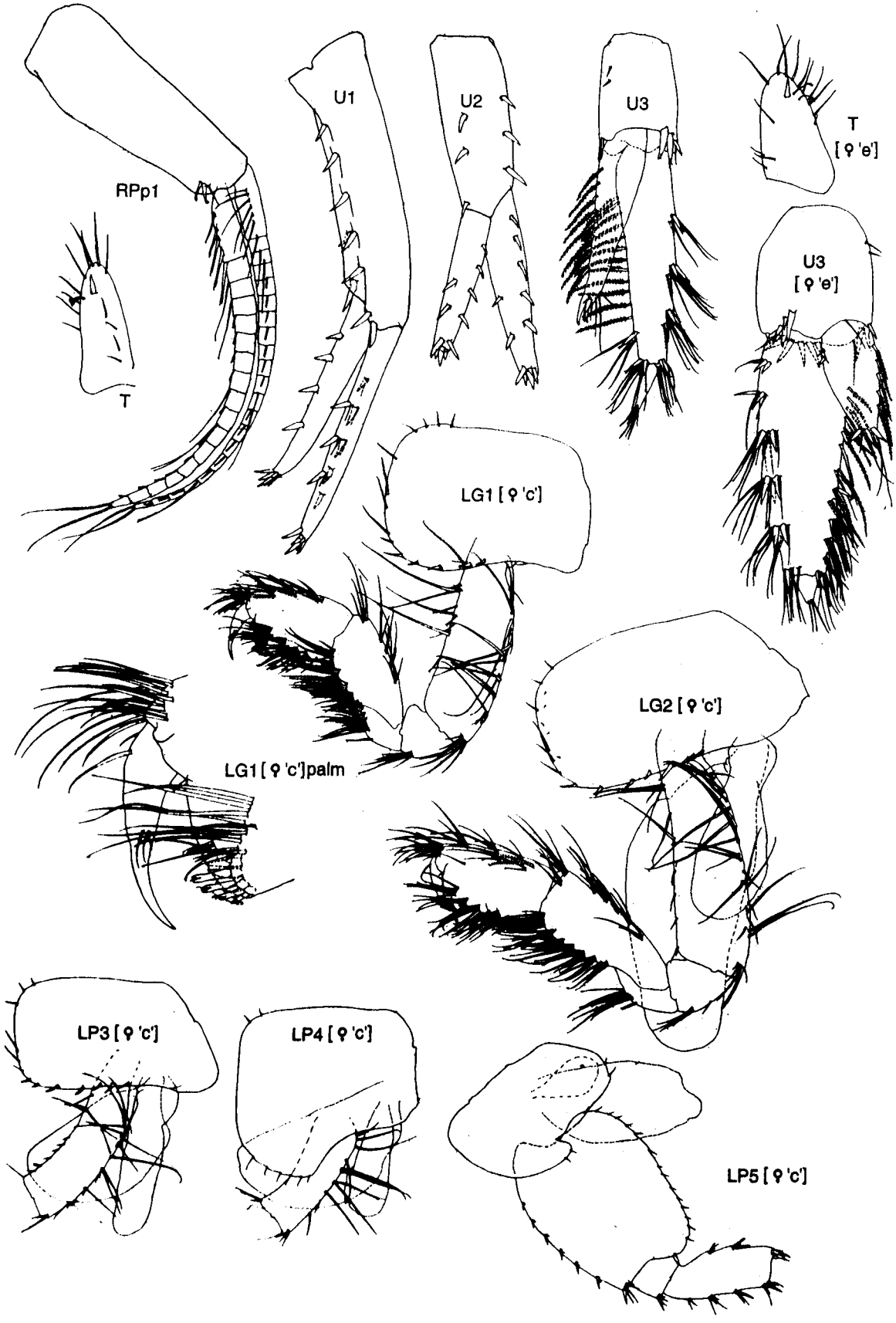

Fig. 3.6. *Austrogammarus robbins* n. sp. Male 'a' uropods 1-3, telson; female 'e' telson; female 'c' gnathopod 1, gnathopod 1 palm, gnathopod 2, coxae and part legs 3-5 showing oostegites and coxal gills.

cuspidate, and 0 naked; left palp with 5 apico-medial and apical naked setae, 1 naked apico lateral seta , and 5 distal facial setae; right palp asymmetrical with left, apex with 0 articulated, and 6 fused broad based tooth setae, and 2 apicolateral setae. *Maxilla 2*: inner plate with slender medial setae tending facial distally, facially setose (pubescent); outer plate bearing apical and sub-apical slender setae, with disto-lateral seta. *Gnathopod 1*: subequal to gnathopod 2; coxa one with 2 robust posterior setae, 8 ventral setae, and 0 anterior setae; merus without posterior scythe seta; carpus subtriangular, short, shorter than 0.5 x propodus; propodus trapezoidal, palmar angle slightly oblique, palm without bifid robust setae but bearing simple setae along margin, with 5 lateral, and 3 medial robust setae around posteroventral corner, corner rounded; dactyl not reaching to palmar corner, with no recumbent inner tooth spine, nail with accessory setules at the junction of the dactyl. *Gnathopod 2*: subequal to gnathopod 1; coxa with 4 robust posterior setae, 8 ventral setae, and 0 anterior setae; merus without posterior scythe seta; carpus subtriangular, short, shorter than 0.7 x propodus; propodus trapezoidal, palmar angle slightly acute, palm with only simple setae along margin, with 4 lateral robust setae around posteroventral corner, and 5 medial robust setae around posteroventral corner, corner rounded; dactyl not reaching to palmar corner, with single recumbent inner tooth spine, with accessory setules at the junction of the nail. *Pereopods*: Pereopods 3-4: longer than gnathopod 2. Pereopod 3: coxa with 0 anterior setae, 7 ventral setae, and 6 robust posterior setae; propodus with more than one robust seta in posterior sets. Pereopod 3 subequal in length to pereopod 4 and similar in form. Pereopod 4: coxa large, ovate, deeply excavate, coxa with, strong postdorsal emargination, with 3 anteroventral setae, 5 posteroventral setae, 0 robust posterior setae; merus moderately setate posteriorly; propodus with more than one robust seta in posterior sets. Pereopod 5: longer than P4; basis moderately expanded, with moderate posteroventral lobe, posteroventral corner without elongate setae, anterior margin with short robust setae, posterior margin with short slender setae; merus to propodus without long setae. Pereopod 6: longer than P5; coxa smaller than coxa 5; basis moderately expanded, without posteroventral lobe, posteroventral corner without elongate setae, anterior margin with short robust setae, posterior margin with short robust setae or short slender setae; merus to propodus without long setae. Pereopod 7: coxa smaller than coxa 5; basis weakly expanded, without posteroventral lobe, posteroventral corner

without elongate setae, anterior margin with short robust setae, posterior margin with short robust setae or short slender setae; Pereopod 7 shorter than P6. *Pleonites 1-3*: with transverse band of dorsodistal slender setae, without dorsodistal robust setae. *Epimera*: Epimeron 1: without anteroventral setae, without robust setae on the anteroventral margin, with 1 robust setae on the posteroventral margin, without slender setae on the ventral margin, with 2 slender setae on the posterior margin, posterior margin convex, posteroventral corner acuminate, without spine or seta. Epimeron 2: with 6 robust setae on the anteroventral margin, without robust setae on the posteroventral margin, without slender setae on the ventral margin, with 4 slender setae on the posterior margin, posterior margin straight, posteroventral corner acuminate, without spine or seta. Epimeron 3: with 5 robust setae on the anteroventral margin, without robust setae on the posteroventral margin, without slender setae on the ventral margin, with 4 slender setae on the posterior margin, posterior margin straight, posteroventral corner acuminate, without spine or seta. *Pleopods*: biramous. Pleopod 1: peduncle with 2 retinaculae, 1 accessory retinaculum. Pleopod 2: peduncle with 2 retinaculae, 1 accessory retinaculum. Pleopod 3: peduncle with 2 retinaculae, 1 accessory retinaculum. *Urosomites*: Urosomite 1: with transverse band of dorsodistal slender setae, without distolateral robust setae, without dorsodistal robust seta. Urosomite 2: with transverse band of dorsodistal slender setae, with 1 distolateral robust setae, without dorsodistal robust seta. Urosomite 3: with transverse band of dorsodistal slender setae, with 1 distolateral robust setae, without dorsodistal robust seta, bearing distoventral seta at the base of uropod one. *Uropods*: Uropod 1: peduncle 1.2 x length of inner ramus, with 5 dorsolateral, 2 apicolateral, 4 dorsomedial, and 1 apicomedial robust setae; medial ramus longer than lateral ramus; lateral ramus with 4 lateral, 0 medial, and 5 apical robust setae; medial ramus with 3 lateral, 5 medial, and 5 apical robust setae. Uropod 2: 0.7 x length of uropod one, peduncle 1 x length of inner ramus, with 2 dorsolateral, 1 apicolateral, 2 dorsomedial, and 1 apicomedial robust setae; medial ramus longer than lateral ramus, lateral ramus with 2 lateral, 4 medial, and 5 apical robust setae; medial ramus with 2 lateral, 5 medial, and 5 apical robust setae. Uropod 3: much longer than uropods 1-2 in intact specimen, 1.5 x the length of uropod 1; peduncle short, length 0.4 x outer ramus, 0.7 x the length of urosomite three, with 0 robust dorsolateral setae, 0 small dorsolateral setae, with 3 robust apicolateral setae, 1 small apicolateral setae, with 0

robust dorsomedial setae, 2 small dorsomedial setae, with 0 robust apicomedial setae, 2 small apicomedial setae, with 0 robust apicodorsal setae, 0 small apicodorsal setae; inner ramus shorter than outer ramus, inner ramus about 0.6 x outer ramus; outer ramus two articulate, proximal article setae arranged laterally and medially in transverse bands or arranged medially singly, with 3 lateral transverse bands of mixed robust and small setae, with 1 medial bands of mixed robust and small setae, 12 medial small setae, 2 apicolateral robust setae, 7 apicolateral small setae, 2 apicomedial robust setae, and 2 apicomedial small setae, distal article short, narrow, sub triangular, with 0 lateral robust setae, 0 lateral slender simple setae, 0 medial robust setae, 0 medial slender simple setae, 0 medial slender plumose setae, 0 apical robust setae, 6 apical slender simple setae, 0 apical plumose setae; inner ramus with 0 lateral robust setae, 3 lateral slender setae, with 0 medial robust setae, 0 medial slender setae, and 8 medial plumose setae, with 2 apical robust setae, 3 apical slender setae, 0 apical plumose setae. *Telson*: subequal in length to 1 x urosomite three, deeply cleft, (88 %), longer than broad, length 1.2 x breadth, lateral margins tapering, convex, apices rounded, left lobe with 0 dorsal robust setae, left lobe with 4 dorsal slender setae, left lobe with 1 apical robust setae, left lobe with 5 apical slender setae, apical penicillate setae absent, and paired lateral penicillate setae, at M0.8 from the telson base, bearing 4 distolateral slender setae at M0.5, 0.6, 0.75, 0.8 from telson base.

Description of female 'c'.

Similar to male 'a' except: length 6mm; antenna two lacking calceoli; carpus and propodus of gnathopd two longer than broad, gnathopodal palmar robust setae bifid, accessory setae moderately dense and long; coxae of pereopods 2-5 bearing elongate oostegites with few marginal setae; third uropod broader than male 'a', the inner ramus short, less than 0.5x the length of the first article of the outer ramus, without apical hooked robust setae; the telson shorter and broader than male 'a' and bearing small submarginal basal setae.

Description of female 'e'.

Similar to female 'c'.

Relationships

Austrogammarus robbins differs from all other austrogammarids in that the propodus of gnathopod one bears five lateral robust setae. The species is similar to all except *A. australis* and *A. telsosetosus* in that peduncular setae of the second

antenna are not borne ventrally, and calceoli are present on the fifth article, unlike *A. smithi*, *A. australis* and *A. saycei*; like the majority of species except *A. australis* the length of the carpus of the second gnathopod is less than the propodus; the basis of pereopod five is moderately expanded posteriorly, unlike *A. badgerhill* and, similar to *A. saycei* and *A. dovel*, the basis bears a moderate sized posteroventral lobe; like *A. smithi* the telson is cleft about 90%.

Distribution.

Seepage, south of Robbins Rd., along Millwood Rd., north of Yarra Creek, King Island, approximately 144°05'E 40°00'S

3.1.1.3 *Austrogammarus pegarah* n.sp. Figs. 3.7 - 3.9.

Etymology.

Named for the type location.

Type locality.

Unnamed lagoon, Pegarah-Grassy Rd junction, King Is.

Material examined. Male 'b' 6mm; female 'd' 6mm, male 'a' 6.5mm, female 'c' 8mm. Coll. B.Knott, 08 Dec. 72. Ref#.T275.

Type specimen.

Holotype, Male 'b' 6mm; female 'd' 6mm, male 'a' 6.5mm, female 'c' 8mm

Diagnosis.

Body with numerous dorsal setae on pleon segments restricted to posterior bands. Antenna 1 very long, as long as body. Antenna 2 robust, tending pediform, bearing moderate numbers of medium setae on peduncle and flagellum, peduncle and flagellum bearing calceoli. Mandibular palp article 3 bearing ABDE setae. Maxilla 1 outer plate with 11 cuspidate setal teeth. Inner plate of maxilla 2 with a weakly oblique row of slender setae. Gnathopods sexually dimorphic, seen mainly in the enlargement of the male gnathopods, palmar angles nearly transverse. Coxae 1-3 bearing posterior robust setae; coxa 3 subrectangular, coxa 4 large, deeply emarginate. Pereopods 5-7 long, 5 shortest. Pleonites and urosomites bearing posterior transverse bands of setae. Urosomites 2-3 bearing distolateral robust setae. Uropod 1 without basofacial robust seta; uropod 3 peduncle short, outer ramus two articulate the distal article short, inner ramus 0.6x length of the outer

ramus. Telson shorter than urosomite 3, fully cleft, as broad as long, bearing sparse dorsal setae.

Description of holotype (male 'b').

Body: 6mm, with numerous dorsal setae on pleon restricted to posterior band on each segment. *Gills*: coxal gills present on coxae 2-7; sternal gills simple (sausage shaped), present on sternites 2-7. *Antenna 1*: very long, 1 x body, 2.5 x antenna 2, with few setae; peduncle 0.2 x length of flagellum; primary flagellum (60) articulate; accessory flagellum short, 6 articulate, extending to M0.1 of article 6 of the primary flagellum. *Antenna* 2: robust, tending pediform, with moderate numbers of medium setae on peduncle and flagellum; flagellum as long as peduncle, 15 articulate, bearing 2 calceoli on article 5 of the peduncle, and calceoli on articles 1 to 5, 7 and 9 of the flagellum. *Mandibles*: incisors asymmetrical, left with 5 teeth; right with 4 teeth; lacinia mobilis asymmetrical, left with 4 teeth, right bifid, strongly denticulate; left mandible with 7 serrate setae, 2 plumose intermediate setae, 4 brushy basal setae; right mandible with 3 serrate setae, 2 plumose intermediate setae, 4 brushy basal setae; molars fully triturating, with long pappose seta on right, short on left; palps of three articles; left palp with 3 A setae, 3 B setae, 13 D setae, 5 E setae; right palp with 3 A setae, 2 B setae, 13 D setae, 5 E setae. *Maxilla 1*: inner plate subtriangular, with 10 plumose setae on medial margin, tending facial distally, and 5 short plumose setae apically and disto laterally, basally and facially bearing many fine setules; outer plate with 11 setal teeth, all cuspidate; left palp with 6 apico-medial and apical naked setae, 1 naked apico lateral seta, 2 distal ventro-facial setae, and 0 distal facial setae; right palp asymmetrical with left, apex with 0 articulated, and 6 fused broad based tooth setae, and 2 apicolateral setae. *Maxilla 2*: inner plate with slender medial setae tending facial distally, facially setose (pubescent); outer plate bearing apical and sub-apical slender setae, with disto-lateral setae. *Gnathopods*: sexual dimorphism seen as enlargement of male gnathopods (particularly G2). Gnathopod 1: slightly smaller than gnathopod 2; coxa one with 2 robust posterior setae, 7 ventral setae, and 0 anterior setae; merus without posterior scythe seta; carpus subtriangular, shorter than (0.4x) propodus; propodus subrectangular, palmar angle slightly acute, palm without bifid robust setae along margin, with simple setae along margin, with 4 lateral, and 3 medial robust setae around posteroventral corner, corner subquadrate or rounded; dactyl reaching to palmar corner, with single recumbent inner tooth spine, with accessory

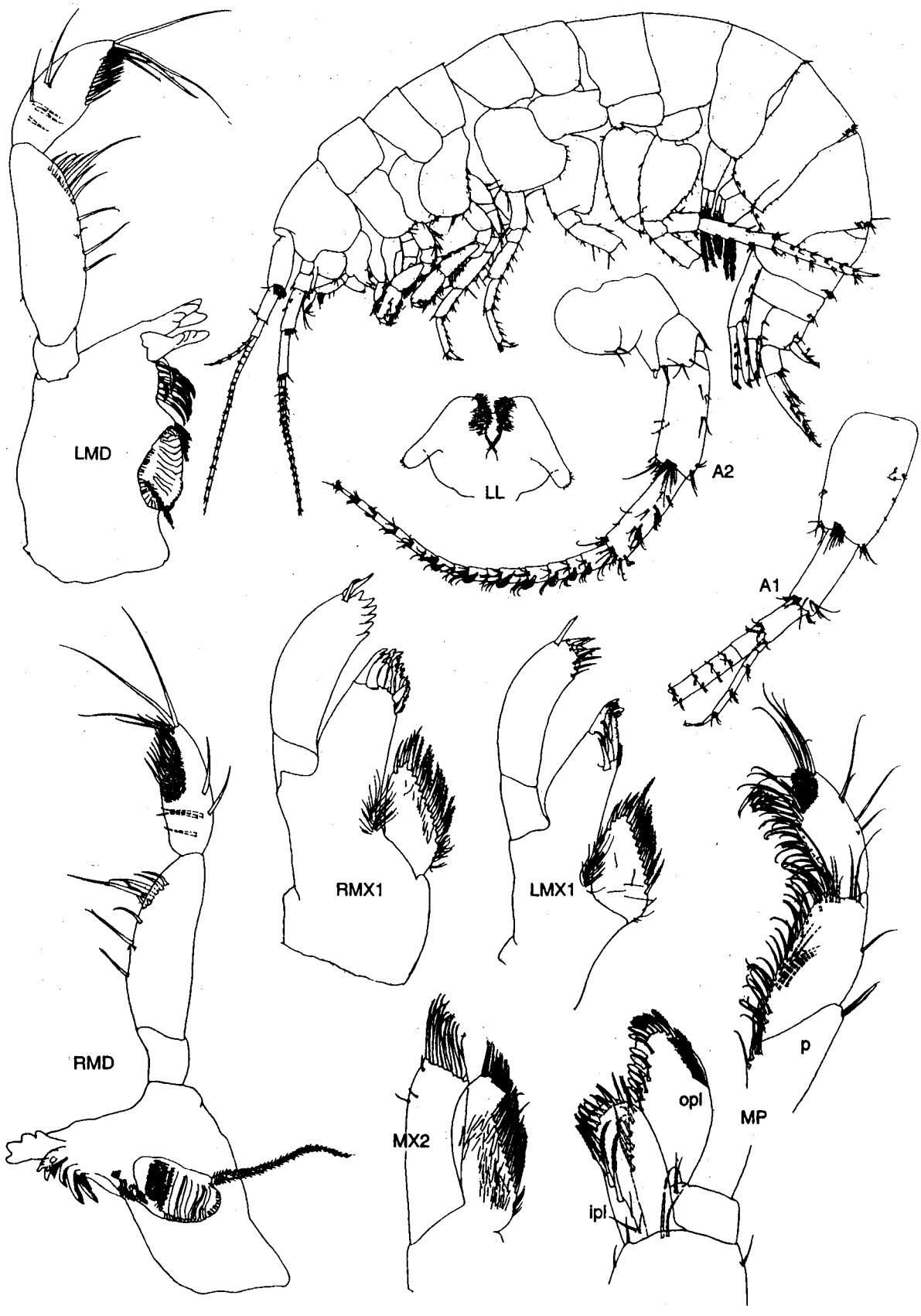

Fig. 3.7. *Austrogammarus pegarah* n. sp. Female 'd' whole; male 'b' antennae 1-2, mouthparts.

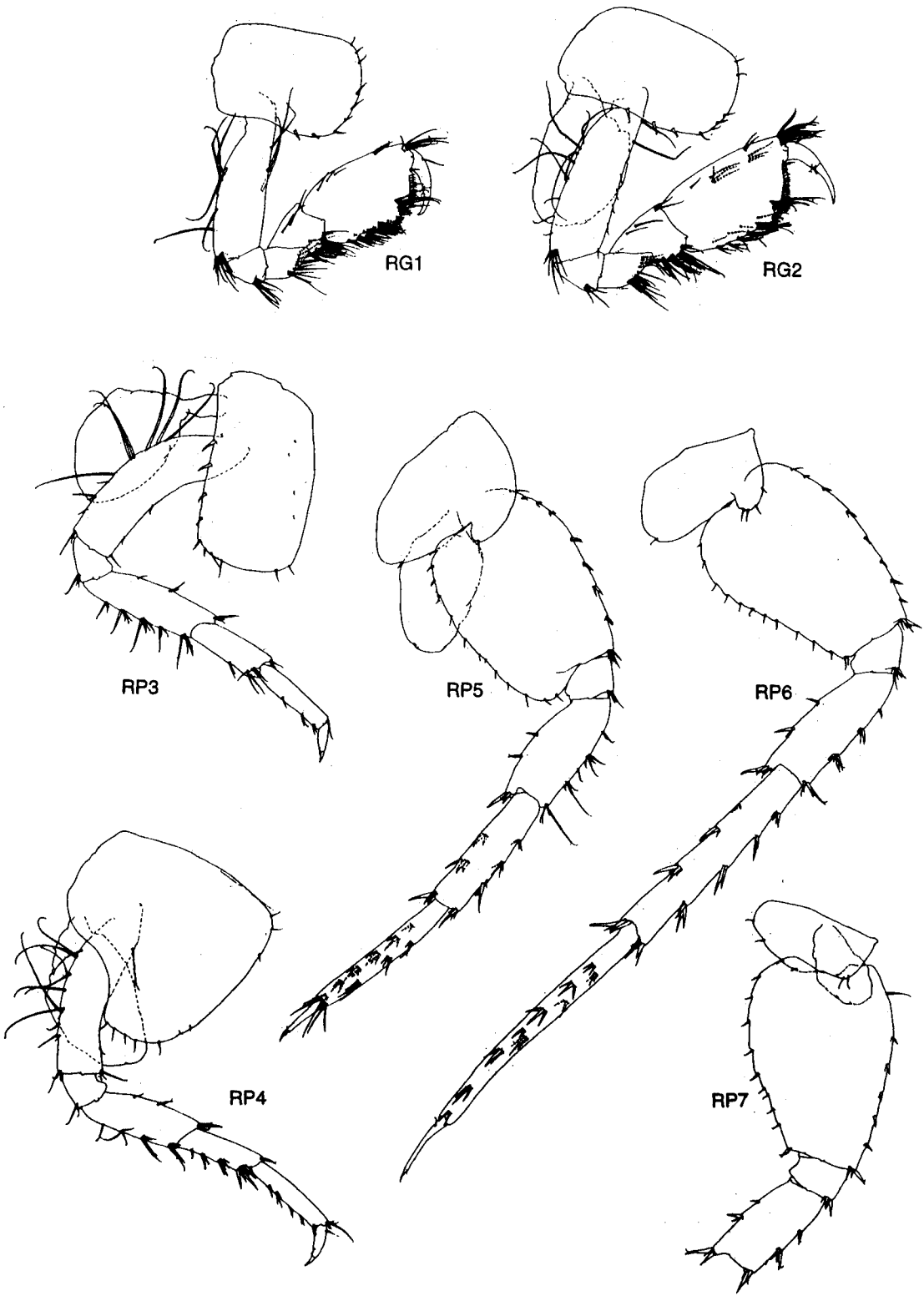

Fig. 3.8. *Austrogammarus pegarah* n. sp. Male 'b' right legs.

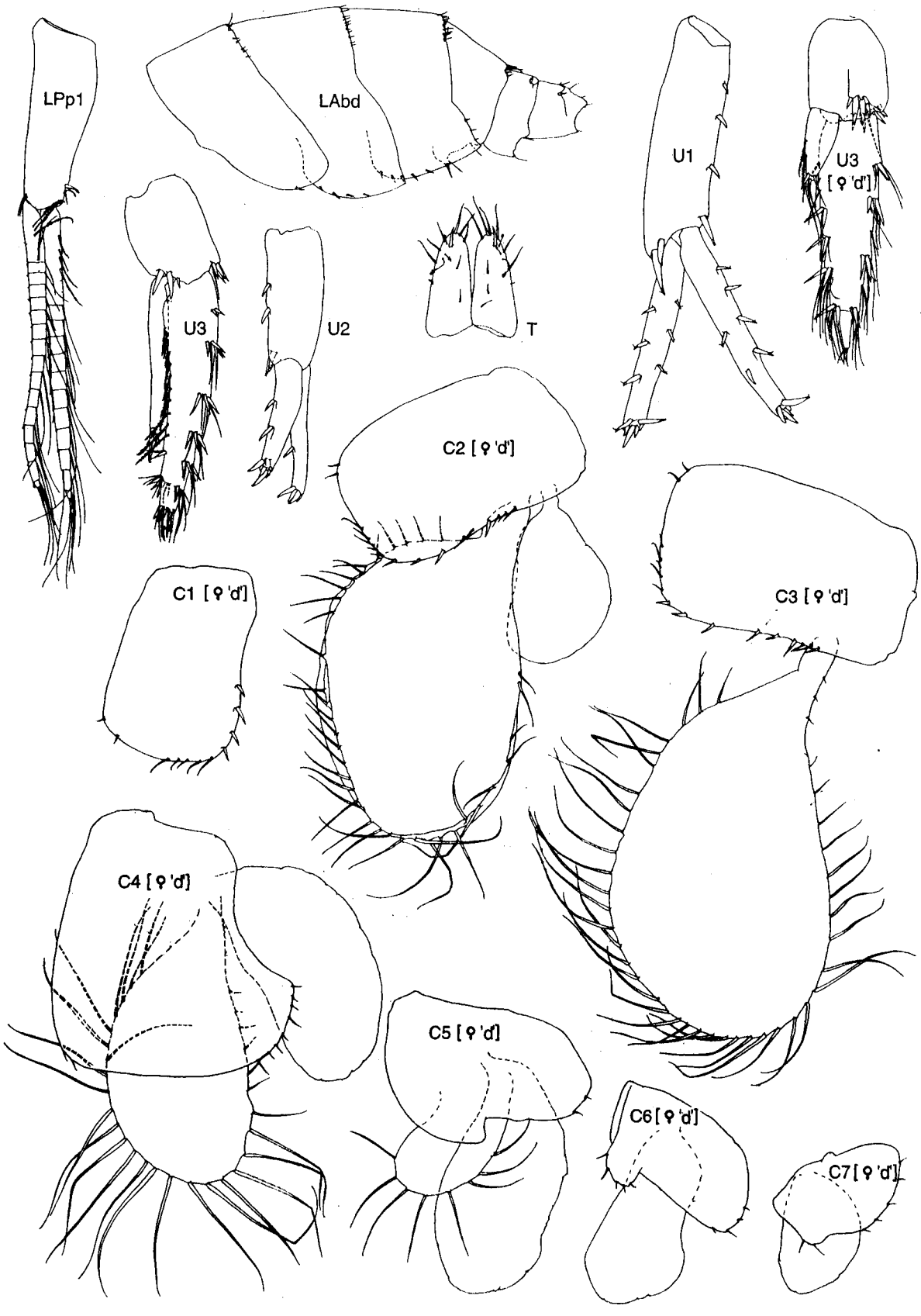

Fig. 3.9. *Austrogammarus pegarah* n. sp. Male 'a' left abdomen; male 'b', pleopod 1, uropods 1-3; female 'd' uropod 3, coxae 1-7 showing oostegites and coxal gills (CG3 lost).

setules at the junction of the nail. Gnathopod 2: slightly larger than gnathopod 1; subrectangular, apically rounded, as in G1, coxa with 3 robust posterior setae, 6 ventral setae, and 0 anterior setae; merus without posterior scythe seta; carpus subtriangular, short, shorter than 0.4 x propodus; propodus subrectangular, palmar angle acute, palm with only simple setae along margin, with 5 lateral and 3 medial robust setae around posteroventral corner, corner rounded; dactyl reaching to palmar corner, with single recumbent inner tooth spine, with accessory setules at the junction of the nail. *Pereopods* 3-4: longer than gnathopod 2. Pereopod 3: coxa 3 subrectangular, ventral margin rounded, coxa with 0 anterior setae, 6 ventral setae, and 4 robust posterior setae; propodus with no more than one robust seta in posterior sets; pereopod three subequal in length to pereopod four, and similar in form. Pereopod 4: coxa 4 large, with strong postdorsal emargination, with 3 anteroventral setae, 7 posteroventral setae, 0 robust posterior setae; merus moderately setate posteriorly; propodus with more than one robust seta in posterior sets. Pereopod 5: longer than P4; basis moderately expanded, with small posteroventral lobe, posteroventral corner without elongate setae, anterior margin with short robust setae, posterior margin with medium length slender setae; merus to propodus with mixed short and long setae. Pereopod 6: longer than P5; coxa smaller than coxa 5; basis weakly expanded, without posteroventral lobe, posteroventral corner without elongate setae, anterior margin with short robust setae, posterior margin with short slender setae; merus to propodus with mixed short and long setae. Pereopod 7: coxa smaller than coxa 5; basis weakly expanded, without posteroventral lobe, posteroventral corner with robust setae, anterior margin with medium length robust setae, posterior margin with short slender setae; pereopod 7 subequal in length to P6. *Pleonites* 1-3: with transverse band of dorsodistal slender setae, without dorsodistal robust setae. *Epimera*: epimeron 1 without anteroventral setae, without robust setae on the anteroventral margin, with 2 robust setae on the posteroventral margin, without slender setae on the ventral margin, with 1 slender seta on the posterior margin, posterior margin convex, posteroventral corner subquadrate, without spine or seta. Epimeron 2: with 3 robust setae on the anteroventral margin, without robust setae on the posteroventral margin, without slender setae on the ventral margin, with 3 slender setae on the posterior margin, posterior margin straight or convex, posteroventral corner acuminate, without spine or seta. Epimeron 3: with 5 robust setae on the

anteroventral margin, without robust setae on the posteroventral margin, without slender setae on the ventral margin, with 5 slender setae on the posterior margin, posterior margin straight, posteroventral corner acuminate, without spine or seta. *Pleopods*: 1-3: biramous; pleopod 1 peduncle with 2 retinaculae, 1 accessory retinaculum. *Urosomites*: Urosomite 1 with transverse band of dorsodistal slender setae, without distolateral robust setae, without dorsodistal robust seta; urosomite 2 with transverse band of dorsodistal slender setae, with 2 distolateral robust setae, with dorsodistal robust seta; urosomite 3 with transverse band of dorsodistal slender setae, with 1 distolateral robust seta , without dorsodistal robust seta, bearing distoventral seta at the base of uropod one. Uropods: uropod 1 peduncle 1x length of inner ramus, with 0 dorsolateral, 2 apicolateral, 3 dorsomedial, and 1 apicomedial robust setae; rami subequal in length; lateral ramus with 3 lateral, 3 medial, and 5 apical robust setae; medial ramus with 2 lateral, 4 medial, and 5 apical robust setae; uropod 2 0.7 x length of uropod one, peduncle 0.9 x length of inner ramus, with 0 dorsolateral, 1 apicolateral, 2 dorsomedial, and 1 apicomedial robust setae; medial ramus longer than lateral ramus, lateral ramus with 2 lateral, 0 medial, and 5 apical robust setae; medial ramus with 0 lateral, 1 medial, and 4 apical robust setae; uropod 3 extending beyond uropods 1-2 in intact specimen, 0.85 x the length of uropod 1; peduncle short, length 0.4 x outer ramus, 0.7 x the length of urosomite three, with 0 robust dorsolateral setae, 0 small dorsolateral setae, with 4 robust apicolateral setae, 3 small apicolateral setae, with 0 robust dorsomedial setae, 0 small dorsomedial setae, with 3 robust apicomedial setae, 0 small apicomedial setae, with 0 robust apicodorsal setae, 0 small apicodorsal setae; inner ramus shorter than outer ramus, inner ramus about 0.6 x outer ramus; outer ramus two articulate, proximal article setae arranged laterally and medially in transverse bands or arranged medially singly ⌒ , with 5 lateral transverse bands of mixed robust and small setae, with 2 medial bands of mixed robust and small setae, 11 medial small setae, 1 apicolateral robust seta , 3 apicolateral small setae, 1 apicomedial robust seta , and 6 apicomedial small setae, distal article short, narrow, sub triangular, with 0 lateral robust setae, 0 lateral slender simple setae, 0 medial robust setae, 0 medial slender simple setae, 0 medial slender plumose setae, 0 apical robust setae, 1 apical slender simple seta or 3 apical slender simple setae, 0 apical plumose setae; inner ramus with 0 lateral robust setae, 1 lateral slender seta , with 0 medial robust setae, 0 medial slender setae, and 0 medial plumose setae, with 2 apical robust

setae, 3 apical slender setae, 0 apical plumose setae. *Telson*: shorter than 0.6 x urosomite three, fully cleft (100 %), as long as broad, length 1 x breadth, lateral margins tapering, convex, apices rounded, left and right lobes with 1 dorsal robust seta, left lobe with 3 dorsal slender setae, right lobe with 2 dorsal slender setae, left lobe with 0 apical robust setae, right lobe with 0 apical robust setae, left lobe with 4 apical slender setae, right lobe with 4 apical slender setae, 1 apical penicillate seta, and paired lateral penicillate setae, at M0.8 from the telson base.

Description of female 'd'.

Similar to male 'a' except: calceoli absent from antenna 2; coxae of pereopods 2-5 bearing large, ovate, marginally setose oostegites; epimera 2-3 bearing 1 and 3 ventro marginal setae unlike male 'a' (4 and 5); the third uropod inner ramus short, about 0.3x the length of the proximal article of the outer ramus, without apical hooked robust setae, the outer ramus medial margin beaing only naked setae and no plumose setae.

Description of female 'c'.

Similar to famale 'd' except length 8mm.

Relationships

Austrogammarus pegarah differs from all other *Austrogammarus* species in that there are five lateral robust setae at the palmar corner of the second gnathopod propodus. Unlike *A. australis* and *A. saycei* setae of the second antennal peduncle are not dense, but are long, as also in *A. spinatus* and *A. saycei*, although not extending ventrally as in *A. australis* and *A. telsosetosus*; calceoli are present on the fifth peduncular article of the second antenna, unlike *A. australis A. smithi* and *A. saycei*; differing from all others except *A. spinatus*, there are four lateral and three medial robust setae on the palmar corner of the first gnathopod; the third epimeron ventral margin bears five robust setae similar to *A. multispinatus* and *A. robins*; the telson is fully cleft, thus differing from *A. australis*, *A. smithi*, *A. saycei*, *A. badgerhill A. robins* and *A. dovel*.

Distribution.

Unnamed lagoon, Pegarah-Grassy Rd junction, King Is., approximately 144°01,E 39°57'S. °

3.1.1.4 Austrogammarus dovel n.sp. Figs. 3.10 - 3.12.

Etymology

Named for the type locality.

Type locality.

Stream on the Willis Track, near Dove Lake turn off.

Material examined.

Male 'a' 9mm, female'b' 11mm. Coll. J. Bradbury, 27 Feb. 97. Ref.# T3055.

Type specimen.

Holotype, Male 'a' 9mm.

Diagnosis.

Body smooth, with numerous dorsal setae in posterior band on pleon. Eyes present. Antenna 1 long, with few setae; accessory flagellum short. Antenna 2 slender, with moderate numbers of short and long setae on peduncle and flagellum; calceoli present on peduncle and flagellum. Mandibles: incisors symmetrical, palps bearing ABDE setae. Maxilla 1 inner plate subtriangular, outer plate bearing 11 setal teeth, 9 cuspidate. Maxilla 2 inner plate with weak oblique facial setal row. Gnathopods not sexually dimorphic. Gnathopod 1 smaller than G2, propodus subquadrate, palmar angle transverse. Gnathopod 2 larger than G1, palmar angle transverse. Coxae 1-3 bearing robust posterior setae. Pereopods 3-4 longer than G2. Pereopod 4 coxa ovate, deeply excavate posteriorly. Pereopd 5 longer than P4, shorter than P6, about the same length as P7. Pleonites and urosomites bearing a transverse band of dorsodistal setae; urosomites also bearing distolateral robust setae; urosomite 3 bearing seta at base of uropod 1. Uropod 1 longer than uropods 2-3, peduncle longer than the inner ramus. Uropod 3 extending beyond uropods 1-2, peduncle shorter than outer ramus; inner ramus shorter than outer ramus, outer ramus two articulate, distal article short. Telson about the length of urosomite 3, very deeply cleft, longer than broad, bearing dorsal setae.

Description of holotype (male).

Body: length 9mm; cuticle smooth, with numerous dorsal setae on pleon restricted to posterior band. *Gills*: coxal gills present on coxae 2-7; sternal gills simple (sausage shaped), present on sternites 2-7. *Head*: eyes present, large, reniform. *Antenna 1*: long, 0.46 x body, 2.5 x antenna 2, with few setae; peduncle 0.3 x length of flagellum; primary flagellum 43 articulate; accessory flagellum short, 6 articulate, extending to M0.5 of article 6 of the primary flagellum. *Antenna 2*:

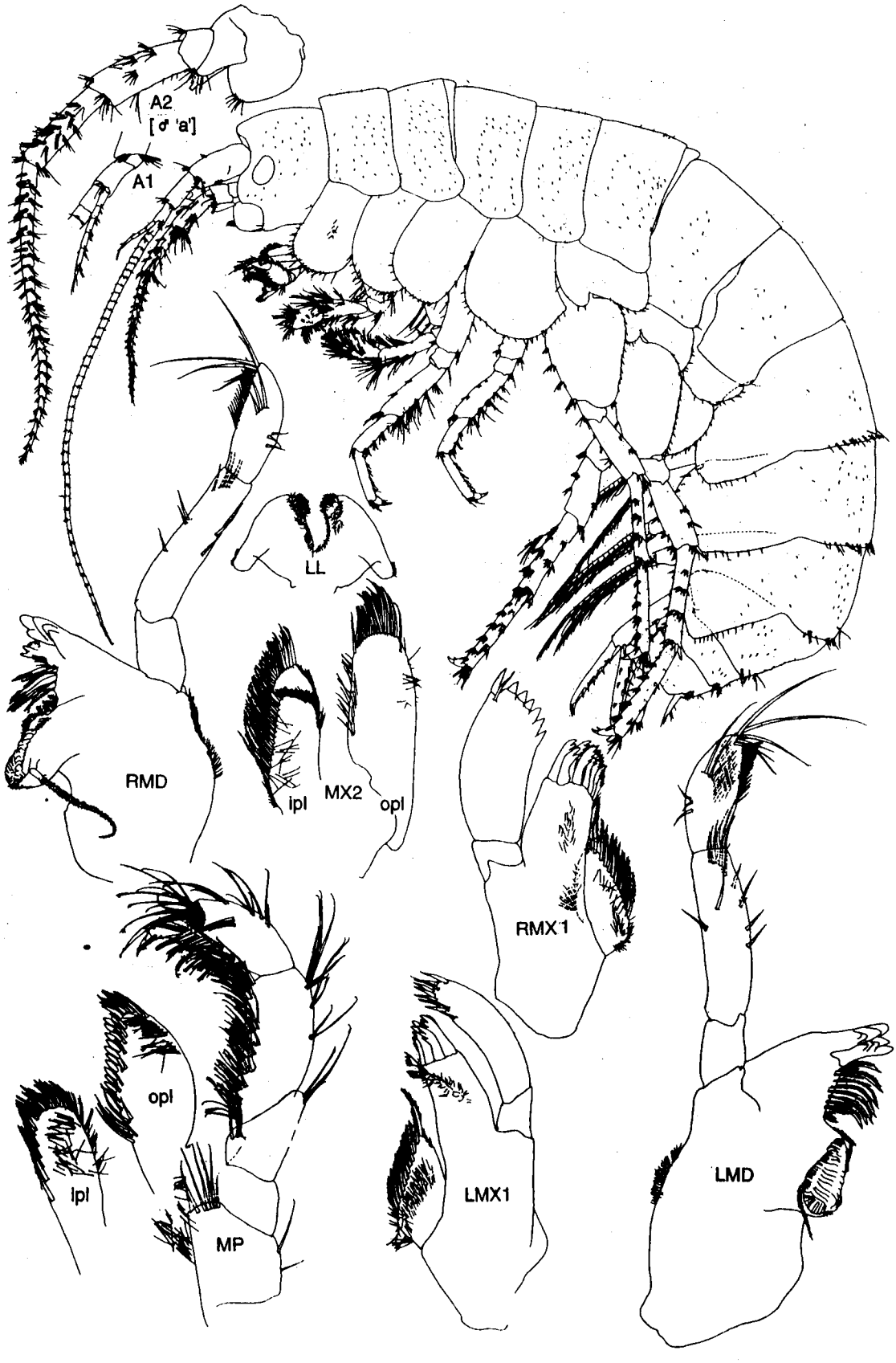

Fig. 3.10. *Austrogammarus dovel* n. sp. Female 'b' whole, mouthparts; male 'a' antenna 1 (part), antenna 2.

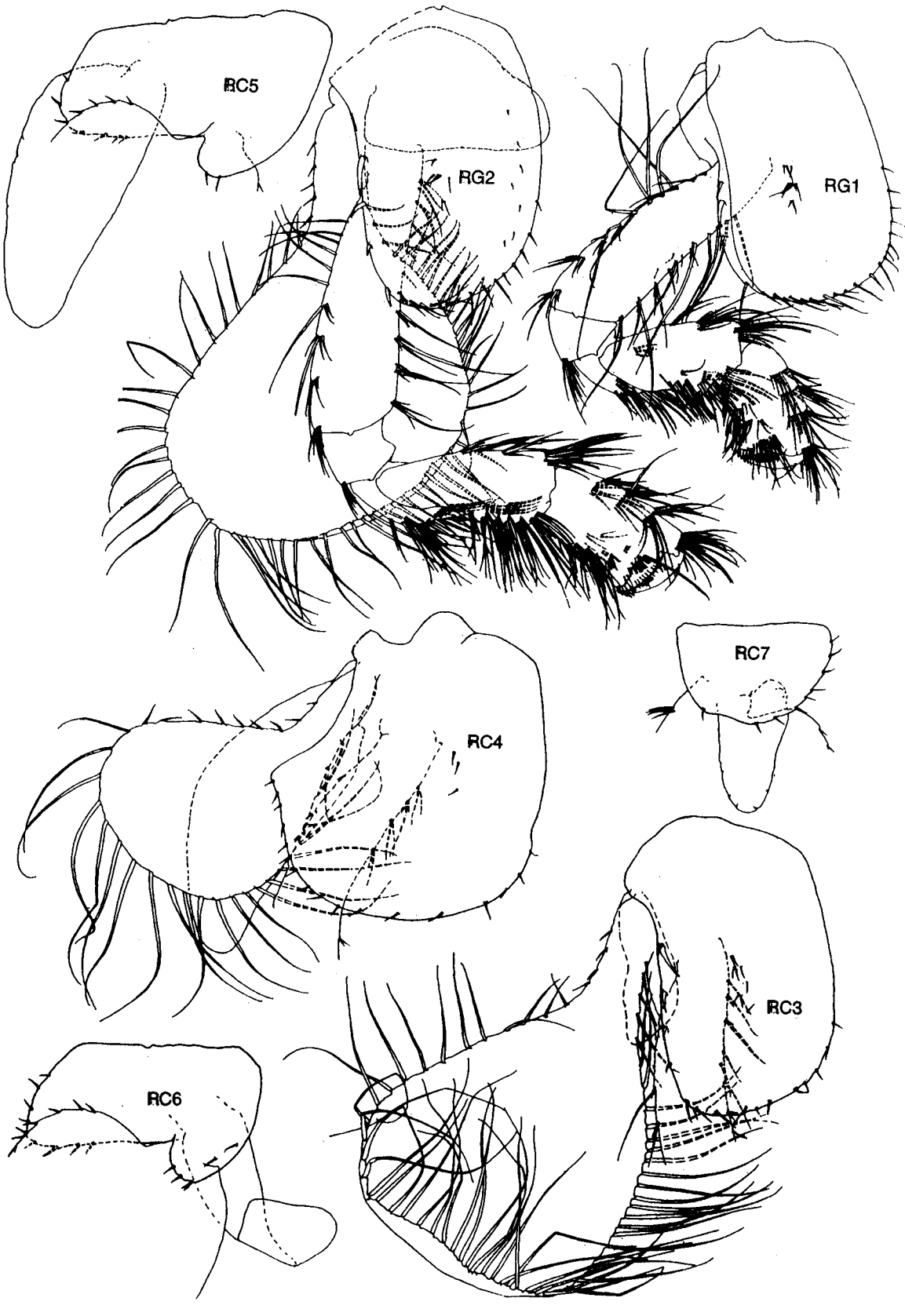

Fig. 3.11. *Austrogammarus dovel* n. sp. Female 'b' gnathopods 1-2, coxae 3-7 showing oostegites and coxal gills.

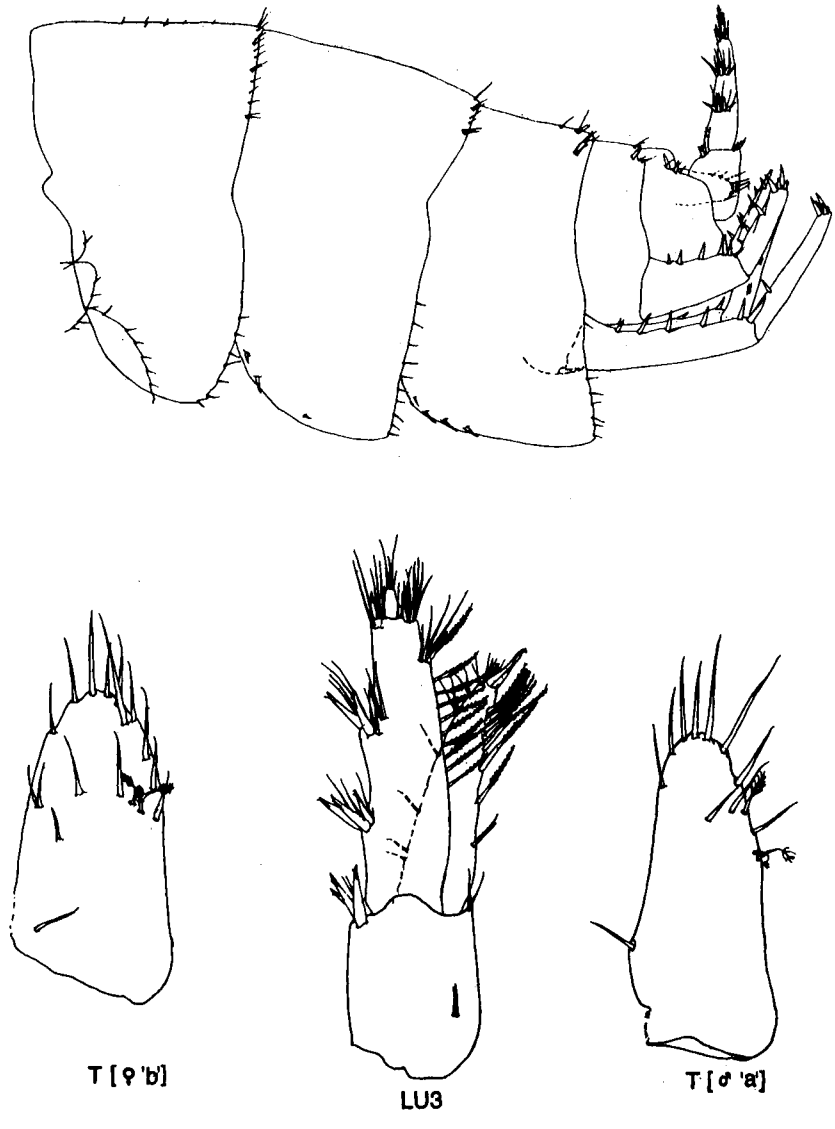

Fig. 3.12. *Austrogammarus dovel* n. sp. Male 'a' left adomen, uropod 3, right telson; female 'b' right telson.

slender, similar to antenna 1, with moderate numbers of both short and long setae on peduncle and flagellum; flagellum as long as peduncle, 23 articulate, bearing 3 calceoli on article 5 of the peduncle, and calceoli on articles 1-4 and 6 of the flagellum. *Mandibles*: incisors symmetrical, with 5 teeth; lacinia mobilis asymmetrical, left with 4 teeth, right bifid, strongly denticulate; left mandible with 7 serrate setae, 6 plumose intermediate setae, 4 brushy basal setae, 1 hooked basal molarial seta , and 0 chisel setae; right mandible with 4 serrate setae, 4 plumose intermediate setae, 4 brushy basal setae, 4 hooked basal molarial setae, and 2 chisel setae; molars fully triturating, with long pappose seta on right, short on left; palps of three articles; left palp with 3 A setae, 3 B setae, 17 D setae, 5 E setae; right palp with 3 A setae, 3 B setae, 17 D setae, 5 E setae. *Maxilla 1*: inner plate subtriangular, with 11 plumose setae on medial margin and 4 short plumose setae apically and disto laterally, basally and facially bearing many fine setules, and 1 apico-medial plumose seta; outer plate with 11 setal teeth, 9 cuspidate, and 2 naked; left palp with 6 apico-medial and apical naked setae, 2 naked apico lateral setae, 0 distal ventro-facial setae and 2 distal facial setae; right palp asymmetrical with left, apex with 3 articulated and 3 fused broad based tooth setae, and 1 apicolateral seta. *Maxilla 2*: inner plate with slender medial setae tending facial distally, but with sub apical marginal row, facially setose (pubescent); outer plate bearing sub-apical slender setae, with disto-lateral seta. *Gnathopods*: sexual dimorphism absent. Gnathopod 1: smaller than gnathopod 2; coxa one with 3 robust posterior setae, 15 ventral setae, and 8 anterior setae; merus without posterior scythe seta; carpus subrectangular, short, shorter than 0.7 x propodus; propodus subquadrate, palmar angle transverse, palm without bifid robust setae, but with simple setae along margin, with 4 lateral and 2 medial robust setae around posteroventral corner, corner slightly out-turned; dactyl reaching beyond palmar corner, with single recumbent inner tooth spine, without nail, with accessory setules at M0.5 of the dactyl length. Gnathopod 2: larger than gnathopod 1; coxal plate ovate, coxa with 4 robust posterior setae, 9 ventral setae, and 7 anterior setae; merus without posterior scythe seta; carpus subtriangular, long, subequal to propodus, propodus subrectangular, palmar angle transverse, palm with simple setae along margin, with 4 lateral robust setae around posteroventral corner and 2 medial robust setae around posteroventral corner, corner slightly out-turned; dactyl reaching beyond palmar corner, with single recumbent inner tooth spine, without nail, with accessory setules

at M0.5 of the dactyl length. *Pereopods*: pereopods 3-4 longer than gnathopod 2. Pereopod 3: coxa ovate, with 4 anterior setae, 8 ventral setae, and 4 robust posterior setae; propodus with more than one robust seta in posterior sets; pereopod three subequal in length to pereopod four, and similar in form. Pereopod 4: coxa ovate, deeply excavate posteriorly, with 6 anteroventral setae, 12 posteroventral setae, 0 robust posterior setae; merus moderately setate posteriorly; propodus with more than one robust seta in posterior sets. Pereopod 5: longer than P4; basis moderately expanded, with moderate posteroventral lobe, posteroventral corner without elongate setae, anterior margin with medium length robust setae or medium length slender setae, posterior margin with short slender setae; merus to propodus with mixed short and long setae. Pereopod 6: longer than P5; coxa smaller than coxa 5; basis weakly expanded, without posteroventral lobe, posteroventral corner without elongate setae, anterior margin with medium length robust and slender setae, posterior margin with short robust and slender setae; merus to propodus with mixed short and long setae. Pereopod 7: coxa smaller than coxa 5; basis moderately expanded, without posteroventral lobe, posteroventral corner without elongate setae, anterior margin with medium length robust setae, posterior margin with medium length robust and short slender setae; Pereopod 7 shorter than P6. *Pleonites*: with transverse band of dorsodistal slender setae, without dorsodistal robust setae. *Epimera.* Epimeron 1: without anteroventral setae, without robust setae on the anteroventral margin, without robust setae on the posteroventral margin, without slender setae on the ventral margin, with 7 slender setae on the posterior margin, posterior margin convex, posteroventral corner rounded, without spine or seta. Epimeron 2: with 2 robust setae on the anteroventral margin, with 1 robust seta on the posteroventral margin, without slender setae on the ventral margin, with 10 slender setae on the posterior margin, posterior margin straight, posteroventral corner subquadrate, without spine or seta. Epimeron 3: with 4 robust setae on the anteroventral margin, without robust setae on the posteroventral margin, without slender setae on the ventral margin, with 7 slender setae on the posterior margin, posterior margin straight, posteroventral corner subquadrate, without spine or seta. *Pleopods*: biramous. Pleopod 1: peduncle with 2 retinuculae, 2 accessory retinuculae. Pleopod 2: peduncle with 2 retinuculae, 2 accessory retinuculae. Pleopod 3: peduncle with 2 retinuculae, 2 accessory retinuculae. *Urosomites.* Urosomite 1: with transverse band of dorsodistal slender setae,

without distolateral robust setae, without dorsodistal robust seta. Urosomite 2: with transverse band of dorsodistal slender setae, with 1 distolateral robust seta, without dorsodistal robust setae. Urosomite 3: with transverse band of dorsodistal slender setae, with 2 distolateral robust setae, without dorsodistal robust seta, bearing distoventral seta at the base of uropod one. *Uropods*. Uropod 1: peduncle 1.4 x length of inner ramus, with 4 dorsolateral, 2 apicolateral, 3 dorsomedial, and 1 apicomedial robust seta ; rami subequal in length; lateral ramus with 4 lateral, 3 medial, and 5 apical robust setae; medial ramus with 4 lateral, 5 medial, and 5 apical robust setae. Uropod 2: 0.6 x length of uropod one, peduncle 0.9 x length of inner ramus, with 3 dorsolateral, 3 apicolateral, 0 dorsomedial, and 0 apicomedial robust setae; medial ramus longer than lateral ramus, lateral ramus with 2 lateral, 0 medial, and 5 apical robust setae; medial ramus with 3 lateral, 3 medial, and 5 apical robust setae. Uropod 3: extending beyond uropods 1-2 in intact specimen, 0.6 x the length of uropod 1; peduncle short, length 0.6 x outer ramus, 1 x the length of urosomite three, with 0 robust dorsolateral setae, 0 small dorsolateral setae, with 3 robust apicolateral setae, 2 small apicolateral setae, with 0 robust dorsomedial setae, 2 small dorsomedial setae, with 0 robust apicomedial setae, 2 small apicomedial setae, with 0 robust apicodorsal setae, 0 small apicodorsal setae; inner ramus shorter than outer ramus, inner ramus about 0.7 x outer ramus; outer ramus two articulate, proximal article setae arranged laterally and medially in transverse bands or arranged medially singly, with 2 lateral transverse bands of mixed robust and small setae, with 1 medial band of mixed robust and small setae, 9 medial plumose setae, 2 apicolateral robust setae, 2 apicolateral small setae, 5 apicolateral long slender setae, 1 apicomedial robust seta, 3 apicomedial small setae, and 5 apicomedial long slender setae, distal article short, narrow, sub triangular, with 0 lateral robust setae, 0 lateral slender simple setae, 0 medial robust setae, 0 medial slender simple setae, 0 medial slender plumose setae, 0 apical robust setae, 4 apical slender simple setae, 0 apical plumose setae; inner ramus with 0 lateral robust setae, 10 lateral slender setae, lateral setae of basal half singly at M0.2, 0.25, 0.4, 0.6, and distal small setae in 3 pairs laterally at M0.85, 0.9, 0.95, with 0 medial robust setae, 2 medial slender setae, and 8 medial plumose setae, with 2 apical robust setae, 6 apical slender setae, 0 apical plumose setae. *Telson*: subequal in length to urosomite three, deeply cleft, (90 %), longer than broad, length 1.2 x breadth, lateral margins tapering, straight, apices rounded, right lobe with 2 dorsal robust

setae, right lobe with 0 dorsal slender setae, with 3 lateral slender setae, at M0.7, 0. 9, 0.95 from base, left lobe with 0 apical robust setae, right lobe with 0 apical robust setae, right lobe with 5 apical slender setae, apical penicillate setae absent, and paired lateral penicillate setae, at M0.6 from the telson base.

Description of female 'b'.

Similar to male 'a' except: length 11mm; second antenna without calceoli; carpus and propodus of the second gnathopod longer than broad; coxae of pereopods 2-5 bearing very large, ovate, marginally setose oostegites; third uropod inner ramus shorter and broader than male 'a', lacking robust hooked apical setae; telson shorter, broader and bearing more dorsal setae than male 'a'.

Relationships

Austrogammarus dovel differs from all others of the genus in bearing moderate numbers of both short and long setae on the peduncle of the second flagellum. Calceoli are present on the fifth article of the peduncle of the male second flagellum, unlike *A. smithi*, *A. australis* and *A. saycei*; the coxa of the first gnathopod bears three robust posterior setae, in common with *A australis*, *A. spinatus* and *A. multispinatus*, the carpus is shorter than propodus, unlike *A. australis* and *A. saycei*; posterior expansion of the basis of pereopod five is moderate, unlike *A. australis* in which expansion is weak, and the posteroventral lobe moderately developed, as in *A. saycei* and *A. robbins*; the telson is cleft 90%, similar to *A. smithi* and *A. robins*, more than in the telson of *A. badgerhill* and *A. saycei.*

Distribution.

Small stream on the Willis Track, near Dove Lake turn off. 145°57'E 41°41'S°

3.1.2 The genus *Pilbarus* n.gen.

Introduction.

This genus was erected to accommodate specimens of a single species collected from the Millstream area of the Fortescue River, Pilbara region, Western Australia. The material was collected by the Australian Museum.

Etymology.

Named for the type location.

Type species.

Pilbarus millsi n.sp.

Diagnosis.

Pleonites with moderate, mostly posterior transverse dorsal setation, rostrum obsolescent, lateral cephalic lobes moderately projecting, antennal sinus strong. Eyes absent. Antenna one elongate, longer than antenna two, ratio of lengths of peduncular articles about 3:2:1.5, accessory flagellum four articulate; second antenna peduncle longer than flagellum - 85:74; flagellum of male bearing large calceoli. Mandibular palp of three articles, ratio of lengths about 2:3:2 to 2:4:3, articles one and two naked laterally, article two with distal oblique row of five strong rastellate setae, article three falcate, setae CDE. Labium with weak inner lobes. Maxillae without medial setae: first maxilla inner plate linear, apically tapered, with two plumose apical setae; outer plate with nine left, ten right denticulate apical robust setae; palps asymmetric, left palp with slender apical robust setae, right with two articulated elements but mostly broad robust setae fused to the article. Second maxilla inner plate without oblique setae, with two plumose mediodistal setae slightly submarginal, both plates with long curved apical setae. Maxillipedal palp with few lateral setae, with dense medial and medio-ventral setae, article three with a row of setae basal to the dactyl, but no comb row. Coxae one to four moderately elongate, coxa three with a few weak posterior setae, coxa one subquadrate, not expanded apically, coxa four moderately emarginate, coxae five to seven posteriorly dominant, shorter than four. Gnathopods small, propodus of first gnathopod of male expanded, wider; carpus of the second relatively long, articles three and four of the first and four of the second with long posterior scythe robust seta, not lobate; propodus rectangular, palms weakly oblique, robust setae at the corner of the palm two and three, along the palm moderately crowded, without triggers. Posterior robust seta sets on article six of pereopods three and four evenly spaced, legs five to seven elongate, second article moderately to broadly expanded posteriorly and lobate, dactyls of pereopods three to seven without additional setules. Coxae two to six with sac like gills, thoracic segments without sternal gills. Basomedial setae of inner rami of pleopods bifid, branches simple; retinacula two each peduncle with one or two accessory robust setae. Pleonites with dorsal setae or robust setae. Epimera without post ventral robust setae, with ventrofacial robust setae and sparse posterior setae. Rami of uropods one and two extending unequally; each with two rows of robust setae; uropod one without basofacial robust setae; uropod three extended beyond one and two in the intact specimen; peduncle short,

variramous; outer ramus two articulate, the second article short, the inner ramus reaching to M0.4 or less in the female, to M0.7 of outer ramus of male; poorly armed. Telson moderate length, about the same length as urosomite three, without dorsal setation, tumid, cleft more than 80%, with apical and dorsal spination.

Additional Description.

Flagellum of first antenna lacking major arms. Upper lip apical margin evenly rounded. Mandibular accessory blades (rakers) with interraker plumose setae, additional penicillate setae beyond rakers riding onto base of molar; molar with pappose apical seta, palp article three shorter than two, article two without sparse basoanterior setae with few facial apico-anterior setae. Maxilla two both plates with rows of long distal setae. Maxillipedal palp article three with ranks of thin setae on inner edge, and a row of three long setae facial, basal to the dactyl; dactyl with two accessory spinules basal to the nail; the apex weakly produced, pubescent; the outer plate with a row of setose robust setae distally, continuous with a row of teeth medially, the inner plate with three thick robust setae and plumose setae apically and a long medial row of plumose setae. Dactyl of gnathopods reaching ends of palms, some with small recumbent inner tooth like robust seta fused to dactyl, and several setules at inner nail articulation line, leg six longer than seven, legs five to seven article two posterior setae small, regularly spaced. Sternal processes absent, epimera without post ventral teeth. Pleopods similar, rami sub-equal. Apicolateral corner of peduncle of first uropod with one robust seta, rami of uropods one and two subequal, with four and five apical robust setae. Third uropod with or without facial robust setae, rami without plumose medial setae, ventrodistal robust seta on urosomite one at the base of uropod one long and strong, longer than *Austrocrangonyx.*

Relationship.

This genus differs from other Paramelitidae, except *Antipodeus*, in the absence of sternal gills. It is closest to *Austrogammarus* in the form of the antennae, palp of first maxilla, gnathopods, and third uropod. *Pilbarus* differs from *Austrogammarus* in the absence of eyes, longer first article of the mandibular palp which lacks A setae but bears C setae, absence of medial setae on the first maxilla inner plate, absence of long straw like pubescence on the second maxilla, absence of dense lateral setae on the maxillipedal palp, presence of inner lobes on the labium, reduction of the palmar robust setae, more expanded and lobate second articles of

pereopods five to seven, absence of coxal gill seven and of sternal gills, absence of marginal setation on the third uropod and of dorsal setation on the telson, and the presence of a long and strong robust seta on the first urosomite at the base of the first uropod. *Pilbarus* differs from *Austrocrangonyx* in absence of medial setae on the maxillae, reduced numbers of retinacula and presence of accessory retinacula, greater numbers of ventrofacial robust setae of the epimera, and presence of single rather than paired apicolateral robust setae on the peduncle of the first uropod. *Pilbarus* is similar to *Uroctena* in the absence of eyes, poor setosity of the mandibular palp, asymmetry of the palps of the first maxilla, weakly oblique gnathopodal palms, broad ovate expansion of the second article of pereopods five to seven, form of the first and second uropods and length of the outer ramus of the third uropod, and absence of posteroventral epimeral teeth, but differs in that lateral cephalic lobes project moderately, accessory flagellum of the first antenna is no more than four articulate, second antenna is not pediform and calceoli are present on the male antenna, first article of mandibular palp relatively long, third article strongly rather than weakly falcate, with CDE setae only, labium bearing inner lobes, inner plate of first maxilla linear rather than ovato-triangular, outer plate with nine or ten (cf. eleven) apical robust setae, medial setae of maxillipedal palp dense rather than moderate, apex of the third article pubescent, coxae one to four moderately long rather than short, coxa one not expanded apically, carpus of second gnathopod long, dactyls of pereopods without additional spinules, thoracic segments without sternal gills, pleopods bearing spinous accessories to the retinacula, third uropod variramous being parviramous in the female and almost magniramous in the male, telson without dorsal setation but with additional dorsal spination. The genus is similar to *Hurleya* in the presence of only sparse lateral setae on the maxillipedal palp; coxal gill six is not reduced; but differs in many ways, including the ratio of lengths of peduncular articles of the first antenna; coxa one not short; gnathopods are not large, but are sexually dimorphic and bear scythe robust setae; palmar robust setae are reduced and simple; Pereopods six is longer than seven; articles two of pereopods five to seven are expanded and lobate; dactyls of the legs are not lobate; accessory retinaculae are present on the pleopods; third uropod is extended and variramous; telson is cleft 83% rather than 63% and has both apical and dorsal spination. *Pilbarus* is similar to *Antipodeus* in the fusion of strong palp setae of right the first maxilla; the small size of gnathopods; broad

expansion and presence of post ventral lobes of article two of pereopods five and seven; broad oostegites; and differs in absence of eyes; greater number of accessory flagellum articles; presence of calceoli in the male; longer first article of the mandibular palp and poor setation of the second palp article, and lack of A setae; presence of inner lobes of the labium; absence of trigger robust setae on the gnathopodal palms; absence of coxal gill seven; uropod three variramous; telson with basofacial arms; and the ventrodistal robust seta on urosomite one long and strong. The new genus is similar to *Chillagoe* in the asymmetry of the palps of the first maxilla; the absence of a gill on coxa seven and lack of reduction of gill six; but differs in that lateral cephalic lobes do not project strongly; flagellum of antenna two is not shorter than peduncle; first article of mandibular palp is relatively short article two poorly setose, and C setae present; inner lobes present on labium; coxa four moderately emarginate; palms not strongly oblique; palmar robust setae reduced; oostegites are not slender; third uropod has an inner ramus; telson cleft more than 70% and with four rather than one apical robust seta. *Pilbarus* is similar to *Toulrabia* in the terminal setae of the mandibular palp are CDE; palps of first maxilla are similarly asymmetric; palmar robust setae of gnathopods are simple; coxae two to six bear gills, the sixth not reduced; peduncles of pleopods bear two retinacula and accessory spinules; but differs in the third peduncular article of antenna one is relatively long; flagellum of the second antenna not greatly shorter than peduncle; second articles of pereopods five to seven ovate rather than pyriform; dactyls of pereopods not multi-spinose; coxae two to four, rather than two to five, bear oostegites; uropod three is moderately extended rather than poorly, am d the outer ramus has two rather than one article; the telson is longer than broad, cleft 83% rather than 60%, without setae, but with baso-lateral spination. *Pilbarus* is similar to *Protocrangonyx* in that eyes are absent; the flagellum of antenna two is not much shorter than peduncle; palps of the first maxillae are asymmetric; coxae two to six bear gills; and differs in that the body is not sub vermiform; the accessory flagellum of antenna one is four rather than two articulate; ; calceoli occur on the second antenna; third article of mandibular palp is falcate, and C setae are present; the labium has inner lobes; coxae are moderately long, not short, and coxa four emarginate; gnathopodal palms are slightly not strongly oblique; palmar corner robust setae are reduced and palmar robust setae without triggers; leg seven is shorter than six and articles two of pereopods five to seven ovate and moderately

lobate; uropod three is strong, not feeble, is extended, variramous, and the outer ramus two articulate; telson cleft, moderately long, and with dorsolateral as well as apical spination; peduncles of pleopods weakly to moderately setose, the outer rather than inner rami shortened; ventrodistal robust seta at the base of uropod one present and strong and long.

3.1.2.1 *Pilbarus millsi* n.sp. Figs. 3.13 - 3.16.

Etymology.

Named for the type locality.

Type locality.

Deep Reach Pool, Pilbara Springs, Millstream, northern Western Australia, on the Fortescue River, 21°37'S, 117°06E.

Material Examined.

Holotype (Australian Museum P51378) female 'a', 9mm. Allotype (Australian Museum P51379) male 'b', 7mm. Others in the type series: females 'c' 7mm. and 'd' 6mm, several small juveniles 3-5mm. Collected by W.Ponder and W.Edgecomb, Deep Reach Pool, Pilbara Springs, Millstream, Western Australia, September 1987. Australian Museum Collection P38475.

Diagnosis.

With the characteristics of the genus.

Description of holotype (female 'a').

Body: pereon with sparse setation; pleon with strong transverse post dorsal setation and spination, length 9mm. *Head*: small anterior marginal setae at the base of antenna one; rostrum weak; lateral cephalic lobe moderate; antennal sinus moderate; eyes absent. *First antenna*: length 0.6x body, 1.9x second antenna; peduncle sparsely setulate, ratio of lengths of articles 10:7:5; flagellum much longer than peduncle, ratio of lengths 200:82, setae sparse, flagellum of 33 articles; accessory flagellum four articulate, reaching to the end of article four of the primary flagellum, without aesthetascs or calceoli. *Second antenna*: length 0.3x body; peduncle longer than flagellum, ratio of lengths 85:74; article four longer than five - 33:29 -articles three to five moderately setose; flagellum of fourteen articles, moderately setose, without aesthetascs or calceoli. *Left mandible*: palp of three articles, ratio of lengths 8:16:11, article one naked, article two naked medially and laterally, mediodistal face bearing an oblique row of six strong rastellate setae the

longest reaching beyond M0.5 of the third article; third article broad, falcate, facially pubescent, setae 1C13D4E; incisor six toothed; lacinia mobilis five toothed; accessory blades of three rakers and three plumose setae, with three blunt bent brushy setae and fine setules onto the base of the molar; molar triturative with an anterior plumose seta and short posterior pappose seta. *Right mandible*: palp articles one and two naked laterally and medially, second article with an oblique distal row of five strong rastellate setae reaching to beyond M0.5 of the third article, third article with long basofacial setules, facial pubescence, setae 14D4E; incisor with seven teeth; lacinia mobilis bifid, denticulate the posterior lobe bearing anterior and posterior teeth; accessory blades of two rakers and two plumose setae; molar triturative with short anterior plumose seta and long posterior pappose seta. *Left first maxilla*: palp article two with seven simple slender distal robust setae; outer plate with nine apical denticulate robust setae; inner plate with two apical plumose setae, the medial slightly sub apical. *Right first maxilla*: with five broad medio-distal to apical robust setae fused to the article and a single strong articulated lateral sub apical robust seta and one plumose seta; outer plate with ten apical denticulate robust setae; inner plate with two apical plumose setae, the medial seta slightly sub apical. *Second maxilla*: lateral margin of outer plate without additional seta, inner margin of inner plate with two plumose setae subdistal sub marginal to the medial edge. *Maxilliped*: outer plate with long medial robust setae and setae, moderately oblique; from the mid-medial margin ten strong robust setae, which increase in size distally, form a moderately oblique row across the face of the article, the ultimate robust seta mid apical, forming a continuous row with five apico-lateral plumose setae; facial to the robust seta row lie four ranks of 1,1,2,2 slender setae; inner plate with five plumose medial setae, transverse row of three stout naked tooth like robust setae, three apicolateral and one ventrofacial plumose seta, and one mid apical fine seta. *First gnathopod*: coxal plate with moderate apical and apico-anterior marginal setae; articles three and four bearing strong posterior scythe robust setae, rastellate on article four; carpus short, about 0.55x propodus, slightly lobate, bearing many strong posterior rastellate robust setae; propodus long, trapezoidal, the posterior margin bearing ranks of moderate rastellate robust setae, corner of palm with one strong and two long slender lateral robust setae and one naked medial robust seta; palm slightly oblique with few short simple robust setae; dactyl with a transverse rank of four accessory setules at M0.4,

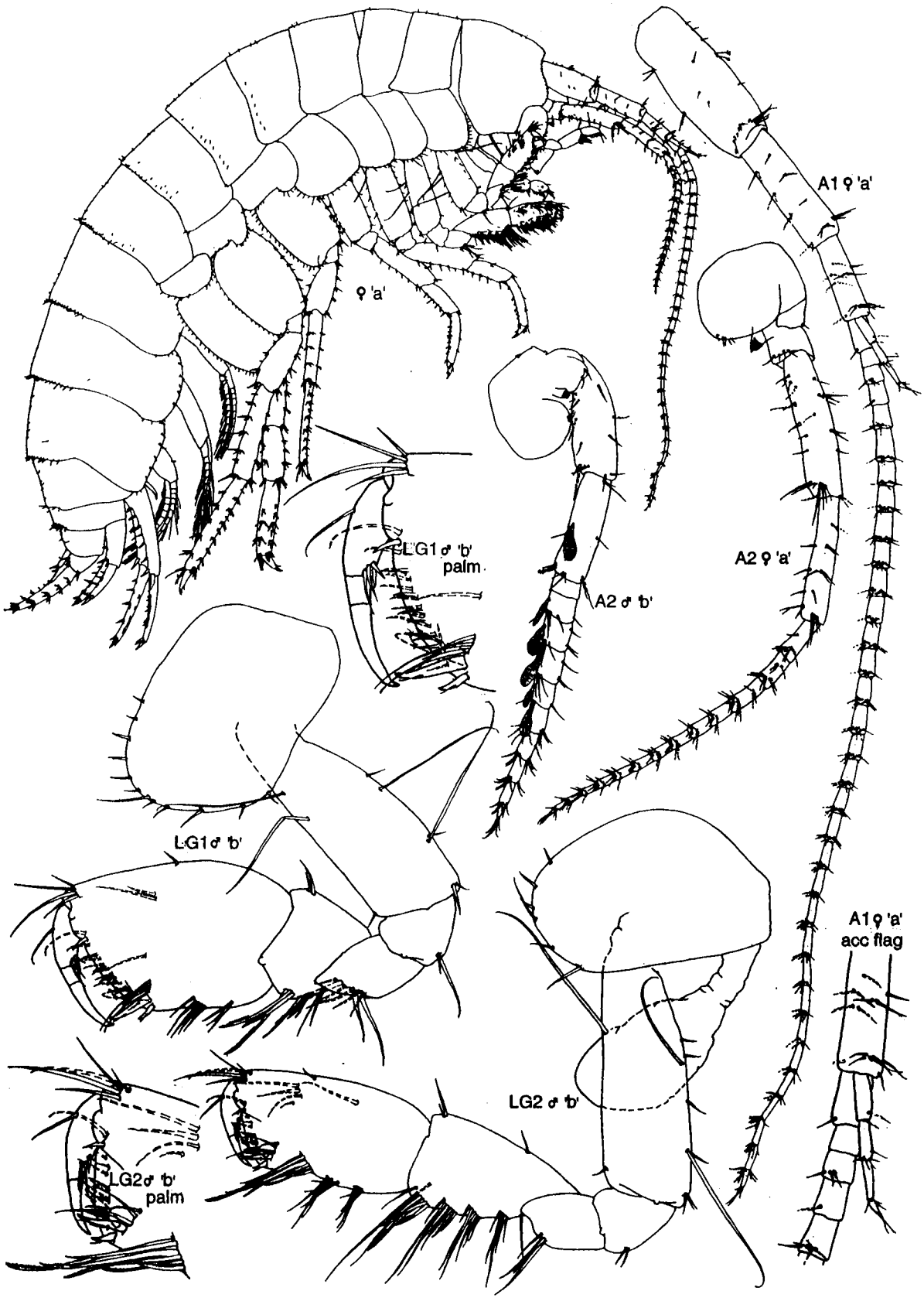

Fig. 3.13. *Pilbarus millsi* n.sp.holotype female 'a' 9mm whole specimen, antennae, accessory flagellum; allotype male 'b' 7mm antenna two, gnathopods one and two.

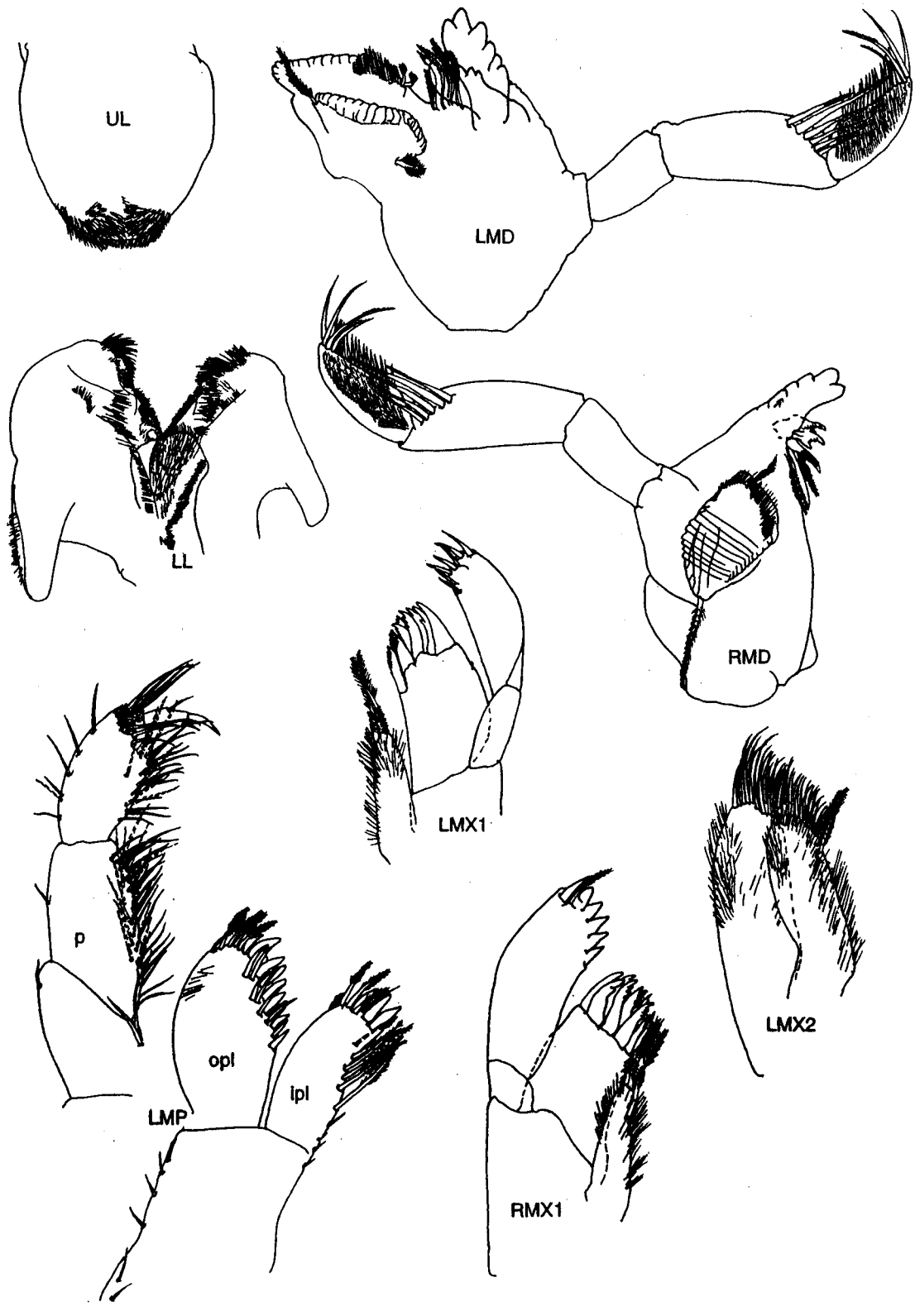

Fig. 3.14. *Pilbarus millsi* n.sp.holotype female 'a' 9mm; mouthparts.

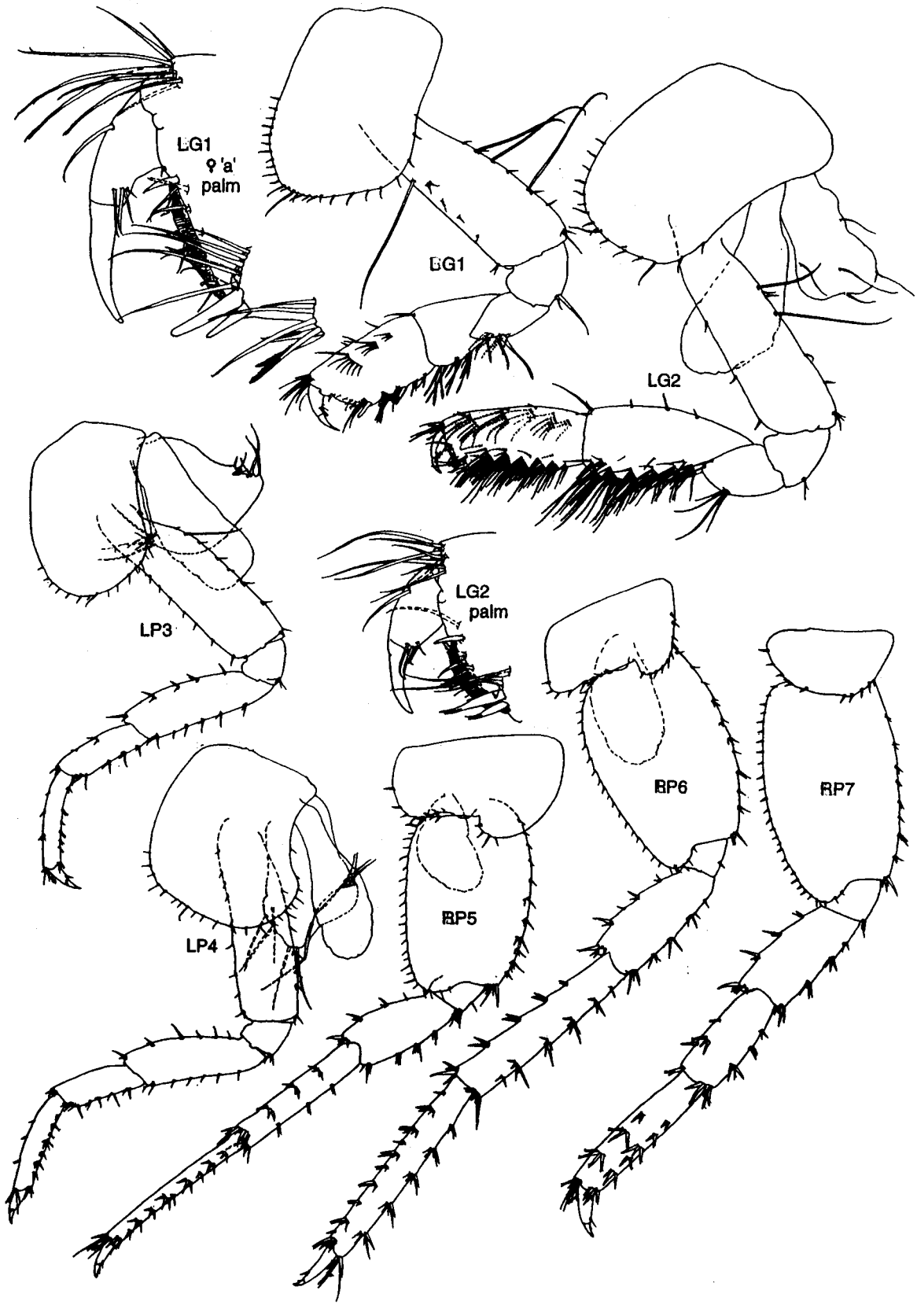

Fig. 3.15. *Pilbarus millsi* n.sp.holotype female 'a' 9mm; legs(all drawings except those indicated); female 'c' palm of first gnathopod.

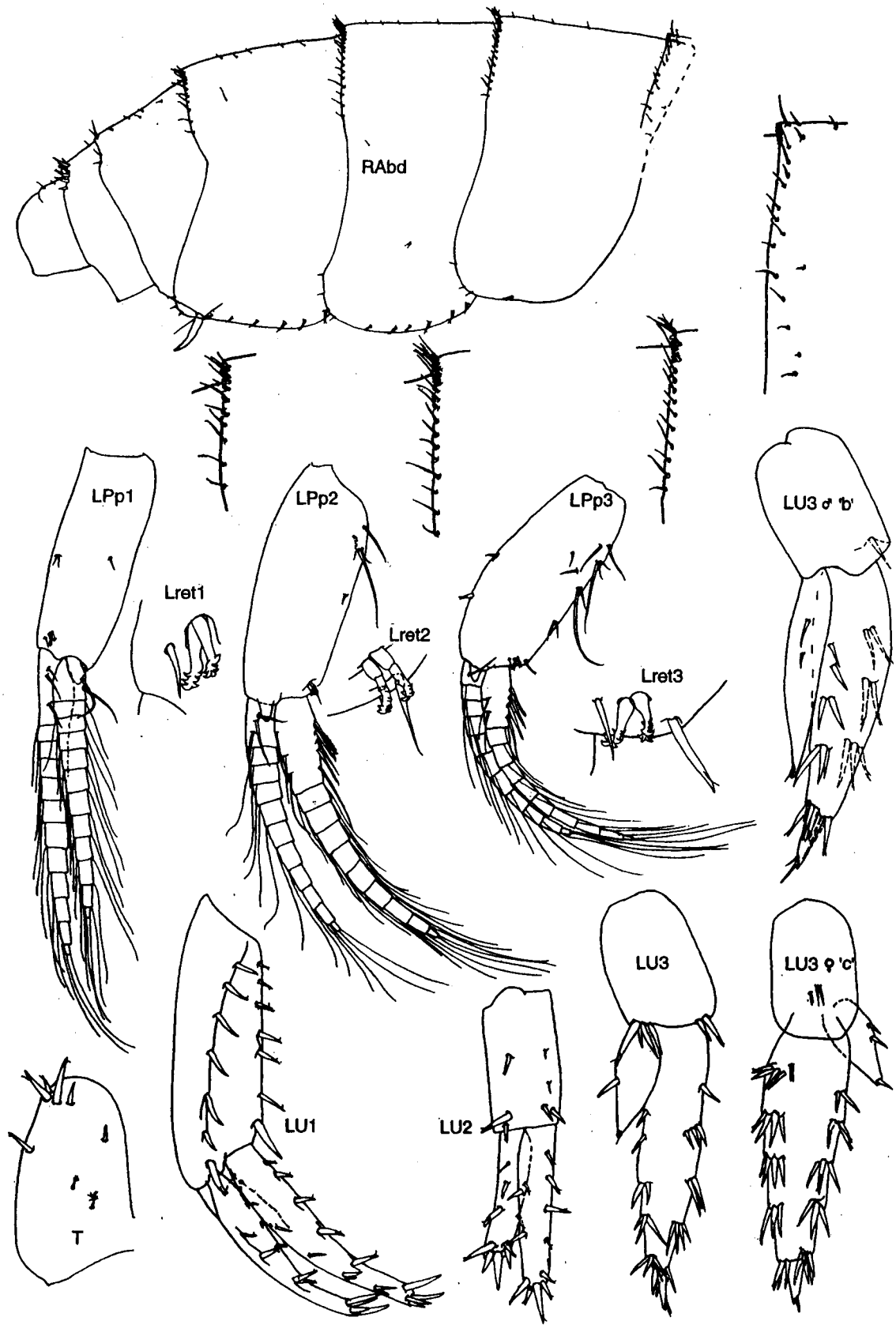

Fig. 3.16. *Pilbarus millsi* n.sp.holotype female 'a' 9mm; abdomen, gills, pleopods, uropods, telson (all drawings except those indicated); allotype male 'b' 7mm, third uropod; female 'c' 7mm, third uropod.

nail reaching the end of the palm. *Second gnathopod*: slightly larger than first gnathopod; coxal plate with two posterior setae, bearing sac like gill and broad sparsely setose oostegite; article four bearing long posterior robust setae; carpus elongate, as long as the propodus, bearing posterior ranks of many long simple setae; propodus elongate; posterior ranks of many long simple robust setae similar to but slightly shorter than of the carpus; palmar corner with one blunt medial robust seta and two lateral bifid robust setae, palm convex, robust setae simple, moderately long and crowded; dactyl with blunt recumbent inner tooth like robust seta, four facial spinules, nail reaching to the palmar corner. *Pereopods*: coxa three with few apical setae, posterior corner indistinct, posterior margin with one or two setae; coxa four sparsely setose apically with a row of posterior setae, moderately emarginate; both coxae bearing sac like gill and apically setose oostegite; pereopods three and four similar, longer than gnathopod two, articles four and five moderately setose posteriorly, article six of Pereopods four with more posterior robust setae than Pereopods three: pereopods five to seven similar, six longest, seven shortest, coxae shorter than coxa four, posterior lobe dominant, coxae five and six bearing sac like gills, articles two expanded posteriorly, ovate, moderately lobate post ventrally, with many short post marginal robust setae, other articles moderately equipped with short stout anterior and posterior robust setae; dactyls of pereopods three to seven each with one disto-facial and one medio-marginal setule. *Epimera*: without post ventral teeth, posterior angles rounded, posterior setae sparse, with 1, 6, 6 ventrofacial robust setae. *Pleon*: with sparse dorsal setae; posterior margins of pleonites one to three with dense, short transverse setules, and small dorsolateral truncated robust setae; pleonite four with sparse, weak posterior spinules; pleonite five with a submarginal transverse rank of five moderate and three small robust setae. *Urosomite one*: with a long strong robust seta at the base of the first uropod. *Pleopods*: peduncles with scarce armature, peduncle one with two mid facial spinules, two retinacula and one accessory robust seta; peduncle two with four medio-basal and one mid medial robust seta, two retinacula and one accessory robust seta; peduncle three with several strong and weak medial robust setae, two short lateral robust setae, two retinacula and two accessory robust setae; rami similar, basomedial setae of inner rami bifid; rami with 12-12, 11-10, 11-10 articles respectively. *Uropods*. First uropod: peduncle length 1.2x outer ramus, 1.0x inner ramus; outer margin with dorsal row of six moderate robust setae and one disto-

lateral robust seta; inner margin with seven dorsal and one disto-medial robust seta; both rami with two rows of dorsal robust setae and four apical robust setae. Second uropod: peduncle as long as outer ramus, 0.8x inner ramus, weakly spinous on both margins, with paired distolateral and distomedial robust setae; rami with two rows of dorsal robust setae, each with four apical robust setae. Third uropod: variramous; peduncle length 0.5x inner ramus, 1.2x outer ramus; without marginal or facial arms; pair of disto-lateral robust setae and rank of four disto-medial robust setae basal to the inner ramus; proximal article outer ramus with four transverse lateral ranks of 1-3-3-4 and one distal robust seta, and five transverse medial ranks of 1-1-2-3-4 and one distal robust seta; distal article small with three fine apical setules; inner ramus short, with one mid medial robust seta and one apical setule. *Telson*: slightly shorter than urosomite three; lobes cleft 83%, laterally tumid; lateral sub apical transverse row of two large and two small robust setae, marginal dorsolateral robust seta at M0.6, small submarginal dorsomedial robust seta at M0.67 and mid dorsal penicillate setules at M0.3 and M0.4.

Description of allotype male 'b'.

As for female 'a' except in the following. *Body*: length 7mm. *Second antenna*: peduncle articles four and five with sparse arms, article five bearing large calceolis ventrally at M0.0.5; flagellum of ten articles with moderate setation; articles two to six bearing large ventral calceoli. *Mandibles*: left palp article three with setae 8D4E; right palp with setae 1C8D5E. *First gnathopod*: articles three and four with strong simple posterior robust setae; carpus short, with moderate and long rastellate setae; propodus ovate rather than long, length 1.2x width; posterior margin with two transverse ranks of moderate setae, palmar corner rounded, with one large medial tooth like-robust seta, two lateral robust setae; palm slightly convex with moderately crowded simple robust setae; dactylus with a mid rank of four accessory spinules, nail reaching to the palmar corner. *Second gnathopod*: coxal plate with sparse, moderately long apical setae, without posterior setae, bearing a large sac like gill; article four with several long, simple robust setae; carpus moderately long, 0.7x propodus, with four transverse ranks of mixed simple and rastellate robust setae; propodus trapezoidal, longer than wide length 2x width, posterior margin with two ranks of moderate simple robust setae and one of mixed long simple and rastellate robust setae; palmar corner broadly curved, with one medial and two lateral strong robust setae; palm convex, with moderate numbers of short simple robust setae;

dactyl with four accessory setules, nail reaching to palmar corner. *Third uropod*: variramous, outer ramus 1.45x inner ramus, 0.45x peduncle; peduncle without marginal or facial arms, with a single moderate distolateral robust seta adjacent the base of the outer ramus; outer ramus proximal article with lateral transverse ranks of 2-2-3 marginal robust setae and three distal robust seta, medial transverse ranks of 1-1-2-3 marginal robust seta and four distal robust setae; distal article small, naked except for two small apical setae; inner ramus with two mid facial setae and one small distal seta.

Description of female 'c'.

As for female 'a' except in the following. *Body*: length 7mm. *Mandibles*: left palp article three with setae 1C12D4E; right palp setae 1C11D4E. *First gnathopod*: palmar corner with one medial strong naked robust seta and five long slender and two strong naked lateral robust setae; palm moderately convex slightly oblique, with moderate numbers of simple robust setae. *Third uropod*: vari-ramous, peduncle length 0.5x outer ramus, 1.5x inner, with three small facial setae; outer ramus two articulate, proximal article with lateral transverse ranks of 4-4-4-3 and three distal robust setae, two small facial setae adjacent the most basal rank of robust setae, and medial transverse ranks of 2-3-3-3 and four distal short robust setae; distal article short with two small apical setules; inner ramus with two medio-facial short robust setae and one short distal robust seta.

Description of female 'd'.

Body: length 6mm. *Right mandible*: right mandibular palp article three setae 1C9D5E. Otherwise similar to female 'a'.

Distribution.

Deep Reach Pool, Pilbara Springs, Millstream, Western Australia, 21°37'S, 117°06E,.

3.1.3 The genus *Totgammarus* gen. nov.

Introduction. This new genus was erected for a single prominent male specimen collected from a surface pool in the south of Western Australia. Examination of all known collections from the region yielded no further specimens of the taxa, and attempts to collect more specimens were unsuccessful.

Etymology.

Named for the combination of features of several genera.

Type species.

Totgammarus eximius sp. nov.

Diagnosis.

Pleon with sparse dorsal setation, rostrum weak. Lateral cephalic lobes strongly projecting, antennal sinus moderate, eye not discernible in preserved specimen. Flagellum of first antenna lacking major armaments, moderately long, about 0.5x body length, twice A2. Ratio of peduncular articles 2:2:1. Flagellum of second antenna and peduncle of sub-equal length, calceoli of type 9 present (Lincoln & Hurley, 1981). Ratio of mandibular palp articles about 2:9:6, article 2 moderately setose, article 3 falcate, setae = ABDE (Barnard & Barnard, 1983). Labium lacking inner lobes. Maxillae 1 - 2 medially setose, inner plate wholly or marginally pubescent. Maxilla 1 outer plate ovate, medially and laterally setose, palps asymmetric; left with thin apical spines, right with thick apical spines. Maxilla 2 inner plate with row of apico-medial weakly sub-marginal setal spines, medial margin heavily setose. Maxillipedal palp articles 2-3 with few lateral setae, article 3 with fine facial pubescence dorsally and a ventro-facial row of moderately long, curved setae. Coxae 1 - 3 with a row of posterior spines, coxae 1 - 4 moderately elongate, coxa 1 tapering below, coxa 4 deeply emarginate post-dorsally, coxae 5 - 6 shorter than 4, coxa 7 shorter than 5 - 6. Gnathopods unequal, gnathopod 1 0.5x gnathopod 2. Carpus of gnathopod 1 long, of gnathopod 2 short. Scythe spine absent from article 4 of both gnathopods, each with a weak lobe. Propodus of both gnathopods rectangular, palms weakly to moderately convex, palmar corners prominent, turned out. First gnathopod lacking strong spines at palmar corner, second with 6 strong spines. Spines along palms of both gnathopods short, simple, without triggers, numerous. Pereopods 3 - 4 with posterior spine sets on article 6 evenly spaced, P5 - 7 moderately elongate, article 2 broadly expanded, lobate. Dactyls with 1 - 3spinules. Coxae 2 - 7 with sac-like gills. Thoracic segments 2-7 with lateral sternal gills. Basomedial setae on inner rami of pleopods 1 - 3 plumose, peduncles each with paired retinacula and paired (first and second pleopod) or single (third pleopod) plumose accessory retinacula. Pleonites with few dorsal setae and/or spines. Epimera with few ventral spines, posterior margins weakly setulate. Rami of uropods 1 - 2 extending sub-equally, each with 2 rows of spines. Facial armaments of uropod 1 weak, largely absent on uropod 2 which bears a strong,

elongate apico-medial spine. Uropod 3 extended, magniramous, peduncle short, outer ramus 2 articulate, article 2 short. Telson longer than broad, 100% cleft, not laterally tumid, apically and disto-laterally weakly setose, bearing a single sub-apical spine on either lobe.

Additional description.

Flagellum of A1 - 2 lacking major armaments. Apical margin of labrum extended. Accessory blades (rakers) on mandibles with inter-raker plumose setae interspersed among rakers and additional short plumose setae lying between rakers and molar. Molar triturative, with plumose apical seta. Mandibular palp article 3 shorter than 2, palp article 2 lacking baso-anterior setae with few median and apico-anterior setae. Both plates of second maxillae with rows of long distal setae. Maxillipedal palp moderately long. Article 3 weakly produced and finely pubescent at the apex which bears long terminal setae; baso-medially bearing a single sub-marginal seta; medially with a row of scythe setae extending to the base of the dactyl; setae of the ventral face constituting a comb row, as well as a single long mid-facial seta and a row of short setae basal to the comb row; the mid-distal dorsal face bearing fine pubescence. Dactyl of first gnathopod not reaching palmar corner, bearing a small, bent, inner tooth-spine. Dactyl of second gnathopod reaching to end of palm, bearing 2 small inner spines. Pereopod 7 shorter than 6. Article 2 of pereopods 5 - 7 equally setose posteriorly. Sternal processes: fleshy sausage-shaped gills on thoracic segments 2 - 7, attached to mid-lateral margins of segments. Postero-ventral apex of epimera 1 - 3 blunt, as in *Austrogammarus*. Pleopods similar, except for numbers of retinaculae, rami approximately equal. Outer ramus of uropods 1 - 2 slightly shorter than inner ramus. Apicolateral corner of peduncle of uropod 1 with 2 spines, rami of both first and second uropods with 5 apical spines. The third uropod extending beyond the first and second in the entire animal, peduncular spines apical and sub-apical, some medial setae of each ramus plumose. Ventrodistal spine on urosomite 1 at base of uropod 1 short, as in *Austrogammarus*.

Relationship

This genus displays the characteristics of crangonyctoid amphipods in possessing (1) sternal gills (2) an accessory flagellum of the first antenna with two or more articles (3) calceoli of type 9 or linear (4) uropod 1 lacking a basofacial spine on the peduncle (5) a lower lip without inner lobes (6) a first gnathopod that is not melitoid or mittenform in shape (7) a first gnathopod that does not dominate the

second, and (8) a mandibular palp of typical form (Williams and Barnard, 1988). The new genus fits the essential criteria of the family Paramelitidae in possessing sausage-like sternal gills, dorsal setae on the telson, and linear or type 9 calceoli. It differs from the Neoniphargidae in the absence of rugosities on the third article of the maxillipedal palp and gnathopods, the form of the gnathopods (not small and mittenform), the form of the carpi (not short and lobate), and non-dendritic or lump bearing sternal gills. It differs from the Perthiidae in that the first antenna is significantly longer than the second, the mandibular molar is normally developed and triturative, the outer plate of the maxilliped is not very small, the gnathopods are not large, nor are the carpi short and deeply lobate, the carpi and propodi are not eusirid, and the sternal gills are not dendritic. *Totgammarus* bears features in common with other paramelitid genera, such as blindness, which occurs in several, and in possession of an elongate spine on the second male uropod (as in some *Uroctena spp.).* The combination of characteristics, however is unique. The genus varies from *Austrogammarus*, the most primitive Australian paramelitid genus, in several ways. In *Totgammarus*, dorsal setation of the pleonites is weak, the lateral cephalic lobes project strongly, the antennal sinus is moderate, eyes are absent, and the second article of the mandibular palp is relatively long with few apico-anterior and no baso-anterior setae. Additionally, there is an extension of the apical margin of the labrum, 5 rather than 3 apical spines occur on the inner plate of the maxilliped, coxae 1-4 are moderately long rather than elongate, the apex of coxa 1 tapers, pereopods 5 - 7 are more even in length, and a scythe spine is not present on article four of the gnathopods although a small lobe is present. The dactyls of legs 3 - 7 are multi-spinose. The peduncles of the pleopods are moderately setose, the apico-lateral and apico-medial spines of peduncles of the first uropod differ, as do the relative lengths of the uropod rami which also bear baso- facial armaments. The third uropod is magniramous.

3.1.3.1 *Totgammarus eximius* sp. nov. Figs. 3.17 - 3.19.

Etymology.

From *eximius*, meaning exceptional or alone.

Type locality.

Temporary roadside water in sands along theScott River Road, south-western Western Australia.

Diagnosis

With the characteristics of the genus (only male known).

Material Examined

Holotype (Western Australian Museum WAM14-95), male 10.6mm.

Description of holotype (male).

Body: pleonites 3 - 6 with sparse transverse dorsal setation and dorso-lateral spines on 5 - 6. *First antenna*: primary flagellum sparsely setose, flagellum of 35 articles, 1.8x peduncle. No calceoli. Accessory flagellum 7 - 8 articulate, reaching to article 8 of the primary flagellum. *Second antenna*: length 0.25x body length, peduncular articles 4 - 5 subequal, flagellum of 19 articles, setae sparse. Calceoli on articles 1 - 13. *Labrum*: broadly rounded with apex slightly extended, laterally and apically pilose. Labium: medially and laterally pilose with 10 curved apico-medial spines on either lobe. *Left mandible*: palp article 3 setation 1A - 2B - 15D - 4E, article 2 with 2 medial setae and oblique row of 6 apico-medial setae. Incisor 6-toothed, lacinia mobilis 4-toothed, 9 setose accessory blades, 3 short plumose setae and 1 short blunt spine toward base of molar. Anterior of molar densely pilose. Molar with short plumose seta. *Right mandible*: incisor 4-toothed, lacinia mobilis bifid with 4 denticulate teeth on one side and 9 cuspate teeth and a blunt terminal tooth on the other, accessory blades of 3 toothed spines and 4 setose inter-rakers, 3 short plumose setae and 1 narrow blunt spine toward the base of the molar. Molar with 1 setose median, short, blunt spine, and long plumose seta. *Left first maxilla*: palp article 2 with 10 thin apical spines, otherwise naked. Outer plate medially setose, 10 denticulate terminal spines. Inner plate ovate, laterally and medially with sparse straw-like pubescence, 5 apico-medial plumose setae. *Right first maxilla*: palp article 2 with 6 thick apical spines, 1 disto-lateral moderately long spine and 1 lateral sub-apical curved spine. Outer plate with 10 denticulate terminal spines and 1 antero-medial plumose seta, median area with long pubescence. Inner plate as for left side. Second maxillae: symmetrical, outer plate laterally setose, sub-terminal row of 10 curved spines, terminal row of many curved setae. Inner plate laterally setose, sub- marginally pubescent; medial margin with fine setae proximally, row of setal spines distally. *Maxilliped*: palp article 3 with 9 medial scythe setae, 16 antero-facial comb row setae extending from M0.4 to the sub-apex, 4 long terminal setae, 2 mid lateral setae and 1 median seta. Dactyl bearing 1 distal and 1 medial accessory spines and, dorsally, 4 short post-facial setae basal to the

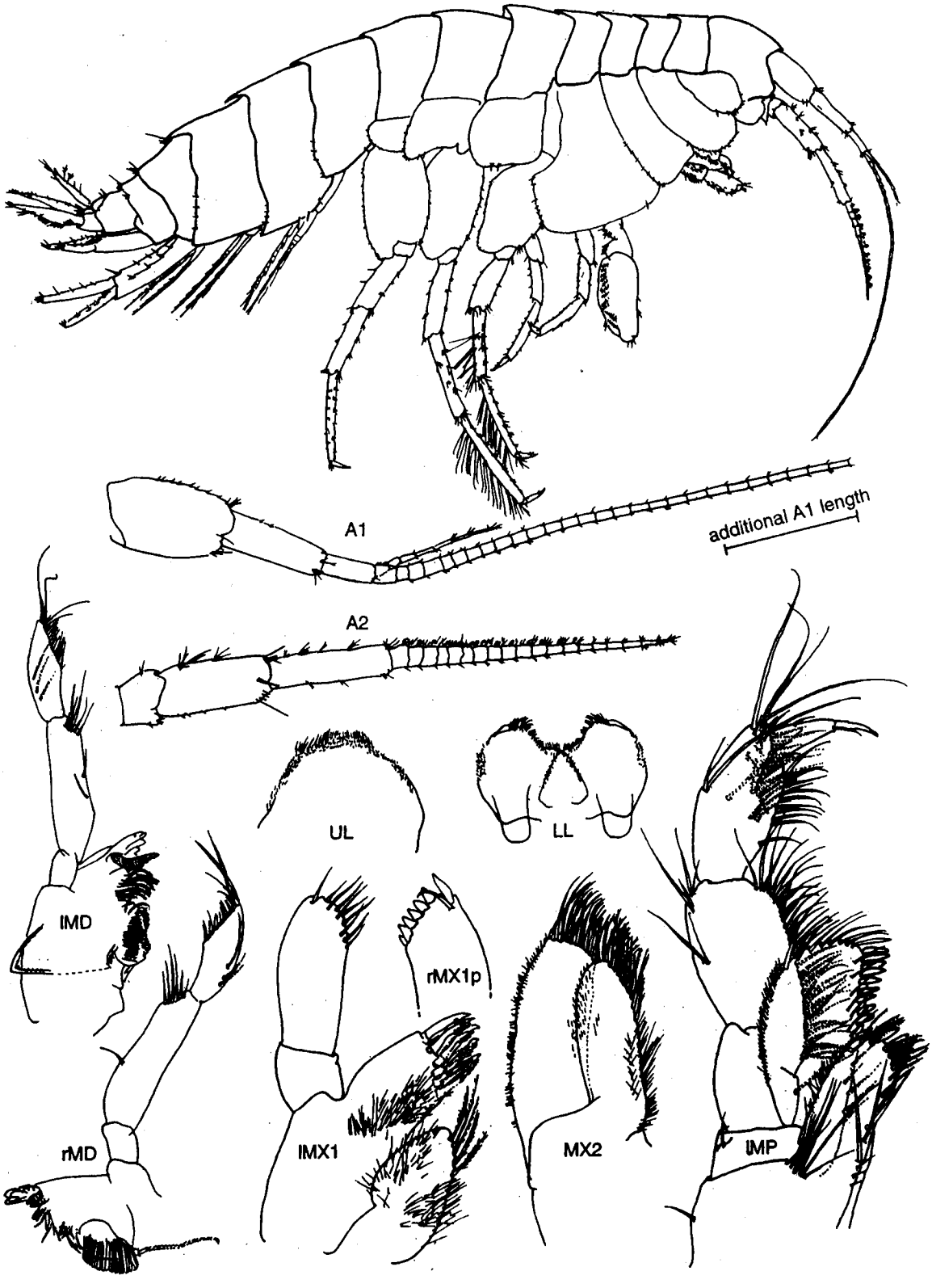

Fig. 3.17. *Totgammarus eximius*, n. sp. holotype, male 10.6 mm. Whole animal, antennae and mouthparts.

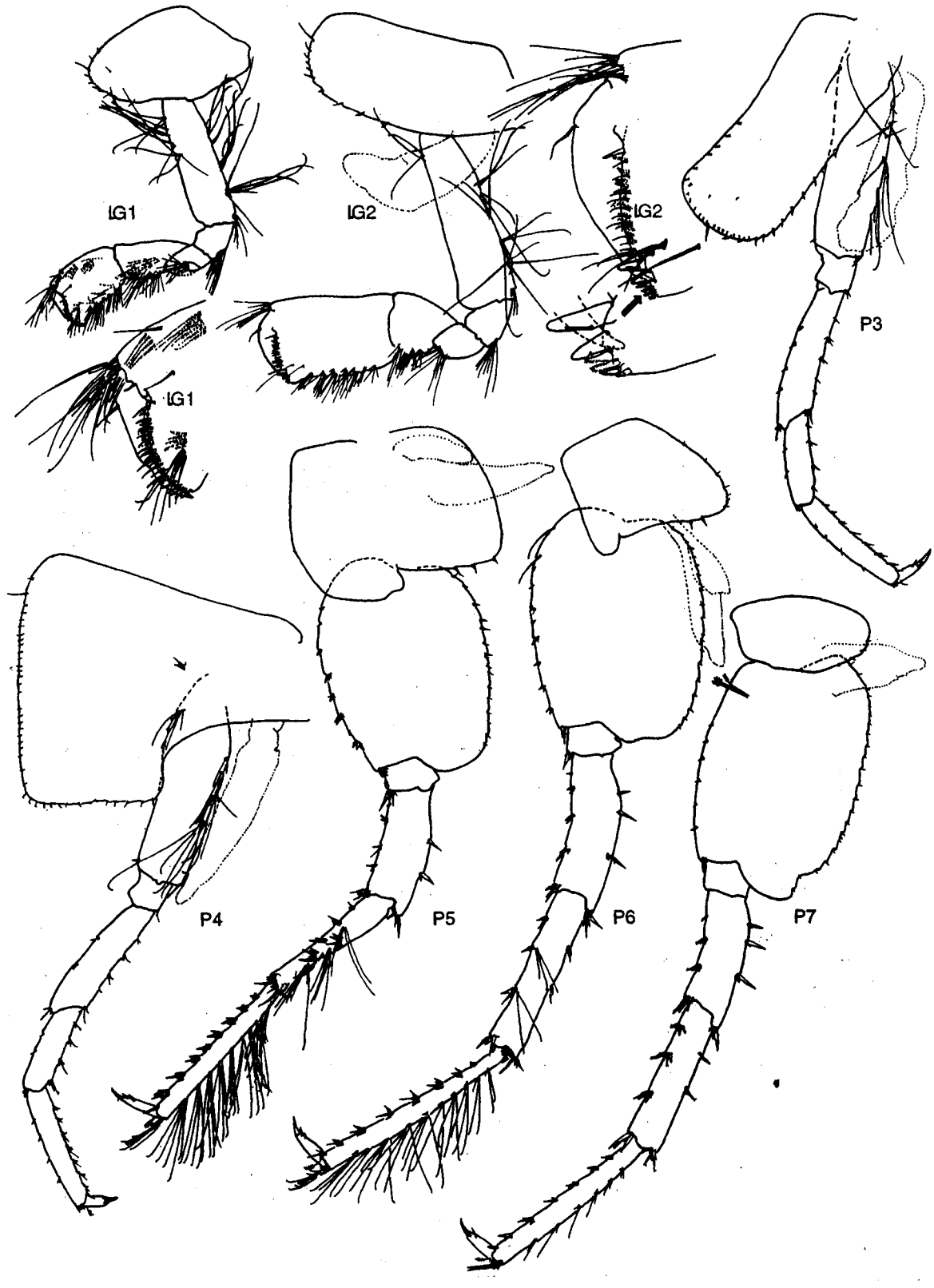

Fig. 3.18. *Totgammarus eximius*, n. sp. holotype, male 10.6 mm. Gnathopods and pereopods.

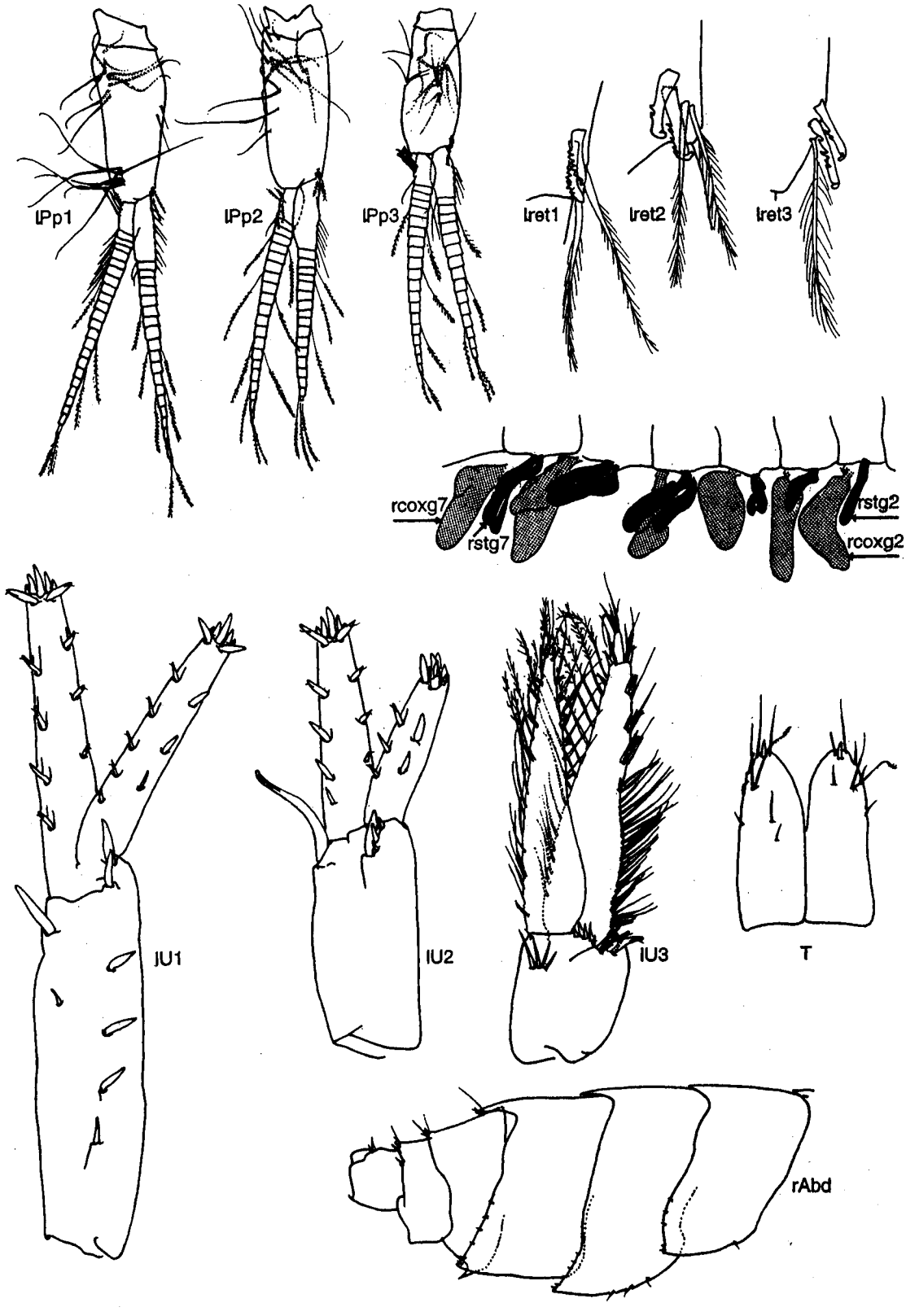

Fig. 3.19. *Totgammarus eximius*, n. sp. holotype, male 10.6 mm. Pleopods, uropods, telson, gills and abdomen.

comb row; outer plate laterally setose, apically bearing sub - terminal row of 8 strong curved spines, a disto-medial sub-facial row of 10 tooth spines and 13 setae setae distally sub-facial to the teeth, proximally facial. Inner plate terminating in 5 strong tooth spines and 8 plumose setae; medially 6 long setal spines, the distal 4 plumose; basal to the inner plate a transverse row of 8 medium to long naked setae. *First gnathopod*: coxa tapered, 3 posterior spines, weakly setose marginally; carpus moderately long, sub-equal to propodus, not lobed; propodus rectangular, palmar corner prominent, extended posteriorly, palm acute, convex, dactyl reaching corner of palm, bearing small bent inner tooth, 5 plumose and 1 naked spines at palmar corner; numerous short spines along palm. *Second gnathopod*: larger than the first (Left 2x, Right 1.7x); coxa with row of 4 or 5 posterior spines, few small distal setae; carpus short, about 0.5x propodus; propodus rectangular, longer than wide, palmar corner with 2 strong, naked spines and 4 plumose spines, corner prominent and slightly extended posteriorly; dactyl not reaching corner, but reaching to the second naked spine, bearing 2 inner teeth at approximately M0.5; palm slightly convex with numerous short spines. *Pereopods*: coxa 3 with 9 posterior spines, coxa 4 deeply emarginate, small setae and spines below, no posterior spines. Coxa 5 bearing 3 posterior ventral spines, coxa 6 with 3 posterior ventral spines and 4 small posterior setules. Coxa 7 with 4 posterior spines. Pereopods 3 - 4 length 1.2x G2, subequal, article 2 of both bearing long posterior setae. Article 5 of P3 apico-posterior spine formula (proximal to distal); 1 - 2 - 2 - 2, article 6; 1 - 3 - 3 - 3 - 2 - 2 - 2, article 5 of P4; 2 - 3 - 3 - 4, article 6; 3 - 3 - 3 - 3 - 3 - 3 -3. Pereopods 5 - 7 of approximately equal length. Pereopod 5 articles 5 - 6 bearing long apico- posterior setae, apico-anterior spine formulae 2 - 3 - 2 and 3 - 4 - 4 - 4 - 3 - 3 - 4 - 4. Pereopod 6 article 5 bearing few long setae, article 6 many apico-posterior setae, spine formulae 4 - 3 - 4 - 0 and 2 - 4 - 4 - 5 - 0 - 4 - 3 respectively. Pereopod 7 apico-anterior spine formulae: article 5: 4 - 6 - 6 and article 6: 3 - 3 - 4 - 4 - 4 - 3. *Gills*: coxal gill 5 slightly reduced, gills 5-7 bi-lobed. Sternal gills 2-7 lateral. *Epimera*: with few ventro-facial spines, posterior margins with few small setules. Epimeron 1 slightly rounded posteriorly with single anterio-ventral spine. Epimeron 2 with 3 small mid-ventral setae only. Epimeron 3 naked ventrally. *Pleon*: pleonites 3 - 6 with dorsal spines and/or setae. Pleonite 5 with 5 spines in transverse groups of 2 and 3. Urosomite 6 with 1 dorsal spine on either side. Pleopods: pleopods 1 and 2 bearing paired, hooked retinaculae and paired

accessory retinaculae, pleopod 3 lacking second accessory retinacula. *Uropods*: first uropod; peduncle length 1.2x rami, outer margin with 1 apico-facial spine, 2 medial spines, and strong row of 5 dorsal spines, without setae. Rami sub-equal, terminating in a cluster of 5 spines. Second uropod: peduncle length equal to rami, lacking spine rows, but with a cluster of 1 large and 4 short apico-facial spines. Inner medial angle with elongate spine 0.5x length of peduncle, terminally spoon shaped. Inner ramus 1.3x length of outer, lacking setae. Both rami terminating in a cluster of 5 spines. Third uropod: peduncle length 0.35x length of outer ramus, about the same length as urosomite 3, bearing median transverse row of 5 spines, distal transverse row of 7 spines at the base of the outer ramus and a group of 4 apico-lateral spines. Outer ramus proximal article strongly setose baso-laterally with 4 disto-lateral clusters of spines and setae, paired medial and single lateral trigger spines apically, medially a single sub-apical trigger spine and evenly spaced plumose setae. Small distal article, 0.13x proximal, terminating in 3 short and 2 long setae. Inner ramus of a single article, equal to the length of the proximal article of the outer ramus, marginally setose, the medial setae plumose, 6 lateral and 5 medial trigger spines distally, 2 terminal spines and 4 setae. *Telson*: 1.25x urosomite 3, cleft 100%. Disto-lateral margins and apex with sparse dorsal setation, paired penicillate setules sub-marginal at M.80. Single sub-apical spine on either lobe.

Distribution

Western Australia (south west), Scott River Road, sands in a roadside ditch. Coll. K.Davies, B.Knott, 03 Oct. 81.

3.1.4 The genus *Chydaekata* gen. nov.

Introduction.

The new genus *Chydaekata* is erected to accommodate fifteen stygobiont species restricted to the Pilbara region of Western Australia and, based on the diagnostic characters, assigned to the family Paramelitidae. *Chydaekata* displays some of the general characteristics of stygobiont amphipods: loss of eyes, de-pigmentation, attenuation of the body and appendages, and reduction of the coxal plates. However, in these species attenuation of the limbs and body are not as highly developed as in some taxa, although the legs are relatively fragile whilst not

markedly elongate. Specimens are from collections made by the Western Australian Museum, from bores associated with mining exploration.

Etymology.

The generic name is derived from the Greek 'chydaios' (poured out in streams, abundant, overflowing), and the Greek 'kata' (down below). *Chydaekata* therefore means 'numerous below'.

Type species.

Chydaekata acuminata, sp. nov.

Diagnosis.

Body: cuticle smooth; pereon and pleon sparsely setose dorsally; urosomite 3 without dorsolateral robust setae. *Head*: rostrum vestigial; eyes absent, antennal sinus moderate. *First antenna*: article 3 shortest; flagellum much longer than peduncle; bearing aesthetascs; articles uniform; and sparsely setulate, accessory flagellum 4-6 articulate. *Second antenna*: setate. *Upper lip*: apical margin evenly rounded; connection to epistome symmetrical. *Left mandible*: palp article 2 with no small outer or medial margin setae, the second article bearing a distofacial oblique row of 3-6 robust rastellate setae article 3 much shorter than article 2, bearing D and E setae only, mandible with 4 setose accessory blades, molar fully triturating. *Right mandible*: palp article 2 with no small outer or medial marginal setae, article 3 much shorter than article 2; lacinia mobilis bifid and denticulate, with no denticles strongly extended; mandible bearing 2 setose accessory blades; molar bearing pappose seta, fully triturating. *Left first maxilla*: inner plate with 2 apicomedial plumose setae, the second article of the palp bearing a single robust articulated seta. *Right first maxilla*: palp asymmetrical with left, article 2 with 1 apicolateral robust seta and setae fused to the article forming broad tooth spines. *Second maxilla*: outer plate subrectangular, elongate, marginally setulose. *Maxilliped*: inner plate subrectangular, elongate; outer plate subovate; dactyl of palp third article bearing 2 accessory setae basal to the nail. *First gnathopod*: coxal plate ovate, with 1 posteroventral corner seta; merus with elongate scythe setae; carpus without posteroventral lobe or expansion; propodus posteroventral corner not lobate, bearing 1 lateral robust seta; palm convex; dactyl ; with accessory setules at the junction of the nail. *Second gnathopod*: coxal plate ovate, with 1 posteroventral corner seta, and large ovate gill; merus (article 4) bearing posterior hump, with elongate scythe setae; carpus long, without posteroventral lobe or expansion,

posterior margin with setae in transverse bands; propodus posteroventral corner rounded; not lobate; palm convex; dactyl with accessory setules at the junction of the nail. *Pereopods*: dactyls of pereopods 3-7 simple; merus of pereopod 3 weakly setose posteriorly; pereopods 5-7 similar; basis of pereopod 5 moderately expanded; coxa 6 bearing 1 seta on the posterior lobe; basis of pereopod 6 bearing short slender posterior setae; coxa 7 bearingnosetae on anterior lobe, moderately expanded, bearing short slender posterior setae. *Gills*: coxal gills present on coxae 2-6; gill of pereopod 6 not reduced. Sternal gills present on sternites 6-7; of simple, sausage form, attached to anterior of lateral edge of segments. *Epimera 1*: without anteroventral setae, without robust setae on anteroventral margin, without robust setae on posteroventral margin, without slender setae on ventral margin; posteroventral corner without spine or seta. *Epimera 2*: without anteroventral setae, without robust setae on posteroventral margin, without slender setae on ventral margin, with 1 slender seta on the posterior margin; posteroventral corner without spine or seta. *Epimera 3*: without anteroventral setae, without robust setae on posteroventral margin, with 1 slender seta on the posterior margin. Epimera 3: posteroventral corner without spine or seta. *Pleon*: pleonite 1 with 1 distolateral robust seta; pleonite 2 with no distolateral robust setae. *Pleopods*: peduncle of first pleopod with no retinacula, but 2 additional setae. Peduncle of pleopods 2-3 with 2 retinacula and 2 additional setae disjunct from the retinacula. *Urosomite 3*: bearing 3 distolateral slender setae, and no distolateral robust setae. *Uropods*: first uropod peduncle with no apicodistal robust setae, no apicolateral robust setae, and 2 apicomedial robust setae, outer ramus shorter than inner; second uropod: with 1 apical robust seta, peduncle with 5 dorsolateral robust setae, outer ramus shorter than inner; third uropod short; peduncle with 2 dorsolateral robust setae, no dorsolateral slender setae, and no mediodistal slender setae; inner ramus shorter than outer ramus; one articulate; proximal article with 1 lateral transverse bands of small setae, no lateral transverse bands of mixed robust and small setae, no medial transverse bands of small setae, no medial small setae, no medial plumose setae, and no apicolateral long slender setae; distal article of outer ramus narrow, subrectangular, with 2 lateral robust setae, no lateral slender setae, no medial robust setae, no medial slender setae, no medial slender plumose setae, no apical plumose setae; inner ramus with no lateral robust setae, no lateral slender setae, no medial slender setae, no medial plumose setae, and no apical plumose setae. *Telson*:

deeply cleft, lateral margins tapering, straight; dorsal setae absent, with paired lateral penicillate setae, and apical robust and penicillate setae.

Relationships.

Chydaekata displays significant differences from other genera of the family Paramelitidae. The body is not vermiform, as in *Giniphargus*, nor robust as is *Pilbarus*; the antennal sinus does not terminate anteroventrally in a tooth as in *Antipodeus*; the first antenna is not long as in *Protocrangonyx*, and the accessory flagellum is of more than two articles thus differing from *Protocrangonyx*, *Toulrabia*, and *Chillogoe*; the second antenna is not pediform as is *Uroctena*, but bears calceoli in each species in contrast to other genera excepting *Pilbarus* and *Totgammarus*, in which calceoli are absent or variably present. The second article of the mandibular palp of *Chydaekata* bears a mediodistal row of strong scythe setae in contrast to other genera except *Totgammarus*, and the third article is without ABC setae similar only to *Hurleya*, *Protocrangonyx* and *Chillogoe*, the latter also differing in the presence of inner lobes on the lower lip. The inner plate of the first maxilla of *Chydaekata* is without medial plumose setae, unlike *Austrogammarus*, *Antipodeus*, *Giniphargus* and *Totgammarus*, and bears two rather than one, three or five apicomedial setae as in *Uroctena*, *Protocrangonyx* or *Totgammarus*; the outer plate of the second maxilla is without an oblique row of setae as in *Austrogammarus* and *Austrocrangonyx*; neither simple nor scythe setae are present basal to the dactyl of the maxillipedal palp unlike *Austrogammarus*, nor is the dactyl long as it is in *Giniphargus*, and the apex of the third article of the palp bears short, fine setules, contrasting with long setules in *Hurleya* and the naked apex of *Chillagoe*. The coxae of pereopods 1-3 of *Chydaekata* do not bear posterior robust setae as in *Austrogammarus*, the fourth coxa is not enlarged like *Totgammarus* but strongly emarginate, contrasting with the absence of, or very little emargination in *Uroctena*, *Giniphargus*, *Protocrangonyx*, *Toulrabia* and *Chillagoe*; coxae 5-7 bear few marginal setae in contrast with *Pilbarus*, nor are they short as in *Giniphargus*; gnathopods are of moderate size, not small as in *Giniphargus*, *Toulrabia*, *Chillagoe* and *Pilbarus*, and of approximately equal relative size whereas in *Uroctena* and *Totgammarus* the second gnathopod is much larger than the first; carpi are not lobate as in *Uroctena*; propodi are subrectangular in form not trapezoidal as in *Antipodeus* nor ovate as in *Hurleya*; setae of the palms are sparse

and simple, not dense as in *Uroctena* and *Totgammarus*, nor bifid like *Hurleya* and *Protocrangonyx*, neither is the male palm excavate as in *Antipodeus*; palmar angle is transverse, contrasting with oblique in *Uroctena*, *Protocrangonyx*, *Toulrabia* and *Pilbarus* and strongly oblique as in *Hurleya*; the palmar corners bear three robust setae, similar only to *Antipodeus*. *Chydaekata* bears gills on coxae 2-6, unlike *Austrogammarus*, *Austrocrangonyx*, *Antipodeus* and *Totgammarus* in which they occur on coxae 2-7. Sternal gills are found only on segments 6-7 similar to *Hurleya*, *Giniphargus* and *Toulrabia*, but unlike other genera. Pleopods bear 2 retinacula similar to *Austrogammarus* and *Antipodeus* and 1 or 2 accessory retinacula like *Giniphargus* only; inner rami of the pleopods bear bifid medial setae unlike the simple setae of *Uroctena* and *Chillagoe*, and the inner rami are not reduced as in *Protocrangonyx*. *Chydaekata* bears no basofacial seta on the peduncle of the first uropod as in *Chillagoe*, the rami of both first and second uropods bear two setal rows unlike *Protocrangonyx* which has only one row, and the second uropod does not bear an elongate seta as in *Totgammarus*. The third uropod of *Chydaekata* is not short as in *Toulrabia* and *Chillagoe*; the inner ramus is elongate in the male, as with *Austrogammarus*, although relatively longer, reaching almost to the end of the first article of the outer ramus, thus differing from most other genera in which the third uropod is parviramous or absent, excepting variramous in *Pilbarus* and magniramous in *Totgammarus*. Dorsal setation is absent from the telson of *Chydaekata*, which is thus unlike *Austrogammarus*, *Austrocrangonyx*, *Pilbarus* and *Totgammarus*; the few apical setae are robust not like *Austrocrangonyx*, and lateral margins are convex, but not tumid as in *Austrogammarus*, *Austrocrangonyx*, *Hurleya* and *Chillagoe*; posterior margins of pleonites are smooth, with sparse setae whereas those of *Pilbarus* are crenellate, with dense setae.

Remarks

Chydaekata displays a number of characters in common with *Hurleya*, *Giniphargus*, *Pilbarus*, and *Uroctena*. Although there are several significant similarities between *Chydaekata* and *Hurleya* particularly the presence of only DE setae on the mandibular palp and in the conformation of the inner plate of the first maxillae and disposition of the gills, the differences in size and form of the gnathopods, and the non parviramous third uropod of *Chydaekata* sufficiently

distance the two taxa to warrant regarding them as individual genera. The most significant characters in common with *Giniphargus* are the presence of gills on coxae 2-6, their absence on coxa 7, and the presence of sternal gills on sternites 6-7 only; otherwise these taxa are not similar. *Pilbarus*, another Western Australian stygobiont amphipod from the Millstream, has similar gnathopods, pleopods, third uropod and the telson is similarly cleft. However, many differences clearly separate these two taxa, although they do share several characters and would appear to have more than distributional association. Despite some similarities, *Toulrabia* and *Uroctena* are distinctly different from *Chydaekata* in many ways, including the absence of calceoli on the second antenna, presence of AB or C setae on the third article of the mandibular palp, and absent or very weak emargination of the posterior edge of the fourth coxal plate. *Chydaekata* is thus regarded as a discrete genus, possibly associated with *Hurleya*, although the genus *Hurleya* is itself inadequately described and in need of review.

Distribution.

The Pilbara region of north western Western Australia.

3.1.4.1 *Chydaekata acuminata* sp. nov. Figs. 3.20 - 3.23.

Etymology.

Derived from the Latin 'acuminatus' (pointed, sharpened), referring to the acuminate posteroventral corner of the second epimeron.

Type locality.

Newman bore W152; 23°16'S, 119°53'E.

Material examined.

Holotype (Western Australian Museum, C24650), male 'a' 5mm. Allotype (Western Australian Museum, C24651), female 'b' 6mm; male 'c' 5.5mm, 90+ others in the type series, mainly juveniles: collection number BES3518, same data as holotype (Western Australia Museum C24652), Coll. S.Eberhard, 11/11/98.

Diagnosis.

Second antenna: peduncle article 5 bearing 2 calceoli, flagellum 13 articulate, with calceoli on articles 1-6. Mandible: palp article 2 with a medio-distal row of 5 robust rastellate setae; article 3 with 9 D and 3 E setae apically. Left first maxilla: palp article 2 with 8 apical setae. Right first maxilla: palp apex with no articulated, and

4 fused broad based tooth setae. Maxilliped outer plate with a row of 7 slender naked, medial submarginal to disto-facial setae; a medial row of 8 submarginal to subapical robust, naked, tooth setae; 3 apicolateral setae. First gnathopod propodus: dactyl reaching to palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 5 transverse bands. Telson: cleft 90%, bearing 2 subapical robust setae.

Description of the holotype (male 'a' 5mm).

Body: urosomite 1 and 2 without dorsolateral robust setae. *First antenna*: length 0. 5 x body, 1.6 x second antenna; peduncle article 1 longest, with moderate setation; primary flagellum of 27 articles; accessory flagellum of 4 articles, reaching to article 6 of primary flagellum. *Second antenna*: length 0.3 x body; peduncle length greater than flagellum, article 5 bearing 2 calceoli, article 4 subequal with article 5, articles 3-5 with moderate ventral setation; flagellum 13 articulate, with moderate setation, bearing calceoli on articles 1-6. *Left mandible*: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 9 D setae and 3 E setae, facially strongly setulose (pubescent); incisor with 5 teeth, lacinia mobilis with 4 teeth, with 3 plumose interraker setae; molar without pappose seta, with 2 penicillate hooked brushy basal setae, and no penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 9 D setae and 3 E setae; incisor with 5 teeth and 2 plumose interraker setae; molar without penicillate hooked brushy basal setae. *Left first maxilla*: palp article 2 with 4 apical and 1 subapical facial strong slender setae, with no apicomedial, 1 submarginal apicomedial, and 2 ventrofacial apicomedial strong slender setae; outer plate with 10 robust setae - 9 denticulate, 1 naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with no articulated, 4 fused broad based tooth setae, and no subterminal apicolateral facial setae. *Second maxilla*: outer plate length 3 x width, bearing distal long, curved rastellate or naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 3.5 x width, extending to M0. 9 of the outer plate, bearing small setules on the lateral margin and medioproximal face, 1 facial pappose setae at M0. 6 of its length, with a row of 6 submarginal pappose setae, extending to a row of 4 similar subapical and 2 apical setae, with 1 apicomedial, 2 mediodistal, and no apical naked tooth setae; outer plate long, length 2 x width, distally naked, with a row of 7 slender naked, medial

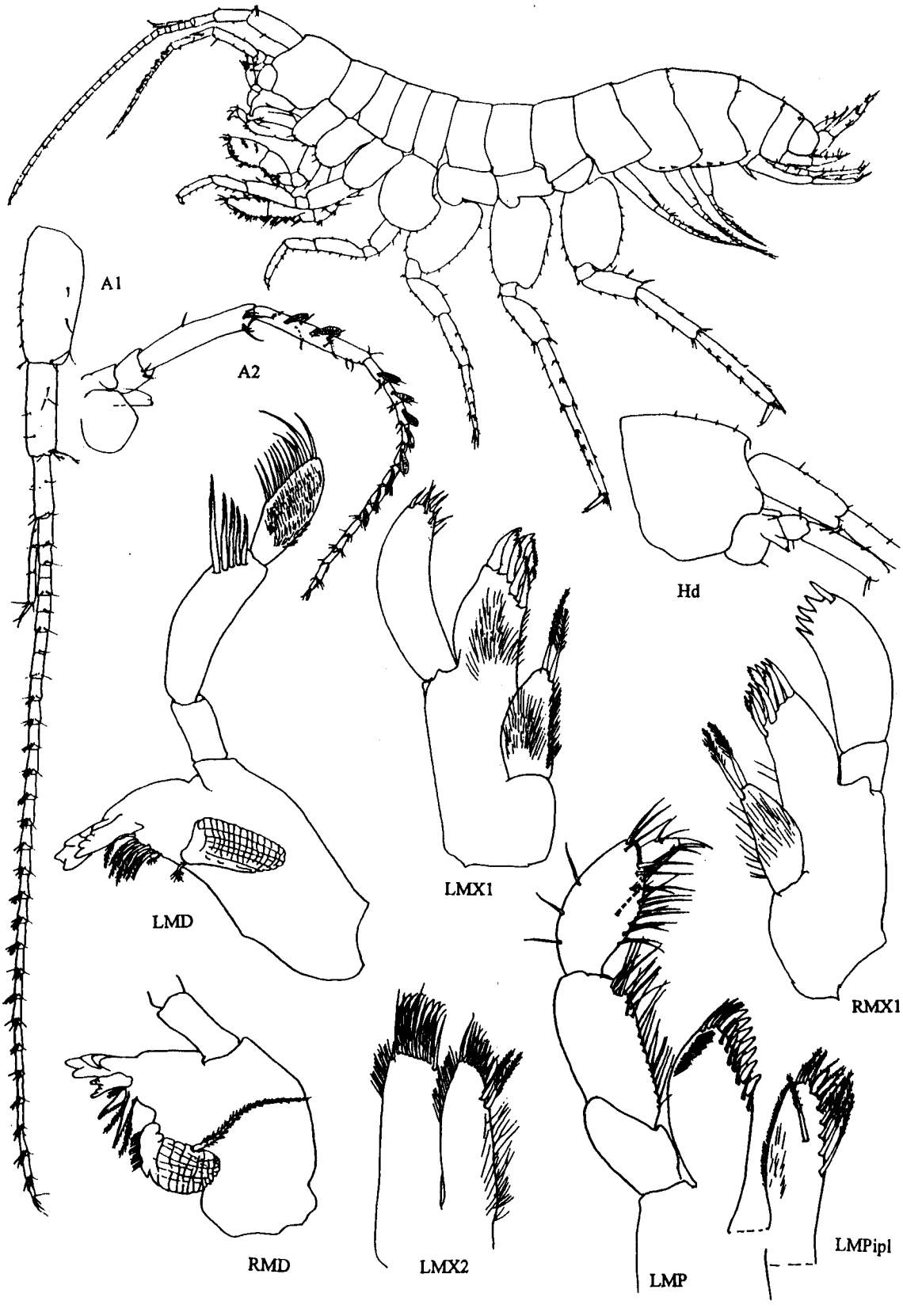

Fig. 3.20. *Chydaekata acuminata* n. sp. holotype, male 'a' 5 mm. Whole animal, head, antennae and mouthparts.

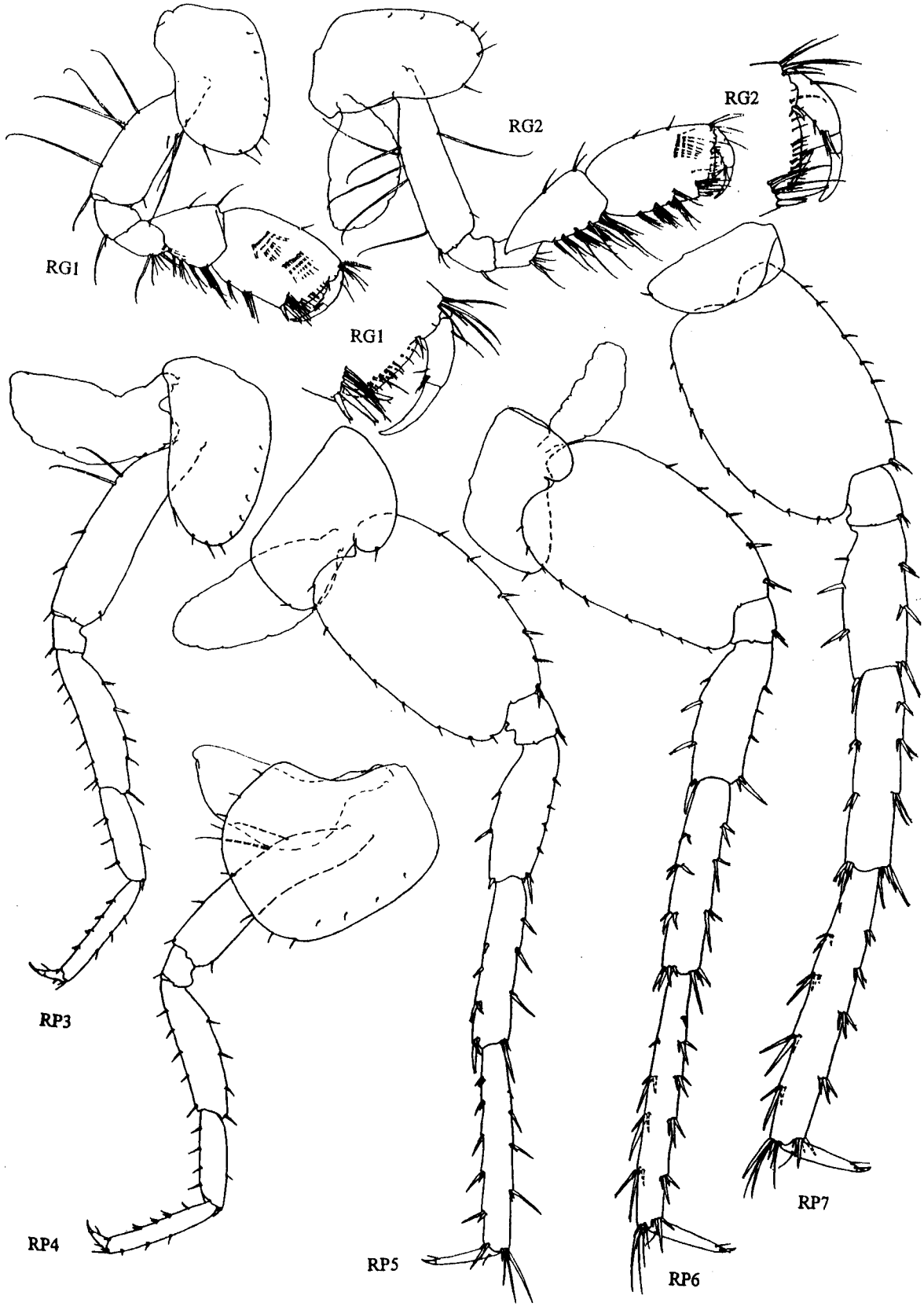

Fig. 3.21. *Chydaekata acuminata* n. sp. holotype, male 'a' 5 mm. gnathopods and pereopods.

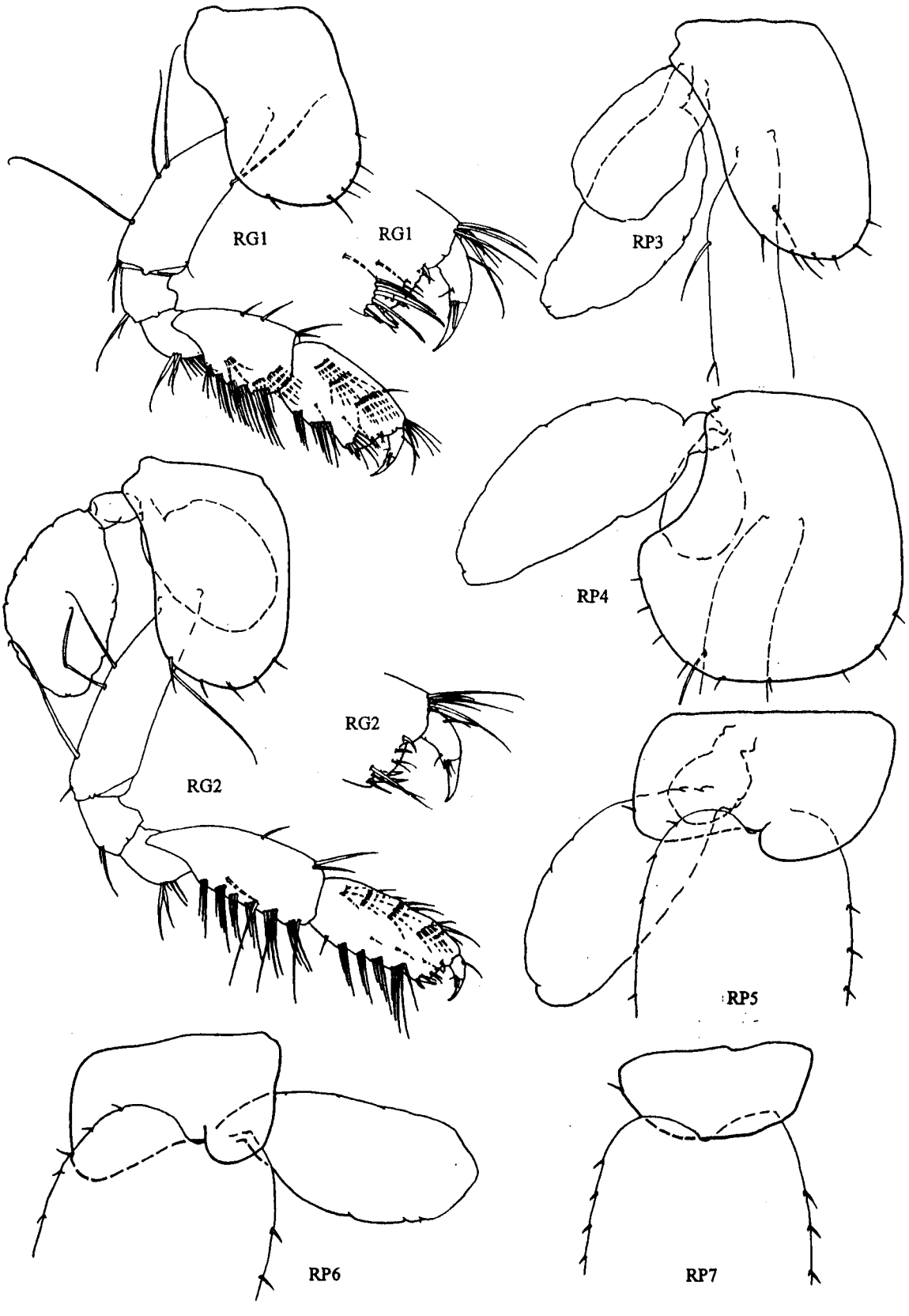

Fig. 3.22 *Chydaekata acuminata* n. sp. allotype, female 'b' 6 mm. Gnathopods and pereopods.

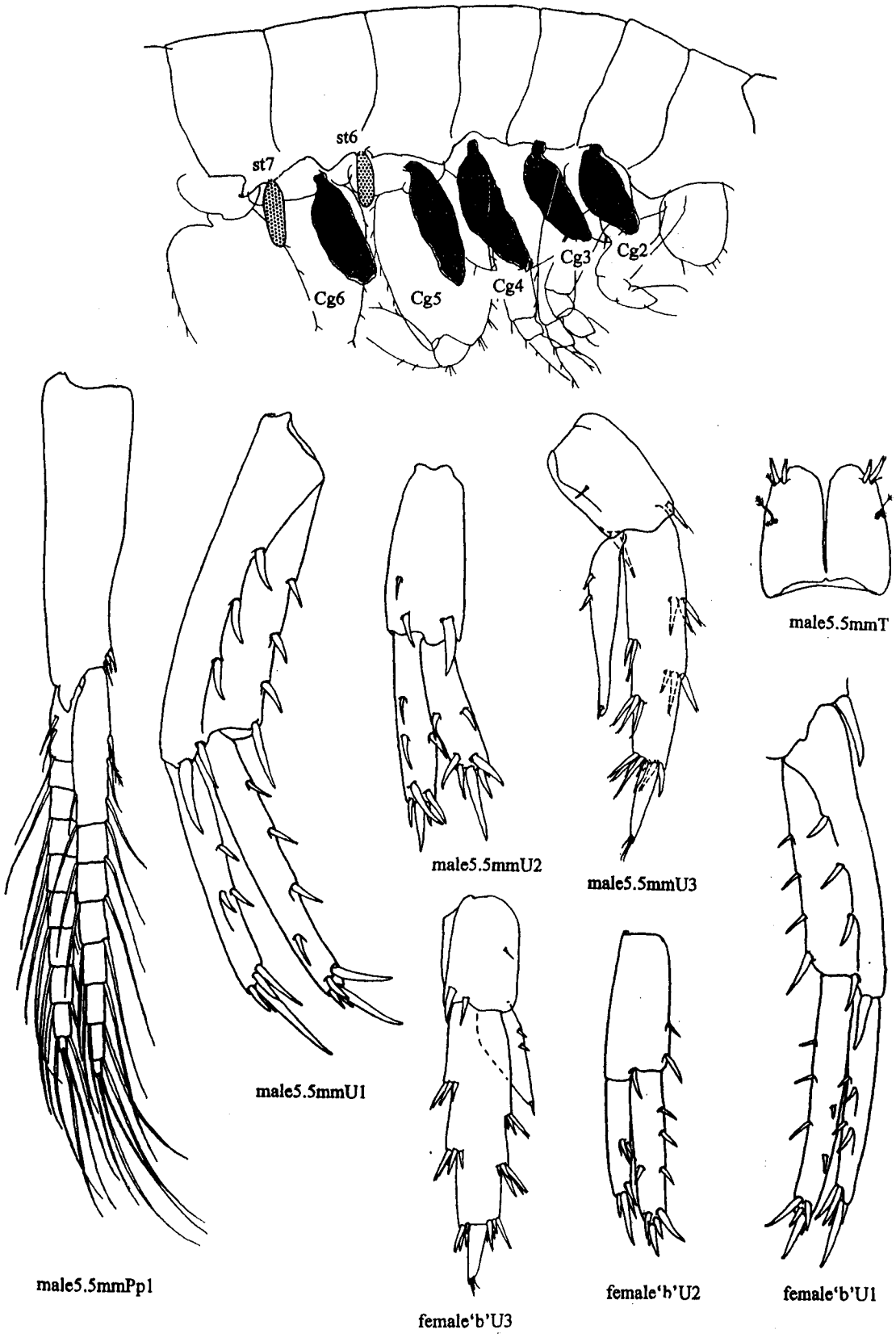

Fig. 3.23 *Chydaekata acuminata* n. sp. holotype, male 'a' 5 mm. gills. Male 5.5 mm. pleopod 1, uropods 1-3, telson. Allotype female 'b' 6 mm. uropods 1-3.

submarginal to distal facial setae, a medial row of 8 submarginal to subapical robust, naked, tooth setae, and 3 apicolateral setae.- 1 naked, and 2 pappose; palp, second article strongly setose medially; third article sparsely setose laterally, strongly setose medially, with 3 facial, and 3 ventrofacial long strong setae basal to the dactyl, the apex moderately produced, setulate, with 3 long slender naked setae and 3 dorsal accessory setae on the dactyl. *First gnathopod*: coxal plate with 3 anteroventral setae, and no ventral setae; merus without posterior hump; carpus of moderate length, 1.2 x width, subtriangular, posterior margin strongly setose, with setae ranked in 4 transverse bands; propodus subrectangular, moderate size, length 1.8 x width, posteroventral corner rounded, with 2 medial robust setae, and 4 additional lateral elongate robust setae, palmar angle weakly oblique, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 3 anteroventral setae, and no ventral setae; carpus length 2 x width, subtriangular, with setae ranked in 5 transverse bands; propodus subrectangular, large, length 2 x width, with 2 lateral robust setae, 1 medial robust seta, and 3 additional lateral elongate robust setae; palmar angle weakly oblique, smooth; dactyl reaching to palmar corner, with no recumbent inner tooth spine. *Pereopods*: pereopod 3 longer than the second gnathopod; coxa with no anterior setae, no long ventral setae, 3 short ventral setae, 1 seta at the posteroventral corner; carpus weakly setose posteriorly. Pereopod 4: subequal in length with pereopod 3; coxa anteroventral margin with 3 setae, posteroventral margin with 4 setae, ventral margin with no setae, posterior margin moderately emarginate; carpus moderately setose posteriorly. Pereopods 5-7: coxa 5 bearing 1 seta on anterior lobe, and 1 seta on the posterior lobe; basis of periopod 5 with slender posterior setae, bearing short robust anterior setae, weakly lobate posteriorly; pereopod 6 coxa bearing no setae on anterior lobe; basis scarcely expanded, bearing short robust anterior setae, weakly lobate posteriorly; pereopod 7 coxa with 1 seta on the posterior lobe; basis bearing short robust anterior setae, moderately lobate posteroventrally; bases of periopods expanded unequally, basis of periopod 7 most expanded, basis of periopod 6 least expanded. *Epimera*: first epimeron without slender setae on posterior margin; posterior margin straight, posteroventral corner acuminate; second epimeron, with 2 robust setae on the anteroventral margin; posterior margin straight, posteroventral corner acuminate; third epimeron with 4 robust setae on the anteroventral margin, without slender

setae on ventral margin; posterior margin sinuous, posteroventral corner acuminate, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 2 feeble setae; of pleonite 2 with 4 feeble setae; of pleonite 3 with 2 feeble setae, and no distolateral robust setae. *Pleopods*: first and second pleopods with 1 accessory retinacula, and third pleopod with no accessory retinacula. *Urosome*: first urosomite bearing 2 distolateral slender setae, and no distolateral robust setae; urosomite 2: with 2 distolateral slender setae, and 1 distolateral robust seta. *Uropods*: first uropod peduncle length 1.2 x the length of the inner ramus; with a strong row of 3 dorsolateral robust setae, and 3 dorsomedial robust setae; outer ramus with 1 dorsolateral robust seta, and 2 dorsomedial robust setae; inner ramus with 1 dorsolateral robust seta, 3 dorsomedial robust setae, and 5 apical robust setae; second uropod 0.6 x length of uropod 1, peduncle about 1 x length of inner ramus; with 1 apicolateral, 1 dorsomedial, and 1 apicomedial robust setae; inner ramus with 1 dorsolateral, 1 dorsomedial, and 5 apical robust setae; outer ramus with 1 dorsolateral, 2 dorsomedial, and 5 apical robust setae; third uropod extending beyond uropods 1 and 2 in intact specimen, 0.7 x length of uropod 1; peduncle length 0. 4 x outer ramus, subequal in length to urosomite 3, with 1 apicolateral robust seta, and no apicolateral slender setae, with 1 dorsomedial robust seta, and 1 dorsomedial slender seta, with 1 apicomedial robust seta, and no apicomedial slender setae, and with no mediodistal robust setae; inner ramus length 0.6 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands, with 2 lateral transverse bands of robust setae, with 2 medial transverse bands of robust setae, 3 apicolateral robust setae, no apicolateral small setae, 4 apicomedial robust setae, no apicomedial small setae, 1 apicomedial long slender seta; distal article long, with no apical robust setae, and 3 apical slender setae; inner ramus with 2 medial robust setae, 1 apical robust seta, and no apical slender setae. *Telson*: subequal in length to urosomite 3; cleft 90 %; as long as broad; apices rounded and laterally notched; 2 subapical robust setae, and no subapical slender setae; with 1 apical penicillate seta; and paired lateral penicillate setae at M0. 6 from the telson base.

Description of the allotype (female 'b' 6mm.)

Similar to the Holotype except in the following. *Body*: length 6mm. *First antenna*: without aesthetascs or caceoli. *Second antenna*; without calceoli. *First gnathopod*: carpus longer than the holotype, length 1.7x width, bearing 5 posterior transverse

setal bands, 3 medio-facial setal bands, the propodus smaller and less robust than the male holotype the length 1.7x width, bearing 3 mediofacial setal bands and an additional accessory slender seta adjacent the 2 lateral palmar corner setae. *Second gnathopod*: coxa bearing an additional ventral seta; carpus elongate (length 2.6x width), subrectangular, bearing 6 posterior transverse setal bands; propodus narrower than the holotype, (length 2.2x width) bearing 4 posterior transverse bands of setae, 4 mediofacial setal bands and 2 lateral setae accessory to the 2 robust lateral corner palmar setae. *Pereopods*: pereopod 5 coxa without a ventral seta on the anterior lobe. *Oostegites*: present on coxae 2-5, of length about 0.5 x coxal plate, except oostegite of coxa 5 which is reduced. *Uropods*: first uropod rami each with an additional dorso-lateral seta; second uropod inner ramus bearing an additional dorso-medial seta: third uropod inner ramus short, extending to M0.5 of the first article of the outer ramus.

Description of male 'c' 5.5mm.

Similar to the Holotype male 'a' 5 mm.

3.1.4.2 *Chydaekata nudula* sp. nov. Figs. 3.24 - 3.27.

Etymology.

From the Latin 'nudus' (bare, naked), referring to the absence of lateral setae on the ultimate article of the maxillipedal palp.

Type locality.

Newman bore field, WB 23/4, 23°19S', 117°51'E.

Material examined.

Holotype (Western Australian Museum, C24653) male 'a' 6mm, Allotype (Western Australian Museum, C24654) female 'b' 6.5mm; 22 others in the type series, same data as the holotype (Western Australian Museum, C24655). Collection number BES4827 taken with haul net, W. F. Humphreys and S. M. Eberhard, 23/07/97.

Diagnosis.

Second antenna: peduncle article 5 bearing 4 calceoli, flagellum 17 articulate, with calceoli on articles 1-13. Mandible: palp article 2 with a medio-distal row of 6 robust rastellate setae; article 3 with 13 D and 4 E setae apically. Left first maxilla: palp article 2 with 7 apical setae. Right first maxilla: palp apex with no articulated, and 5 fused broad based tooth setae. Maxilliped: outer plate with a row of 3 slender

naked, medial submarginal to disto-facial setae; a medial row of 9 submarginal to subapical robust, naked, tooth setae; 2 apicolateral setae. First gnathopod: propodus dactyl reaching to palmar corner, with a single recumbent inner tooth spine. Second gnathopod: carpus with posterior setae ranked in 9 transverse bands. Telson: cleft 71%, bearing 3 subapical robust setae.

Description of the holotype (male 'a' 6mm.)

Body: urosomites 1 and 2 without dorsolateral robust setae. *First antenna*: length 0.9 x body, 1.9 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 42 articles; accessory flagellum of 5 articles, reaching to article 8 of primary flagellum. *Second antenna*: length 0.5 x body; peduncle length greater than flagellum, article 5 bearing 4 calceoli, article 4 subequal with article 5, articles 3-5 with sparse setation; flagellum 17 articulate, with sparse setation, bearing calceoli on articles 1 to 13. *Left mandible*: palp article 2 with a medio-distal row of 6 robust rastellate setae, article 3 with 13 D and 4 E setae, facially strongly setulose (pubescent); incisor with 6 teeth, lacinia mobilis with 5 teeth and 4 plumose interraker setae; molar bearing pappose seta, with 2 penicillate hooked brushy basal setae, and no penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 6 robust rastellate setae, article 3 with 12 D and 4 E setae; incisor with 6 teeth and 2 plumose interraker setae; molar without penicillate hooked brushy basal setae, and few penicillate setules. *Left first maxilla*: palp article 2 with 4 apical and 1 subapical facial strong slender seta, with 1 apicomedial and 1 ventrofacial apicomedial strong slender setae; outer plate with 10 robust setae - 10 denticulate, none naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with no articulated, and 5 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 3 x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 3 x width, extending to M0. 9 of the outer plate, bearing small setules on the lateral margin and medioproximal face, no facial pappose setae, no medial pappose setae, with a row of 4 submarginal to subapical pappose setae, extending to a row of 5 similar subapical and 2 apical setae, and 3 apical naked tooth setae; outer plate broad, length 1.8 x width, distally naked, with a row of 3 slender naked, medial submarginal to distal facial setae, a medial row of 9 submarginal to subapical robust, naked, tooth setae, and 2 apicolateral setae - 1

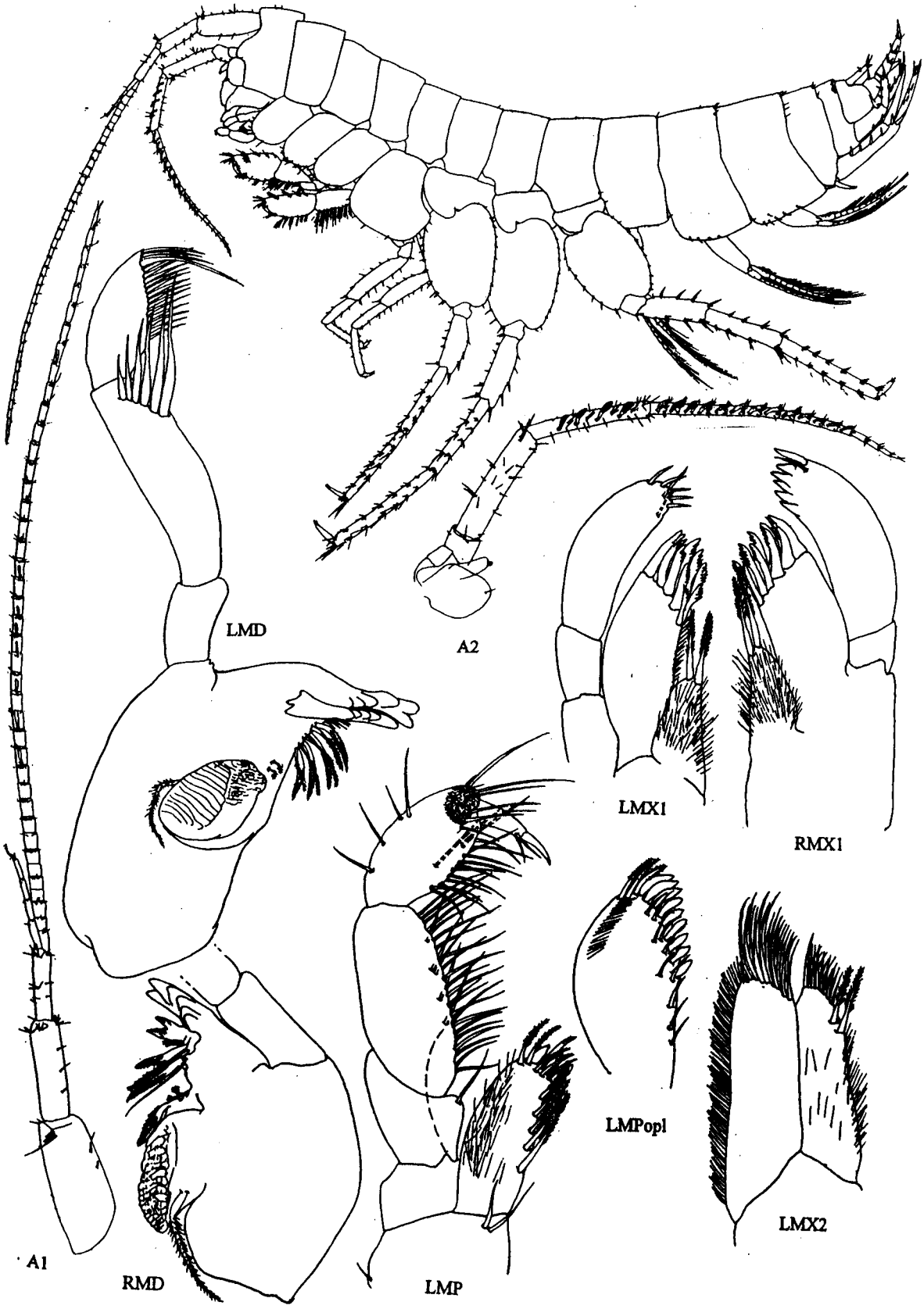

Fig. 3.24 *Chydaekata nudula* n. sp. holotype, male 'a' 6 mm. Whole animal, antennae and mouthparts.

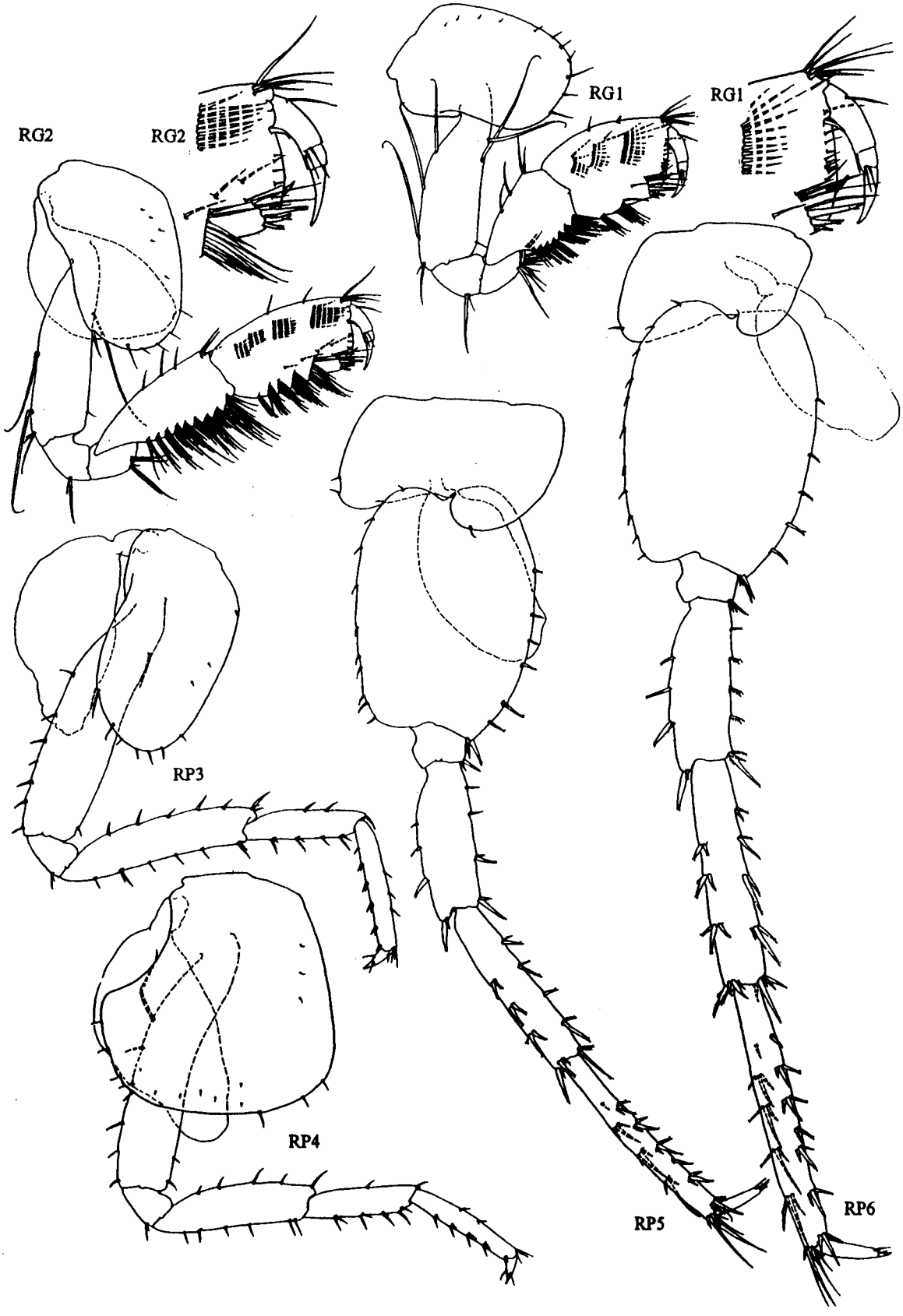

Fig. 3.25. *Chydaekata nudula* n. sp. holotype, male 'a' 6 mm. Gnathopods and pereopods 1-6.

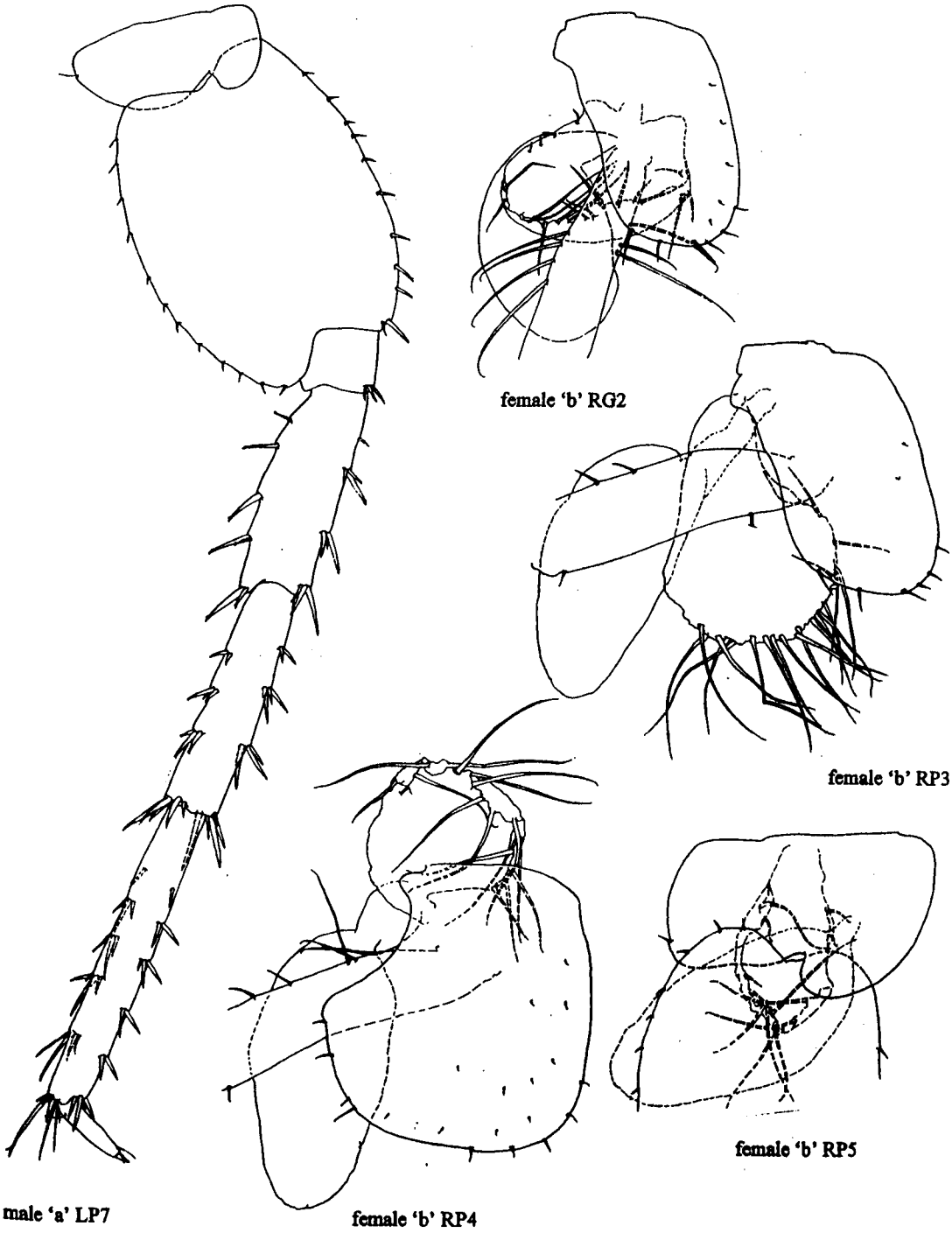

Fig. 3.26. *Chydaekata nudula* n. sp. holotype, male 'a' 6 mm. pereopod 7. Allotype female 'b' 6.5 mm. coxae of second gnathopod and of pereopods 3-5.

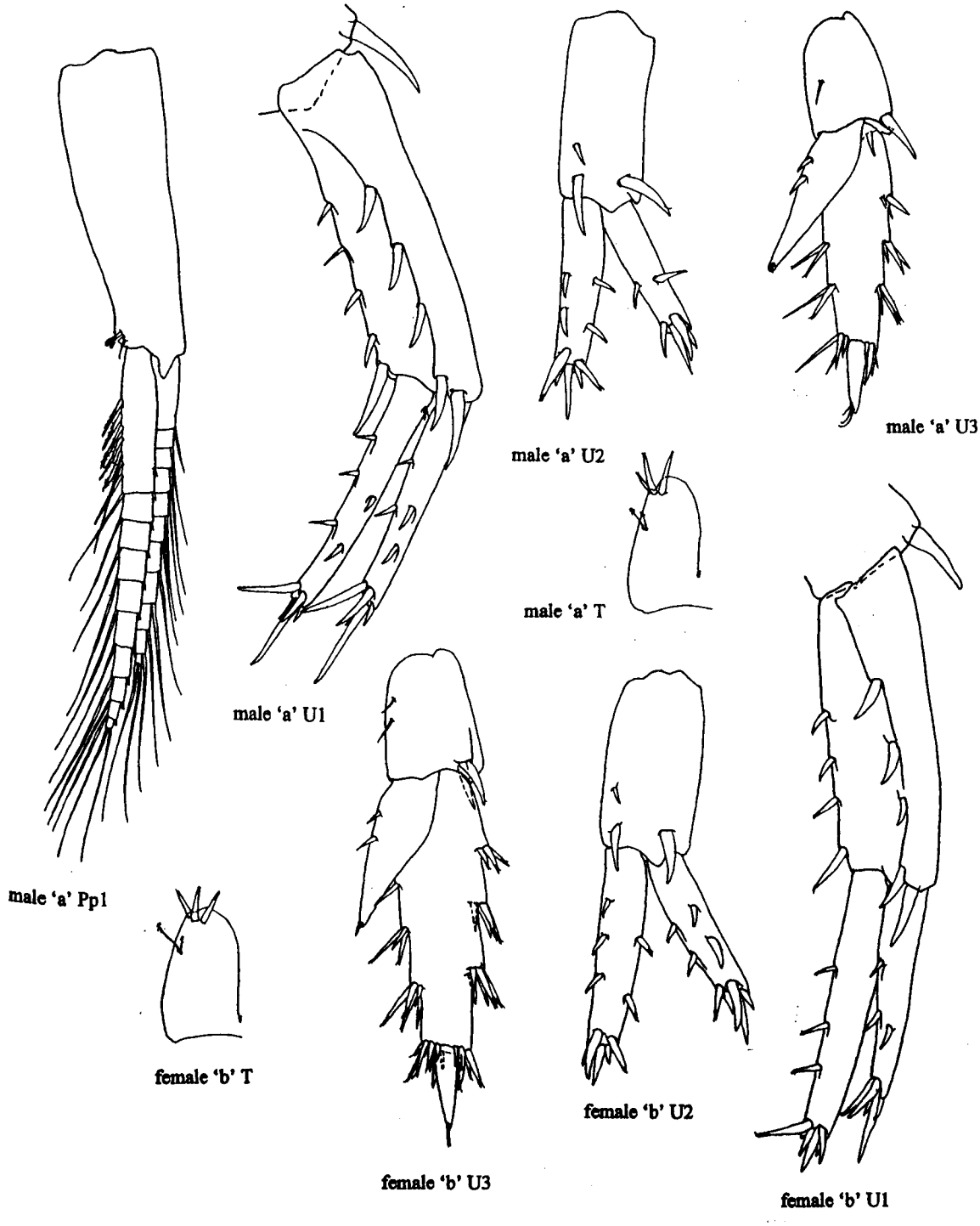

Fig. 3.27. *Chydaekata nudula* n. sp. holotype, male 'a' 6 mm. pleopod 1, uropods and telson. Allotype female 'b' 6.5 mm. uropods and telson.

naked, and 1 pappose; third article naked laterally, moderately setose medially, with 3 facial, and 2 ventrofacial long strong setae basal to the dactyl, the apex weakly produced, setulate, with 3 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate bearing 1 ventral seta; merus bearing posterior hump; carpus of moderate length, 1.5 x width, subtriangular, posterior margin strongly setose, with setae ranked in 7 transverse bands; propodus ovate, small, length 1.6 x width, posteroventral corner rounded, with 3 lateral robust setae, 4 additional lateral elongate setae, palmar angle weakly oblique, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 4 anteroventral and 1 ventral setae; carpus length 2.4 x width, subtriangular, with posterior setae ranked in 9 transverse bands; propodus subrectangular, small, length 0.8 x width, with 3 lateral robust setae, 1 medial robust seta, and 3 additional lateral elongate setae, palmar angle weakly oblique, smooth, dactyl reaching beyond palmar corner, with a single recumbent inner tooth spine. *Pereopods*: pereopod 3 longer than the second gnathopod, coxa with 4 anterior setae, 1 long ventral setae, and 1 seta at the posteroventral corner, carpus weakly setose posteriorly; pereopod 4: subequal in length with pereopod 3, coxa anteroventral margin with 3 setae, posteroventral margin with 4 setae, ventral margin with no setae, posterior margin strongly emarginate, carpus weakly setose posteriorly; coxa of pereopod 5 bearing 1 seta on anterior lobe, and 2 setae on the posterior lobe, basis of pereopod 5 with short slender posterior setae, bearing short robust anterior setae or bearing long robust anterior setae, weakly lobate posteriorly; pereopod 6 coxa bearing no setae on anterior lobe; basis moderately expanded, bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 1 seta on the posterior lobe, basis bearing short robust anterior setae or bearing long robust anterior setae, strongly lobate posteroventrally; bases of pereopods equally expanded. *Epimera*: first epimeron with 1 slender seta on the posterior margin, posterior margin convex, posteroventral corner rounded; epimeron 2 with 3 robust setae on the anteroventral margin, posterior margin straight, posteroventral corner rounded; epimeron 3 with 6 robust setae on the anteroventral margin, without slender setae on ventral margin, posterior margin sinuous, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonites 1 and 2 with 6 feeble setae, of pleonite 3 with 2 feeble setae, and no distolateral robust setae. *Pleopods*: each bearing 1

accessory retinacula. *Urosomites*: first urosomite bearing 1 distolateral slender seta and 2 distolateral robust setae; urosomite 2: with no distolateral slender setae, and 3 distolateral robust setae. *First uropod*: peduncle length 1.4 x the length of the inner ramus, with strong rows of 3 dorsolateral and 4 dorsomedial robust setae; outer ramus with 2 dorsolateral and 2 dorsomedial robust setae; inner ramus with 2 dorsolateral, 3 dorsomedial and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1; peduncle about 1.2 x length of inner ramus with 1 apicolateral, 1 dorsomedial, and 1 apicomedial robust setae; inner ramus with 2 dorsolateral, 3 dorsomedial, and 5 apical robust setae; outer ramus with 1 dorsolateral, 1 dorsomedial, and 5 apical robust setae. *Third uropod*: not extending beyond uropods 1 and 2 in intact specimen, 0.6 x length of uropod 1; peduncle length 0.8 x outer ramus, shorter than, 0.9 x urosomite three, with 1 apicolateral robust seta, and no apicolateral slender setae, with no dorsomedial robust setae, and 1 dorsomedial slender seta, with 1 apicomedial robust setae, and no apicomedial slender setae, and with no mediodistal robust setae; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands, with 3 lateral transverse bands of robust setae, 2 medial transverse bands of robust setae, with no medial transverse bands of mixed robust and small setae, 4 apicolateral robust setae, no apicolateral small setae, 4 apicomedial robust setae, no apicomedial small setae, no apicomedial long slender setae; distal article short, with 3 apical robust setae, and no apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender setae. *Telson*: subequal in length to urosomite 3; cleft 71 %; longer than broad, length 1.1 x breadth; apices rounded and laterally notched; 3 subapical robust setae, and no subapical slender setae; with 1 apical penicillate seta; and paired lateral penicillate setae at M0. 6 from the telson base.

Description of the allotype (female 'b' 6.5mm.).

Similar to the Holotype except in the following. *Body*: length 6mm. *First antenna*: without aesthetascs or calceoli. *Second antenna*: without calceoli. *Second gnathopod*: coxa bearing large, ovate, marginally setose and involute oostegite, length about 0.7x coxa. *Pereopods*. Third pereopod: coxa with fewer marginal setae, bearing large, paddle shaped marginally setose oostegite, about equal in size to the coxal plate. Fourth pereopod; coxa with more marginal setae than the holotype; bearing moderately sized round oostegite, apically inturned, and

marginally setose apically and posteriorly. Fifth pereopod; coxa without anteroventral seta, and with 1 posterior seta (rather than 2 as in the holotype); bearing moderate to small paddle shaped, marginally setose and involute oostegite. *Uropods*. First uropod; peduncle bearing 3 medial robust setae; outer ramus with 1 lateral robust seta; inner ramus without lateral setae. Second uropod; outer ramus bearing 2 lateral and 2 medial robust setae, and 5 apical robust setae; inner ramus bearing 3 medial robust setae. Third uropod; peduncle bearing 2 small dorsomedial setae; outer ramus first article with 3 medial transverse rows of setae, apex of the second article with 2 slender setae. *Telson*: similar to the male.

Relationships.

C. nudula differs from others of the genus in that: first antenna accessory flagellum reaches to article 8 of primary flagellum; second antenna flagellum bears calceoli on 13 articles; maxilliped outer plate with a row of 3 slender naked medial submarginal to disto facial setae; first gnathopod coxal plate with no anteroventral setae, carpus with strong posterior rastellate setae ranked in 7 transverse bands; second gnathopod carpus with strong posterior rastellate setae ranked in 9 transverse bands, propodus length less than 0.8 x width; pereopods - coxa 3 bearing 1 long ventral seta; coxa 5 bearing 2 setae on the posterior lobe; pleon - dorsolateral margin of pleonites 1 and 2 with 6 feeble setae; second uropod inner ramus with 3 dorsomedial robust setae; third uropod not extending beyond U1-2 in intact specimen, third uropod outer ramus distal article with 3 apical robust setae, third uropod outer ramus distal article with no apical slender setae.

3.1.4.3 *Chydaekata dolichodactyla* sp. nov. Figs. 3.28 - 3.31.

Etymology

From the Greek 'dolichos' (long), and 'dactylo' (finger), hence long finger, referring to extension of the dactyl of the second gnathopod propodus beyond the palmar corner.

Type locality.

Newman bore field, WB23/4, 23°19'S, 117°51'E.

Material examined.

Holotype (Western Australian Museum, C24656) male 'a' 4.5mm, Allotype (Western Australian Museum, C24657) female 'b' 6mm. Collection number BES 4841, taken with trap, W. F. Humphreys and S. M. Eberhard, 24/07/97.

Diagnosis.

Second antenna: peduncle article 5 bearing 1 calceolus, flagellum 9 articulate, with calceoli on articles 1-5. Mandible: palp article 2 with a medio-distal row of 3 robust rastellate setae; article 3 with 7 D and 3 E setae apically. Left first maxilla: palp article 2 with 6 apical setae. Right first maxilla: palp apex with no articulated, and 4 fused broad based tooth setae. Maxilliped outer plate with no medial submarginal to disto-facial setae; a medial row of 7 submarginal to subapical robust, naked, tooth setae; 2 apicolateral setae. First gnathopod propodus: dactyl reaching beyond the palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 4 transverse bands. Telson: cleft 68%, bearing 2 subapical robust setae.

Description of the holotype (male 'a' 4.5mm).

Body: urosomite 1 bearing 1 dorsolateral robust seta, urosomite 2 bearing 2 dorsolateral robust setae. *First antenna*: length 0.6 x body, 1.7 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 26 articles; accessory flagellum of 4 articles, reaching to article 5 of primary flagellum. *Second antenna*: length 0.6 x body; peduncle length greater than flagellum, article 5 bearing no calceoli, article 4 subequal with article 5, articles 3-5 with sparse setation; flagellum 11 articulate, with sparse setation, bearing calceoli on articles 2 - 4. *Left mandible*: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 9 D and 3 E setae, facially strongly setulose (pubescent); incisor with 5 teeth, lacinia mobilis with 5 teeth, and 2 plumose interraker setae; molar bearing pappose seta, with 1 penicillate hooked brushy basal seta. *Right mandible*: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 9 D and 3 E setae; incisor with 5 teeth, and 2 plumose interraker setae; molar, with 2 penicillate hooked brushy basal setae, and , few penicillate setules. *Left first maxilla*: palp article 2 with 4 apical and 1 subapical-facial strong slender setae, and 1 apicomedial seta; outer plate with 10 robust setae - 10 denticulate, none naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: with no articulated and 4 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 3.4 x width, bearing distal long,

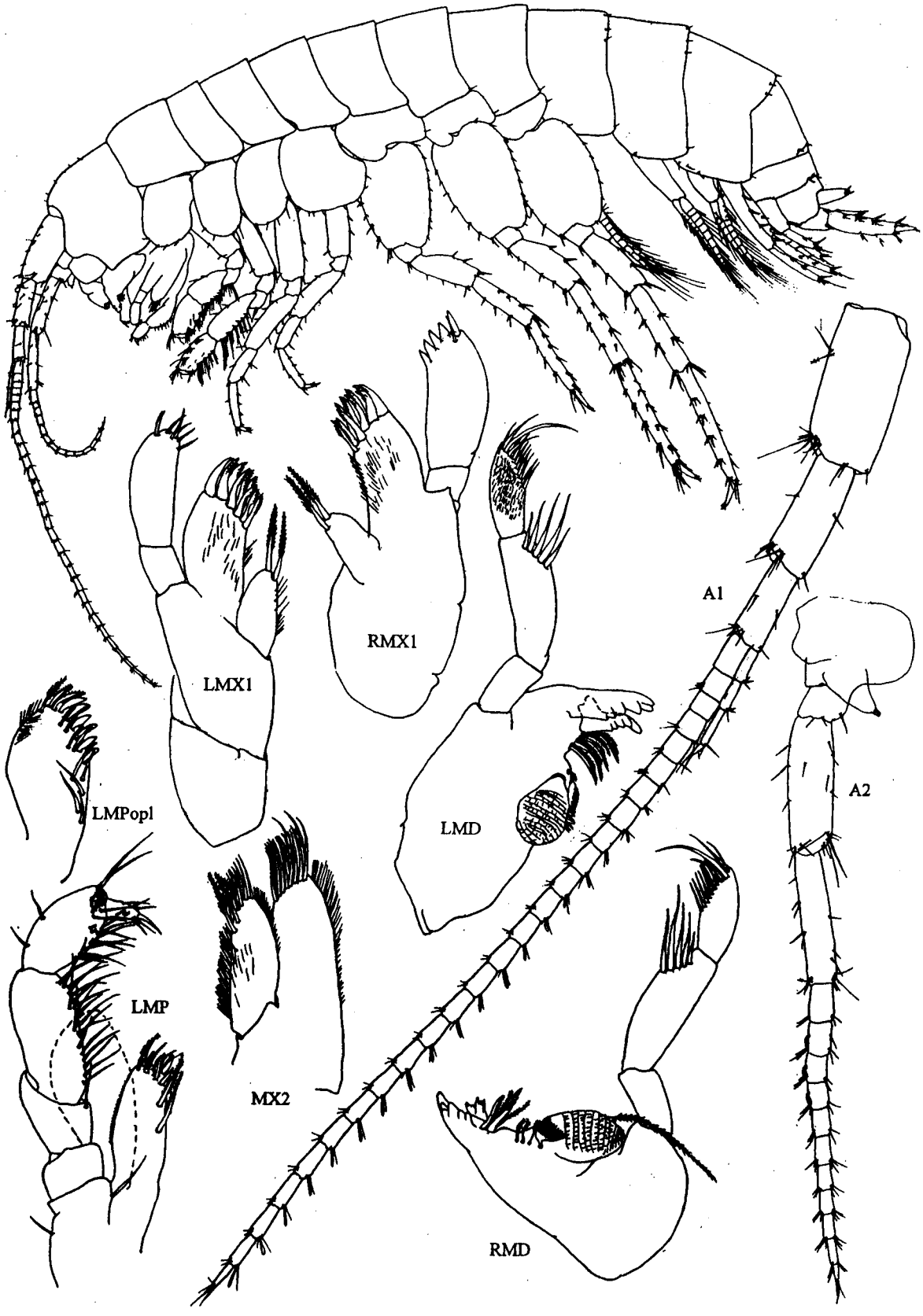

Fig. 3.28. *Chydaekata dolichodactyla* n. sp. holotype, male 'a' 4.5 mm. Whole animal, antennae and mouthparts.

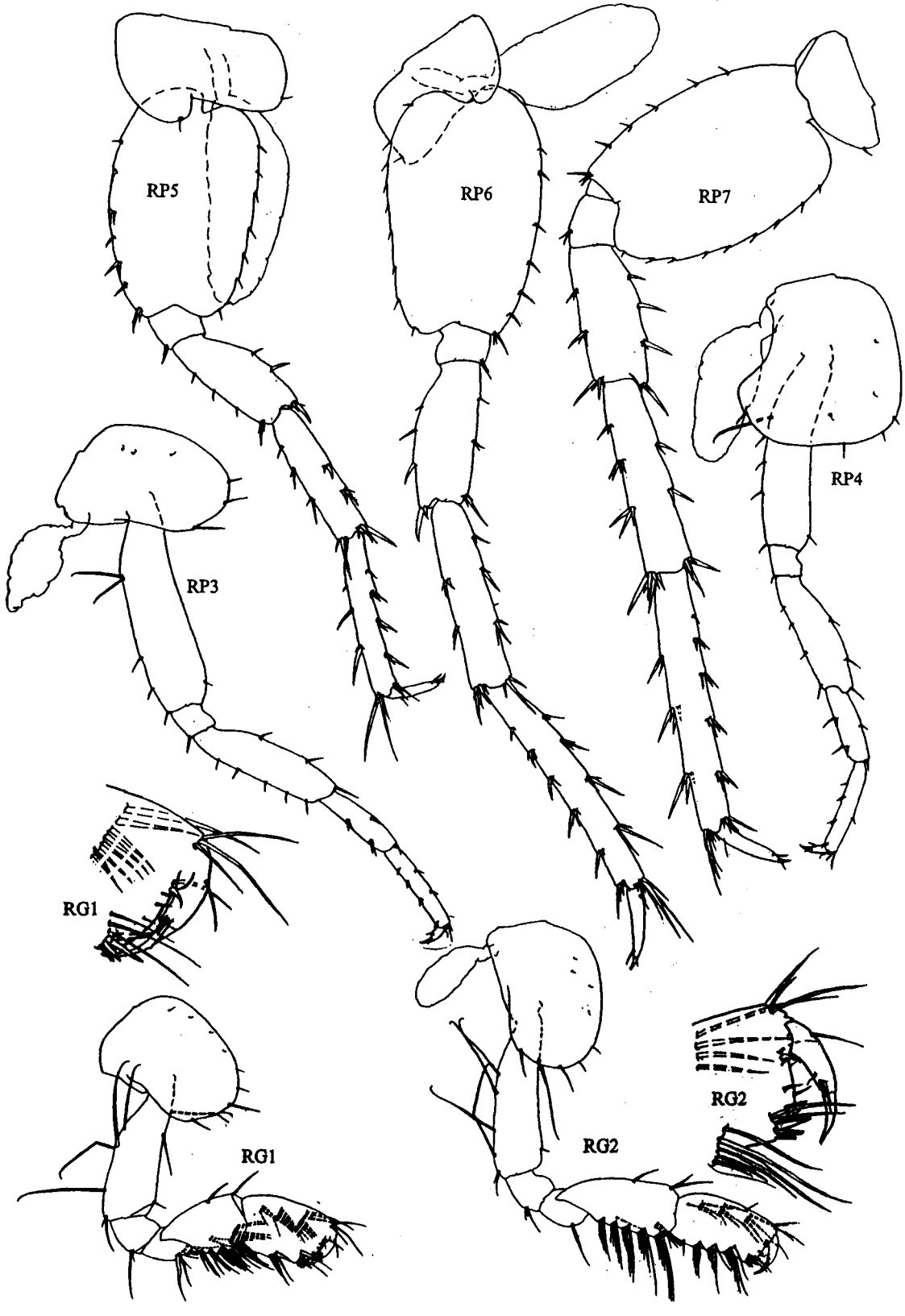

Fig. 3.29. *Chydaekata dolichodactyla* n. sp. holotype, male 'a' 4.5 mm. Gnathopods and pereopods.

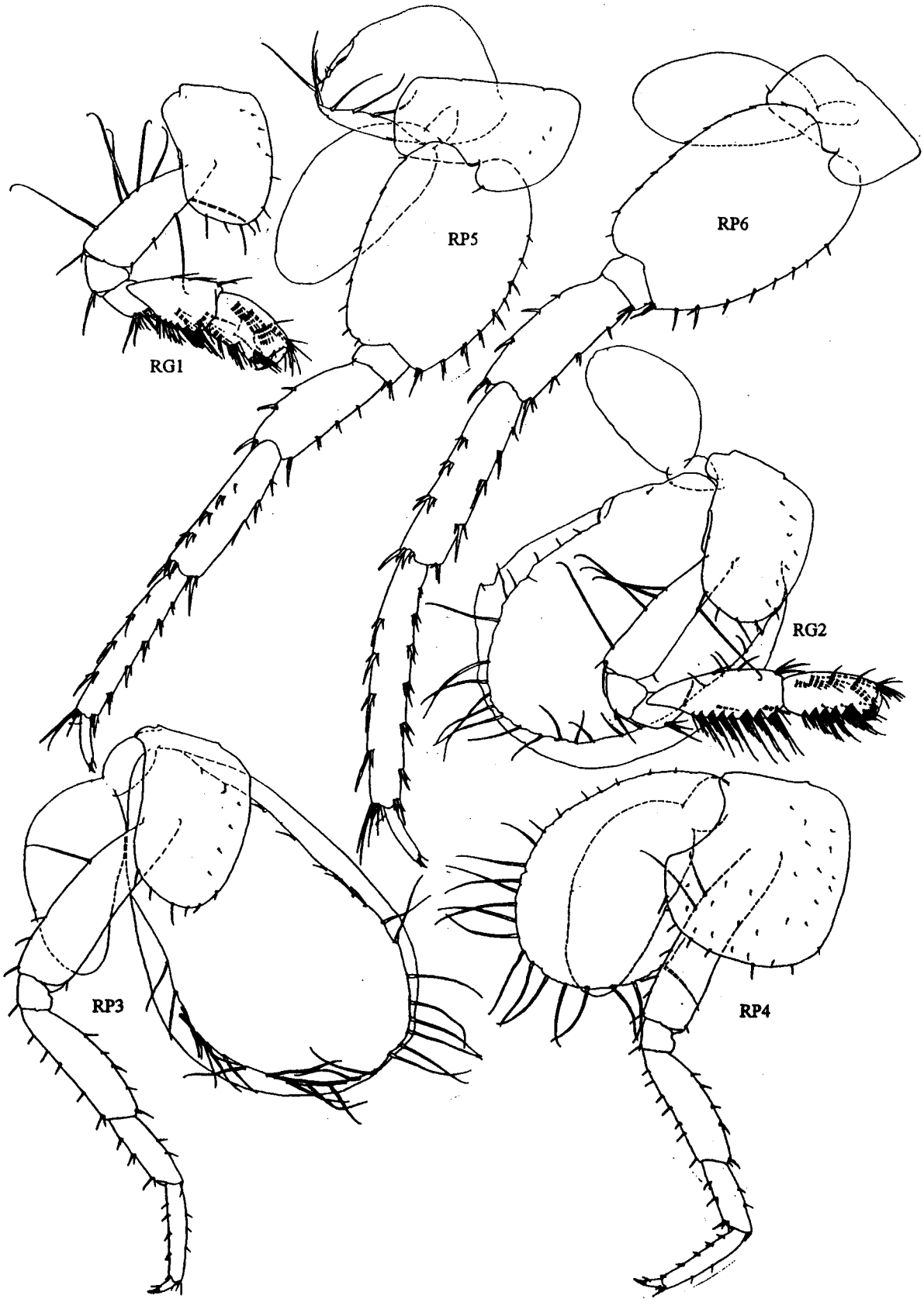

Fig. 3.30. *Chydaekata dolichodactyla* n. sp. allotype, female 'b' 6 mm. Gnathopods 1-2 and pereopods 3-6.

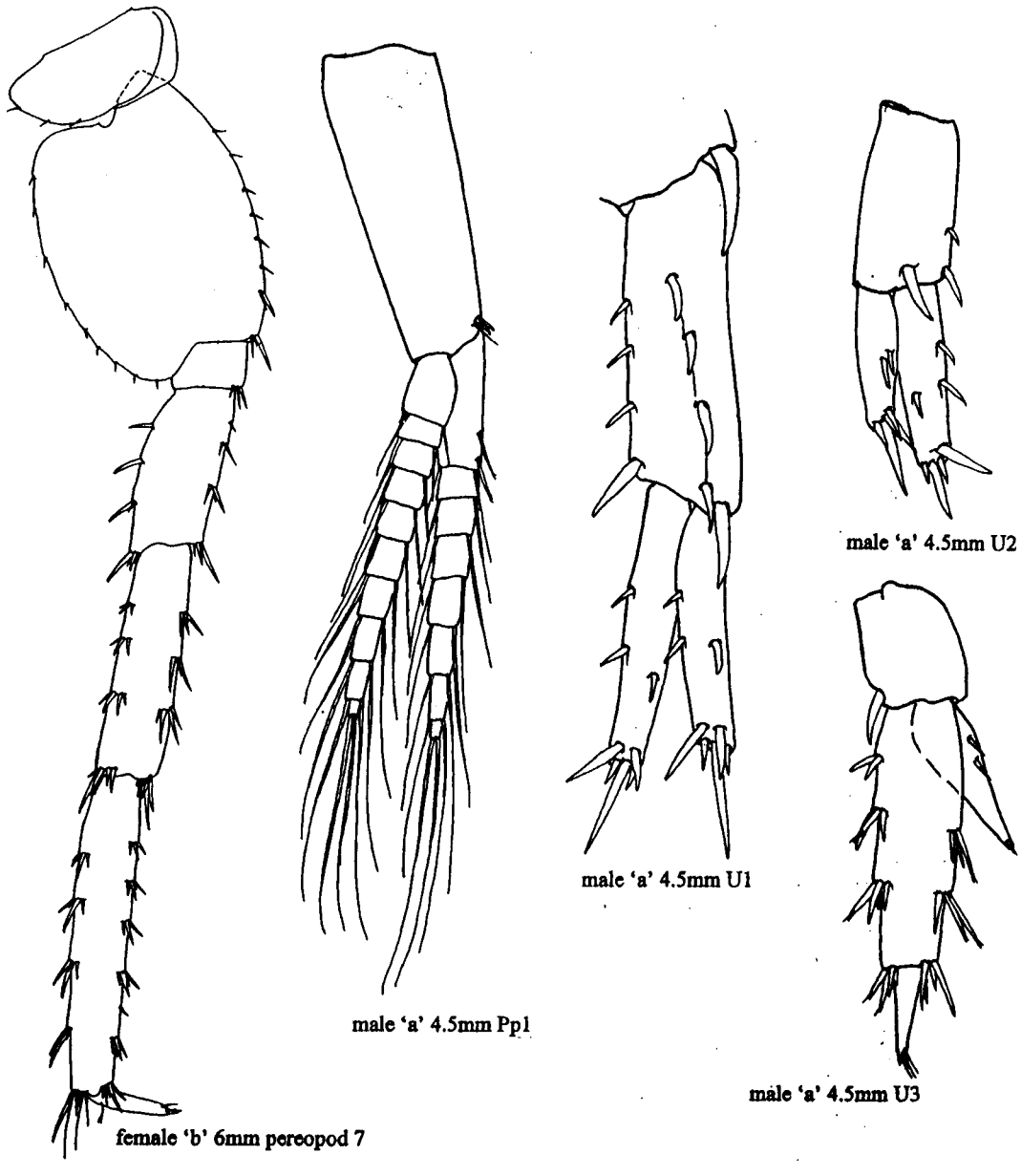

Fig. 3.31. *Chydaekata dolichodactyla* n. sp. holotype, male 'a' 4.5 mm. pleopod 1, uropods 1-3. Allotype female 'b' 6 mm. pereopod 7.

curved naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 2.8 x width, extending to M0.7 of the outer plate, bearing small setules on the lateral margin, no facial or medial pappose setae, with a row of 2 submarginal pappose setae, extending to a row of 2 similar subapical, and 4 apical setae, with 1 apicomedial and 3 apical naked tooth setae; outer plate broad, length 1.8 x width, distally setulose (pubescent), with a row of 10, slender naked, medial submarginal to distal facial setae, a medial row of 6 submarginal to subapical robust, naked, tooth setae, and 3 apicolateral setae - none naked, 3 pappose; palp second article moderately setose medially, third article sparsely setose laterally, moderately setose medially, with 2 facial and 2 ventrofacial long strong setae basal to the dactyl, the apex not produced, setulate, with 2 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 3 anteroventral setae, and 1 ventral seta; merus bearing posterior hump; carpus of moderate length, 1.6 x width, subtriangular, posterior margin , with setae ranked in 4 transverse bands; propodus subrectangular, small, length 1.5 x width, posteroventral corner rounded, with 2 lateral and 1 medial robust setae, and 3 additional lateral elongate setae, palmar angle slightly oblique, bearing fine marginal teeth, dactyl reaching beyond palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 2 anteroventral setae, and 1 ventral seta; carpus length 1.2 x width, subtriangular, with setae ranked in 5 transverse bands; propodus subrectangular, moderate size, length 2 x width, with 2 medial robust setae, 2 lateral robust setae, and 2 additional lateral elongate setae, palmar angle transverse, bearing fine marginal teeth, dactyl reaching beyond palmar corner, with a single recumbent inner tooth spine. *Pereopods*: pereopod 3 longer than the second gnathopod, coxa with 1 anterior seta, no long ventral setae, 1 short ventral seta, 1 seta at the posteroventral corner, carpus weakly setose posteriorly; pereopod 4 subequal in length with pereopod 3, coxa anteroventral margin with 2 setae, posteroventral margin with 2 setae, ventral margin with 1 seta, carpus moderately setose posteriorly; coxa 5 bearing 1 seta on anterior lobe, and 1 seta on the posterior lobe, basis of pereopod 5 with short slender posterior setae, bearing short robust anterior setae and long robust anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing no setae on anterior lobe, basis moderately expanded, bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate

posteroventrally; pereopod 7 coxa with 1 seta on the posterior lobe, basis bearing short and long robust anterior setae, moderately lobate posteroventrally; bases of pereopods expanded unequally, basis of pereopod 7 most expanded, basis of pereopod 6 least expanded. *Epimera*: first epimeron with 1 slender seta on the posterior margin, posterior margin convex, posteroventral corner rounded; second epimeron without robust setae on anteroventral margin, posterior margin straight, posteroventral corner rounded; third epimeron with 2 robust setae on the anteroventral margin, without slender setae on ventral margin, posterior margin straight, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonites 1 and 2 with 1 feeble seta, of pleonite 3 with 2 feeble setae, and no distolateral robust setae. *Pleopods*: first and second pleopods with 1 accessory retinacula, third pleopod with no accessory retinacula. *Urosomites*: first urosomite bearing no distolateral slender setae, and 2 distolateral robust setae; second urosomite with no distolateral slender setae, and 2 distolateral robust setae. *First uropod*: peduncle length 1.2 x the length of the inner ramus, with a strong row of 3 dorsolateral and 3 dorsomedial robust setae; outer ramus with 1 dorsolateral and 2 dorsomedial robust setae; inner ramus with 1 dorsolateral and 2 dorsomedial robust setae, and 4 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about 1 x length of inner ramus, with 1 apicolateral, 1 dorsomedial, and 1 apicomedial robust setae; inner ramus with 1 dorsolateral, 2 dorsomedial, and 5 apical robust setae; outer ramus with 1 dorsolateral, 1 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.6 x length of uropod 1; peduncle length 0.4 x outer ramus, subequal in length to urosomite 3, with 1 apicolateral robust seta, and no apicolateral slender setae, with no dorsomedial robust or slender setae, with no apicomedial robust or slender setae, and with 1 mediodistal robust seta; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands, with 3 lateral and 2 medial transverse bands of robust setae, 4 apicolateral robust setae, no apicolateral small setae, 4 apicomedial robust setae, no apicomedial small setae, no apicomedial long slender setae; distal article long, with no apical robust setae, and 3 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender seta. *Telson*: shorter than, 0.9 x, urosomite 3; cleft 74 %, shorter than broad, length 0.8 x breadth; apices rounded and laterally

notched, 2 subapical robust setae, with 1 apical penicillate seta; and paired lateral penicillate setae at M0.7 from the telson base.

Description of the allotype (female 'b' 6mm).

With the characteristics of the Holotype except. *Body*: length 6mm. *First antenna*: flagellum of 30 articles, without aesthetascs or calceoli, accessory flagellum of 5 articles. *Second antenna*: flagellum of 14 articles, without calceoli. *First gnathopod*: coxa bearing 7 (versus 5) marginal setae; carpus bearing 6 (versus 4) posterior translateral setal bands; propodus less robust, narrower and longer than male, tapering apically, bearing 2 (versus 1) posterior translateral setal bands and additional mediofacial setae, palmar corner bearing 2 (versus 3) lateral robust setae. *Second gnathopod*: coxa smaller than in male, bearing a huge ,ovate, marginally setose and involuted oostegite, length about 2.2x length of coxal plate; carpus longer and narrower than male with 8 (versus 5) posterior translateral setal bands but fewer mediofacial setae; propodus smaller, less robust than male, tapering apically, with 5 (versus 3) posterior translateral setal bands and additional mediofacial setae; palmar corner bearing 2 (versus 3) lateral robust setae. *Pereopods*. Pereopod three: coxa bearing additional marginal setae (6 versus 3), and a huge, ovate/paddle shaped, marginally setose and involuted oostegite, length about 2.3x coxal plate. Pereopod four: coxa with 8 (versus 5) marginal setae and many small facial setules, bearing large, marginally setose oostegite, length about 1.4x coxal plate. Pereopod five: coxa bearing large, apically setose oostegite, length about equal to coxal plate, 0.4x oostegite of coxa 3. Pereopod six similar to holotype. Pereopod seven: coxa bearing 3 (versus 1) posterior setae.

Relationships

C. dolichodactyla differs from others of the genus in that: second antenna peduncle article 5 bearing no calceoli, flagellum without calceoli on article 1, bearing calceoli on 3 articles only; maxilliped inner plate with a row of 2 submarginal pappose setae, extending to a row of 2 similar subapical setae and 4 similar apical setae, outer plate bearing a medial row of 6 submarginal to subapical robust, naked, tooth setae; second gnathopod carpus length less than 1.2 x width, propodus palmar angle oblique; first uropod inner ramus bearing 4 apical robust setae.

3.1.4.4 *Chydaekata breviclava* sp. nov. Fig. 3.32 - 3.35

Etymology

From the Latin 'brevis' (short) and 'clavus' (nail), hence 'short nail', referring to the length of the dactyl of the propodus of the second gnathopod.

Type locality

Newman bore field, WB23/4, 23°19'S, 117°51'E.

Material examined

Holotype (Western Australian Museum, C24658) male 'a' 5mm, Allotype (Western Australian Museum, C24659) female 'b' 6mm, 17 others in the type series (Western Australian Museum, C24660). Collection number BES 4846, taken with haul net, W. F. Humphreys and S. M. Eberhard, 24/07/97.

Diagnosis

Second antenna: peduncle article 5 bearing 4 calceoli, flagellum 15 articulate, with calceoli on articles 1-9. Mandible: palp article 2 with a medio-distal rows of 4 robust rastellate setae; article 3 with 12 D and 4 E setae apically. Left first maxilla: palp article 2 with 8 apical setae. Right first maxilla: palp apex with no articulated, and 5 fused broad based tooth setae. Maxilliped outer plate with a row of 9 slender naked, medial submarginal to disto-facial setae; a medial row of 8 submarginal to subapical robust, naked, tooth setae; 4 apicolateral setae. First gnathopod propodus: dactyl not reaching to palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 5 transverse bands. Telson: cleft 69%, bearing 3 subapical robust setae.

Description of the holotype (male 'a' 5mm)

Body: urosomite 1 bearing 2 dorsolateral robust setae, urosomite 2 bearing 3 dorsolateral robust setae. *First antenna*: length 0.9 x body, 1.7 x second antenna; peduncle article 2 longest, with sparse setae; primary flagellum of 36 articles; accessory flagellum of 5 articles, reaching to article 6 of primary flagellum. *Second antenna*: length 0.5 x body; peduncle length greater than flagellum, article 5 bearing 4 calceoli, article 4 longer than article 5, articles 3-5 with sparse setation; flagellum 15 articulate, with sparse setation, bearing calceoli on articles 1 - 9. *Left mandible*: palp article 2 with a medio-distal row of 4 robust rastellate setae, article 3 with 12 D and 4 E setae, facially strongly setulose (pubescent); incisor with 5 teeth, lacinia mobilis with 5 teeth, and 4 plumose interraker setae; molar without pappose seta, with 3 penicillate hooked brushy basal setae, and no penicillate setules. *Right*

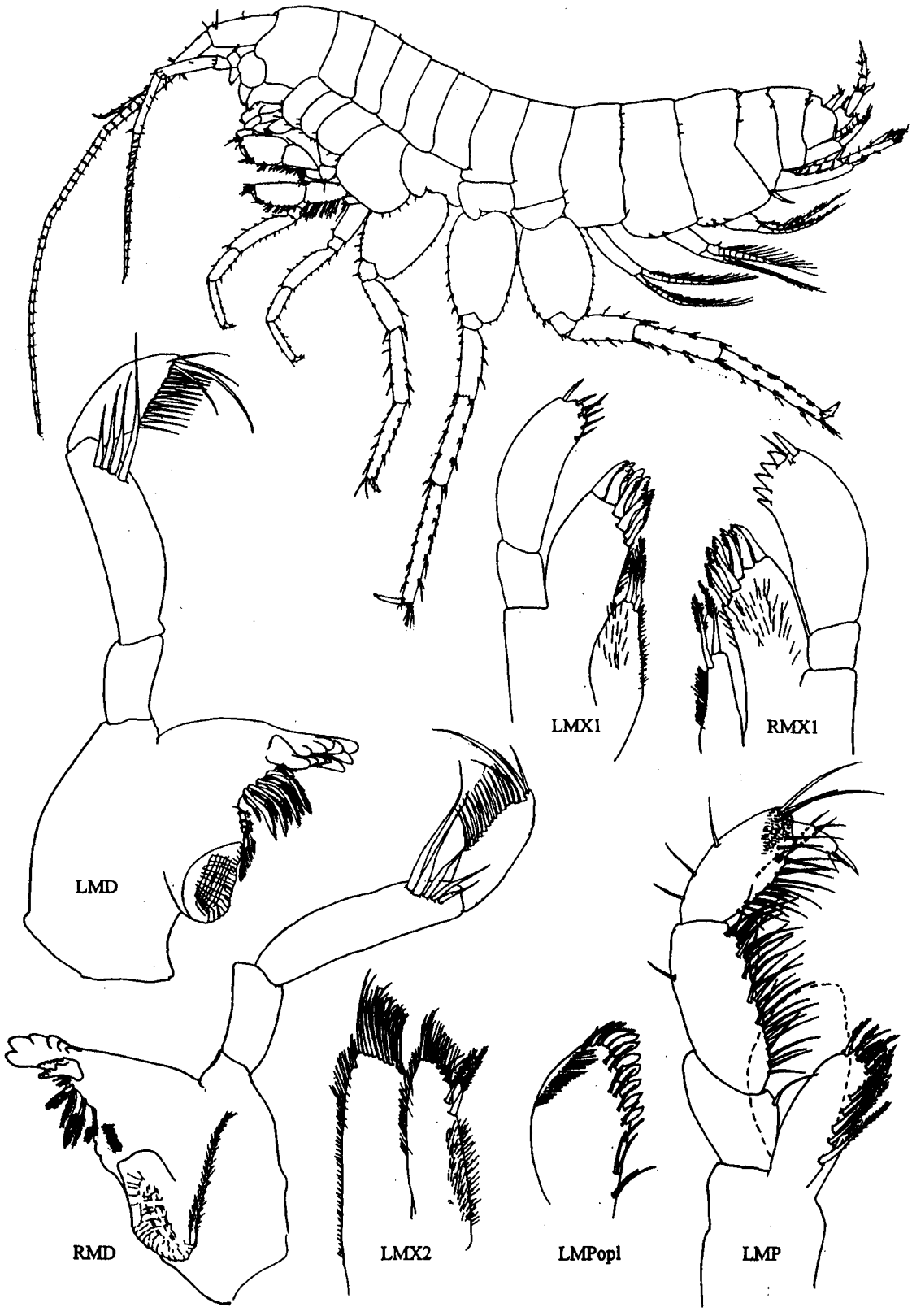

Fig. 3.32. *Chydaekata breviclava* n. sp. holotype, male 'a' 5 mm. Whole animal and mouthparts.

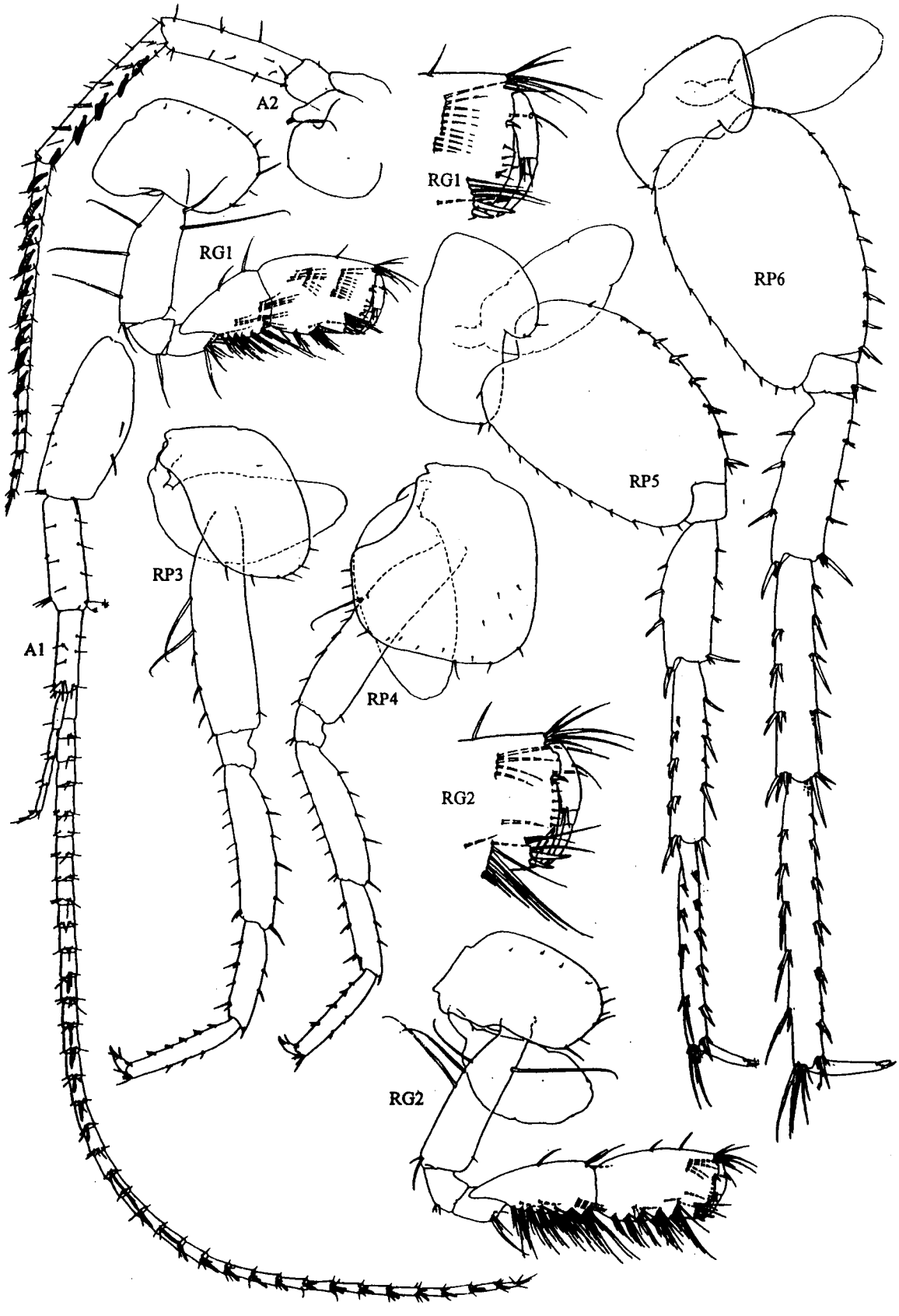

Fig. 3.33. *Chydaekata breviclava* n. sp. holotype, male 'a' 5 mm. Antennae, gnathopods 1-2, pereopods 3-6.

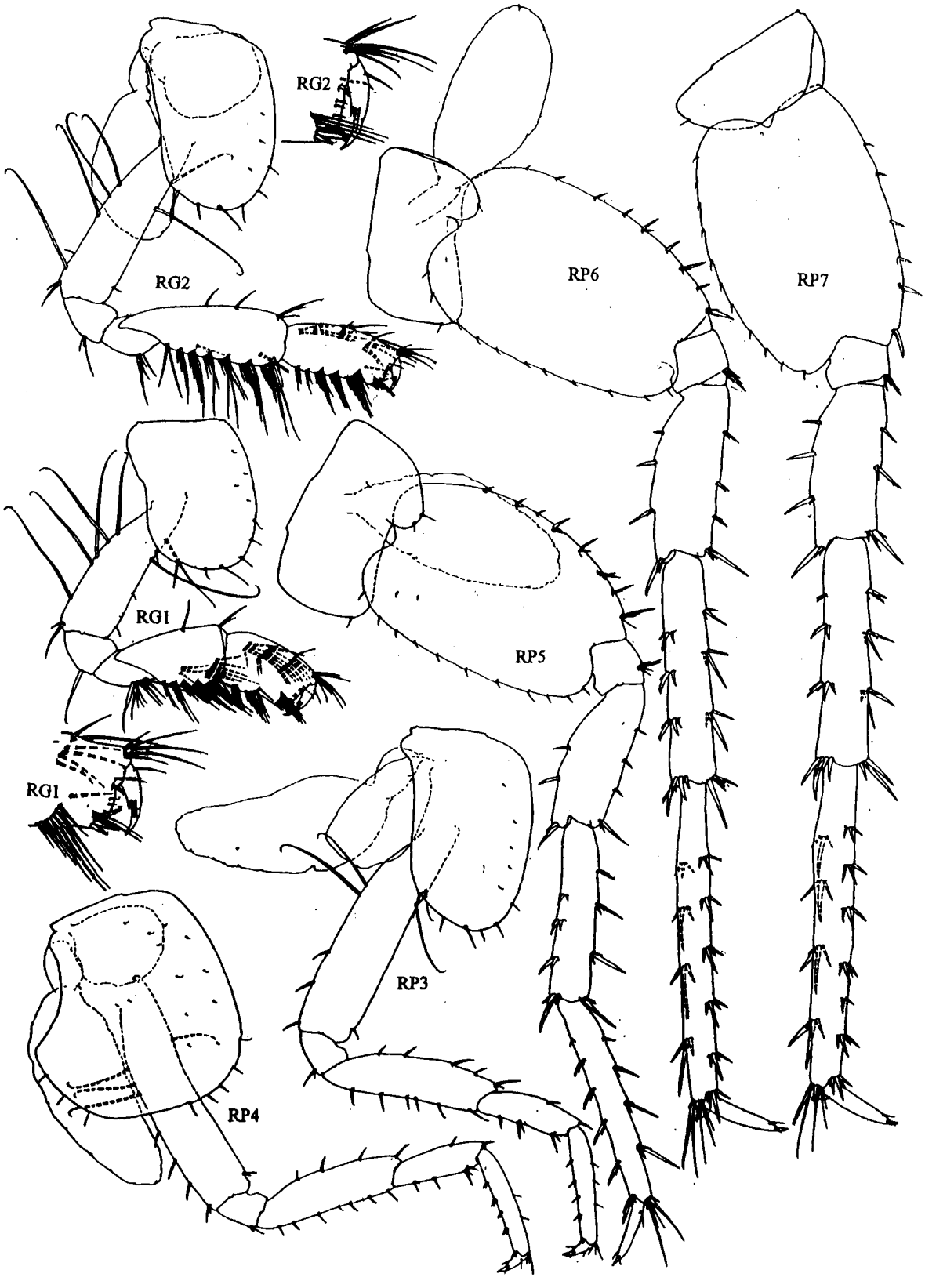

Fig. 3.34. *Chydaekata breviclava* n. sp. allotype, female 'b' 6 mm. Gnathopods and pereopods.

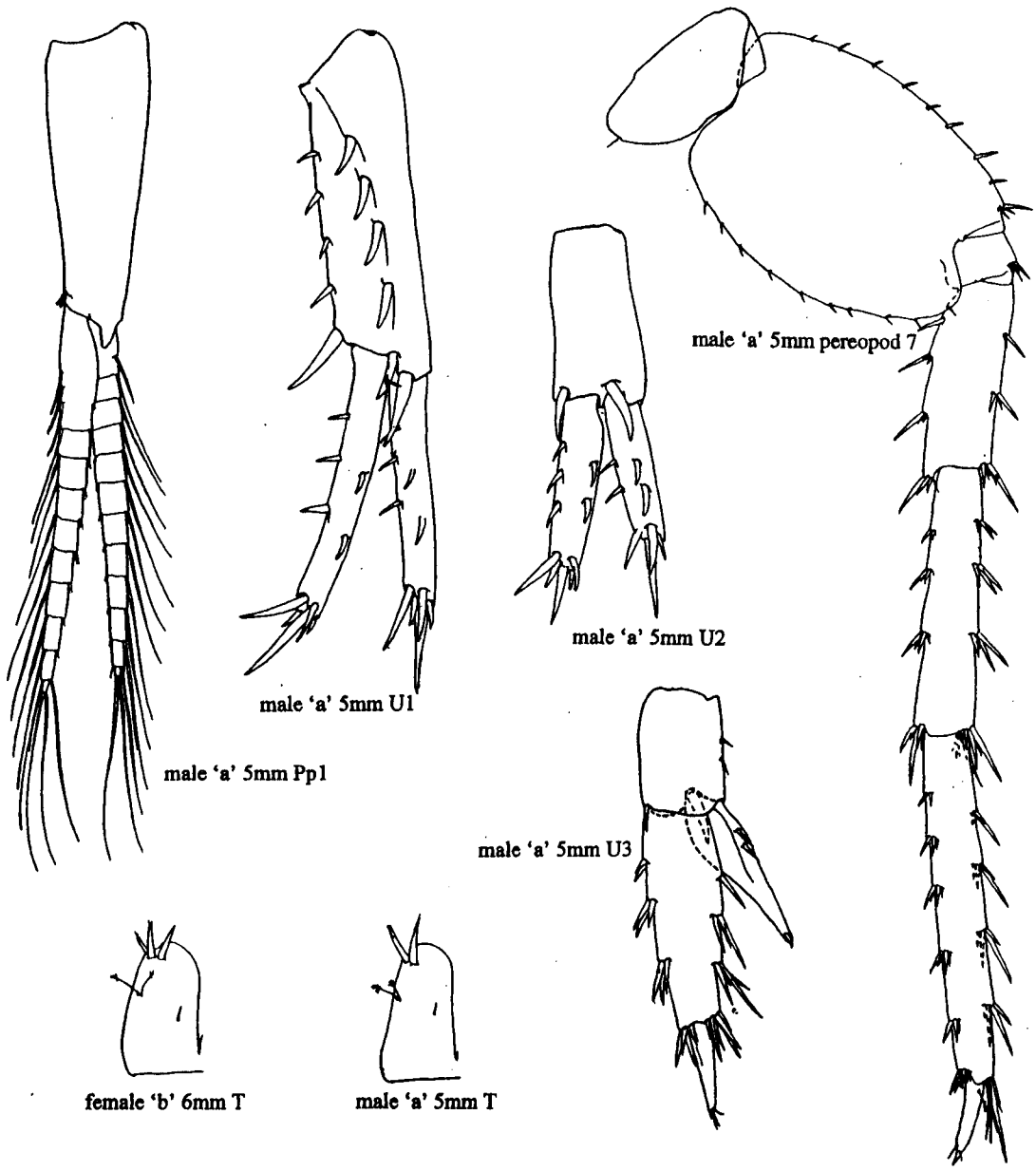

Fig. 3.35. *Chydaekata breviclava* n. sp. holotype, male 'a' 5 mm., pleopod 1, uropods 1-3, telson, pereopod 7. Allotype female 'b' 6 mm. telson.

mandible: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 12 D and 4 E setae; incisor with 6 teeth, and 2 plumose interraker setae; molar with 1 penicillate hooked brushy basal seta, and no penicillate setules. *Left first maxilla*: palp article 2 with 5 apical and 2 subapical facial strong slender setae, with 1 apicomedial seta; outer plate with 10 robust setae - 10 denticulate, none naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with no articulated and 5 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 3.9 x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 2.6 x width, extending to M0.7 of the outer plate, bearing small setules on the lateral margin, no facial pappose setae, no medial pappose setae, with a row of 5, submarginal to subapical pappose setae, extending to a row of 5 similar subapical, but no apical setae, with 1 apicomedial, and 3 apical naked tooth setae; outer plate broad, length 1.7 x width, distally naked, with a row of 9, slender naked, medial submarginal to distal facial setae, a medial row of 8 submarginal to subapical robust, naked, tooth setae, and 4 apicolateral setae - 1 naked and 3 pappose; palp, second article moderately setose medially; third article sparsely setose laterally, moderately setose medially, with 3 facial, and 2 ventrofacial long strong setae basal to the dactyl, the apex moderately produced, setulate, with 3 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 4 anteroventral setae, and 1 ventral seta; merus without posterior hump; carpus of moderate length, 1.5 x width, subtriangular, posterior margin , with setae ranked in 6 transverse bands; propodus subrectangular, small, length 1.6 x width, posteroventral corner rounded, with 2 lateral and 1 medial robust setae, and 4 additional lateral elongate setae, palmar angle slightly oblique, smooth, dactyl not reaching to palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 3 anteroventral setae, and 2 ventral setae; carpus length 2.4 x width, trapezoidal, with posterior setae ranked in 5 transverse bands; propodus subrectangular, moderate size, length 1.8 x width, with 2 lateral robust setae, 1 medial robust seta, and 3 additional lateral elongate setae, palmar angle weakly oblique, smooth, dactyl not reaching to palmar corner, with a single recumbent inner tooth spine. *Pereopods*: pereopod 3 subequal in length to the second gnathopod; coxa with 4 anterior setae, no long ventral setae, 1 short ventral seta, 1

seta at the posteroventral corner; carpus moderately setose posteriorly; pereopod 4 subequal in length with pereopod 3, coxa anteroventral margin with 2 setae, posteroventral margin with 1 seta, ventral margin with 4 setae, posterior margin moderately emarginate, carpus moderately setose posteriorly; coxa 5 bearing 1 seta on anterior lobe, and 1 setae on the posterior lobe, basis with short slender posterior setae, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing no setae on anterior lobe; basis moderately expanded, bearing short and long robust anterior setae and short slender anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 1 seta on the posterior lobe; basis bearing short and long robust anterior setae and short slender anterior setae, moderately lobate posteroventrally; bases of pereopods equally expanded. *Epimera*: first epimeron with 1 slender seta on the posterior margin, posterior margin straight, posteroventral corner rounded; second epimeron with 2 robust setae on the anteroventral margin, posterior margin straight, posteroventral corner rounded; third epimeron with 3 robust setae on the anteroventral margin, without slender setae on ventral margin, posterior margin straight, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 2 feeble setae, of pleonite 2 with 1 feeble seta, of pleonite 3 with 1 feeble seta and no distolateral robust setae. *Pleopods*: first, second and third pleopods with 1 accessory retinacula. *Urosomites*: first urosomite bearing 1 distolateral slender seta, and 2 distolateral robust setae; urosomite 2 with no distolateral slender setae, and 3 distolateral robust setae. *First uropod*: peduncle length 1.3 x the length of the inner ramus, with a strong row of 4 dorsolateral robust setae, and 4 dorsomedial robust setae; outer ramus with 2 dorsolateral robust setae, and 3 dorsomedial robust setae; inner ramus with 2 dorsolateral robust setae, 3 dorsomedial robust setae, and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about 1.1 x length of inner ramus, with 1 apicolateral, 1 dorsomedial, and 1 apicomedial robust setae; inner ramus with 2 dorsolateral, 2 dorsomedial, and 4 apical robust setae; outer ramus with 2 dorsolateral, 3 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.7 x length of uropod 1; peduncle length 0.4 x outer ramus, shorter than, 0.7 x, urosomite three, with 1 apicolateral robust seta, and no apicolateral slender setae, with no dorsomedial robust setae, and 2 dorsomedial slender setae, with no apicomedial robust setae, no apicomedial slender setae, and

with 1 mediodistal robust setae; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands, with 3 lateral and 3 medial transverse bands of robust setae, with no medial transverse bands of mixed robust and small setae, 5 apicolateral robust setae, no apicolateral small setae, 6 apicomedial robust setae, no apicomedial small setae, no apicomedial long slender setae; distal article short, with no apical robust setae, and 3 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender seta. *Telson*: shorter than, 0.9 x, urosomite 3; cleft 69 %, longer than broad, length 1.2 x breadth; apices rounded and laterally notched, 3 subapical robust setae, apical penicillate setae absent; paired lateral penicillate setae at M0.5 from the telson base.

Description of the allotype (female 'b' 6mm)

With the characteristics of the Holotype except. *Body*: length 6mm. *First antenna*: without aesthetascs or calceoli. *Second antenna*: without calceoli. *First gnathopod*: coxa longer than male, similarly armed; carpus more elongate than male though similarly subtriangular, bearing 5 (versus 6) posterior translateral setal bands and 2 (versus 3) medio-facial bands; propodus narrower, less robust than male, tapering apically, with 2 (versus 3) posterior translateral setal bands, and similar to the male 3 medio-facial bands, but each with more setae, palm and dactyl similar. *Second gnathopod*: coxa longer than the male though similarly armed, bearing a moderately sized, round, naked oostegite, length about 0.5x coxal plate; carpus longer and more slender than the male, bearing 7 (versus 8) posterior translateral setal bands and fewer medio-facial setae; propodus less robust than male, tapering apically, similarly armed posteriorly but 4 (versus 1) medio-facial setal bands, palm and dactyl similar to holotype. *Pereopods*. Pereopod three: coxa bearing a moderate size, paddle shaped, naked oostegite, length about 0.7x coxal plate, otherwise similarly armed to holotype. Pereopod four: coxa bearing small, round, naked oostegite, 3 (versus 4) posterior ventral setae and 5 (versus 3) anterior ventral setae. Pereopod five: coxa lacking oostegite. Pereopod six: coxa anterior lobe bearing a single ventro-marginal seta (versus none), otherwise similar to the male. Pereopod seven: similar to the male. *Telson*: bearing 3 (versus 2) distolateral robust setae on either lobe.

Relationships

C. breviclava differs from other species of the genus in that: second antenna flagellum bearing calceoli on 9 articles; left first maxilla palp article 2 with 5 apical strong slender setae and 2 subapical facial strong slender setae; maxilliped outer plate with 4 apicolateral setae; second gnathopod dactyl not reaching to palmar corner; pereopods 4 coxa posteroventral margin with 1 seta, ventral margin with 4 setae; third uropod outer ramus proximal article with 5 apicolateral robust setae, and 6 apicomedial robust setae.

Etymology

From the Latin 'brevis' (short) and 'clavus' (nail), hence 'short nail', referring to the length of the dactyl of the propodus of the second gnathopod.

3.1.4.5 *Chydaekata transversa* sp. nov. Figs. 3.36 - 3.39.

Etymology

From the Latin 'transversus' (crosswise), referring to the almost transverse palmar angle of the propodus of the first gnathopod.

Type locality

Newman bore field, WB23/4, 23°19'S, 117°51'E.

Material examined

Holotype (Western Australian Museum, C24661) male 'a' 7mm, Allotype (Western Australian Museum, 24662) female 'b' 7.5mm, male 'c' 6mm, female 'd' 7.5mm, 10 others in the type series, same data as the holotype (Western Australian Museum, C24663). Collection number BES 4817, taken with haul net, W. F. Humphreys and S. M. Eberhard, 22/07/97.

Diagnosis

Second antenna: peduncle article 5 bearing 3 calceoli, flagellum 17 articulate, with calceoli on articles 1-11. Mandible: palp article 2 with a medio-distal row of 6 robust rastellate setae; article 3 with 12 D and 4 E setae apically. Left first maxilla: palp article 2 with 6 apical setae. Right first maxilla: palp apex with no articulated, and 4 fused broad based tooth setae. Maxilliped outer plate with a row of 6 slender naked, medial submarginal to disto-facial setae; a medial row of 7 submarginal to subapical robust, naked, tooth setae; 3 apicolateral setae. First gnathopod propodus: dactyl reaching to palmar corner, with a single recumbent inner tooth spine. Second

gnathopod carpus: with posterior setae ranked in 7 transverse bands. Telson: cleft 79%, bearing 3 subapical robust setae.

Description of the holotype (male 'a' 7mm)

Body: urosomites 1 and 2 without dorsolateral robust setae. *First antenna*: length 0.7 x body, 1.8 x second antenna; peduncle article 2 longest, with sparse setae; primary flagellum of 40 articles; accessory flagellum of 6 articles, reaching to article 6 of primary flagellum. *Second antenna*: length 0.4 x body; peduncle length subequal to flagellum, article 5 bearing 3 calceoli, article 4 subequal with article 5, articles 3-5 with sparse setation; flagellum 17 articulate, with sparse setation, bearing calceoli on articles 1 - 11. *Left mandible*: palp article 2 with a medio-distal row of 6 robust rastellate setae, article 3 with 12 D and 4 E setae, facially strongly setulose (pubescent); incisor with 6 teeth, lacinia mobilis with 5 teeth, and 1 plumose interraker seta; molar without pappose seta, with 4 penicillate hooked brushy basal setae, and no penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 6 robust rastellate setae, article 3 with 12 D and 4 E setae; incisor with 5 teeth, and 1 plumose interraker seta; molar without penicillate hooked brushy basal setae and few penicillate setules. *Left first maxilla*: palp article 2 with 4 apical and 1 subapical facial strong slender setae, with 1 apicomedial, no submarginal apicomedial and no ventrofacial apicomedial strong slender setae; outer plate with 10 robust setae - 9 denticulate, 1 naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with no articulated, 4 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 3.8 x width, bearing distal long, curved rastellate setae or naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 2.3 x width, extending to M0. 7 of the outer plate, bearing small setules on the lateral margin and latero-proximal face, 1 facial pappose seta at M0. 9 of its length, no medial pappose setae, with a row of 5 submarginal to subapical pappose setae, extending to a row of 5 similar subapical, and 2 apical setae, with no apicomedial, no mediodistal, and 3 apical naked tooth setae; outer plate long, length 2 x width, distally setulose (pubescent), with a row of 6 slender naked, medial submarginal to distal facial setae, a medial row of 7 submarginal to subapical robust, naked, tooth setae and 3 apicolateral setae - none naked, 3 pappose; palp second article strongly setose medially, third article naked laterally, moderately setose medially, with 3

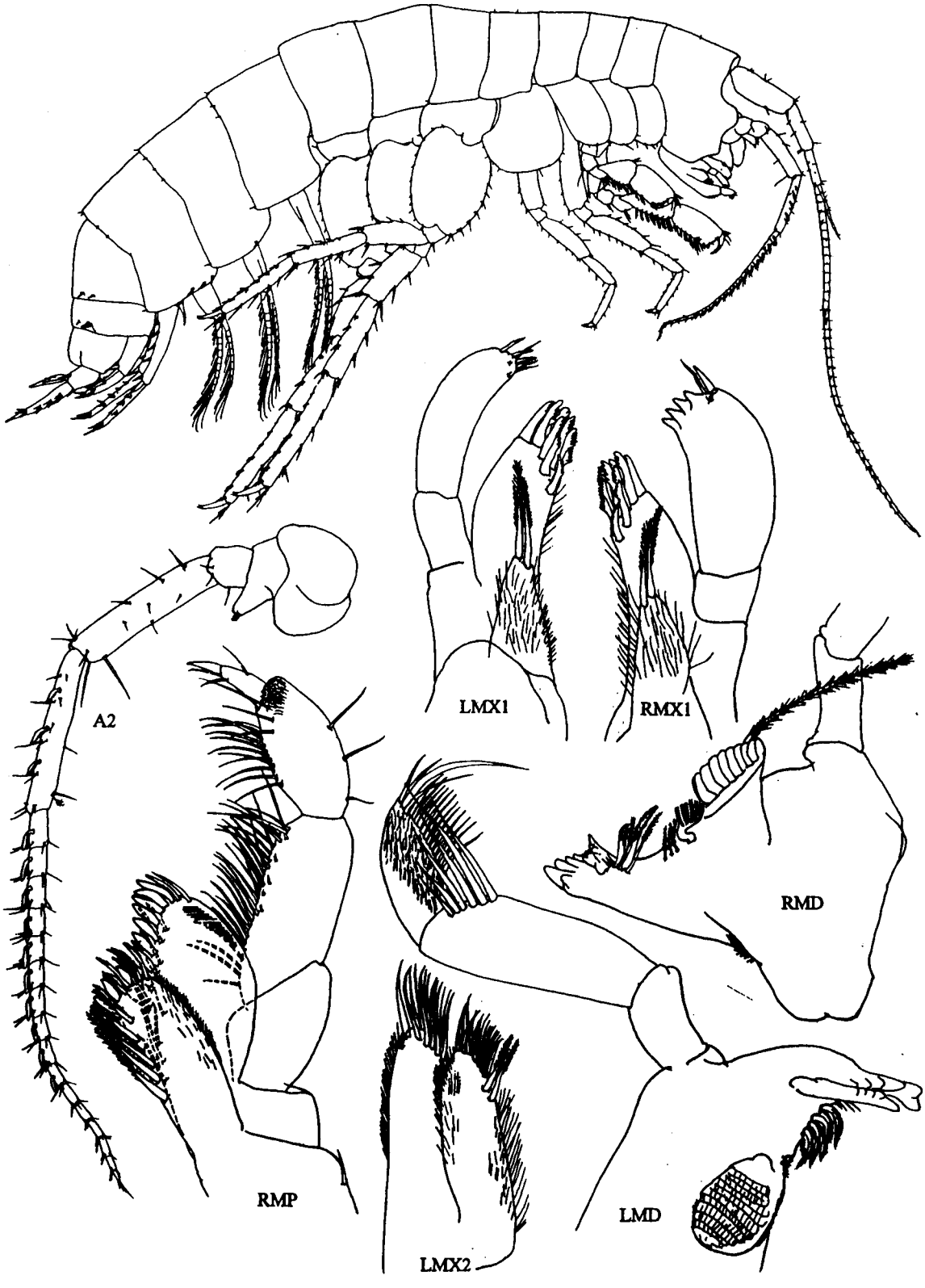

Fig. 3.36. *Chydaekata transversa* n. sp. holotype, male 'a' 7 mm. Whole animal, antenna 2 and mouthparts.

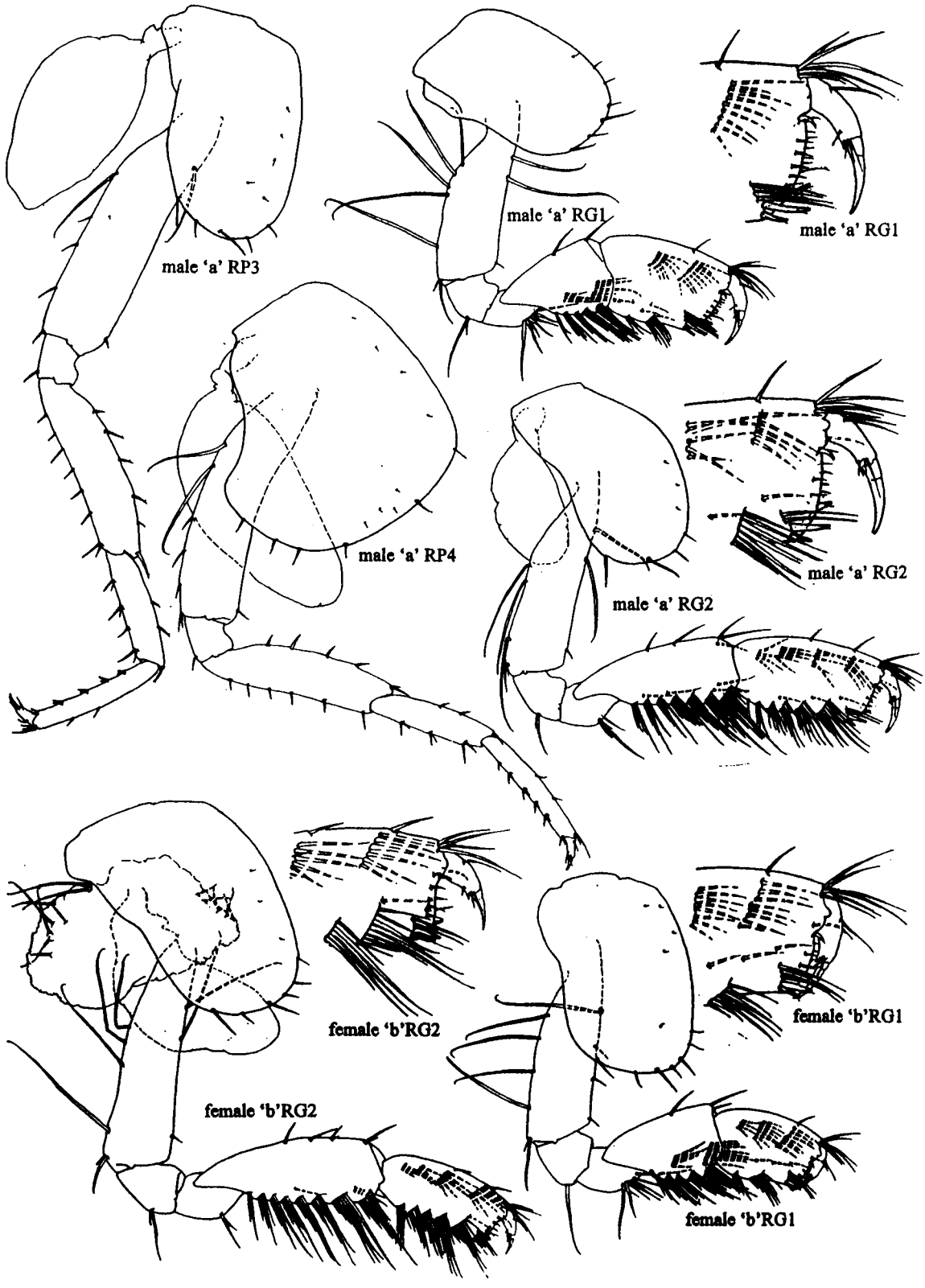

Fig. 3.37. *Chydaekata transversa* n. sp. holotype, male 'a' 7 mm. gnathopods 1-2 and pereopods 3-4. Allotype female 'b' 7.5 mm. gnathopods 1-2.

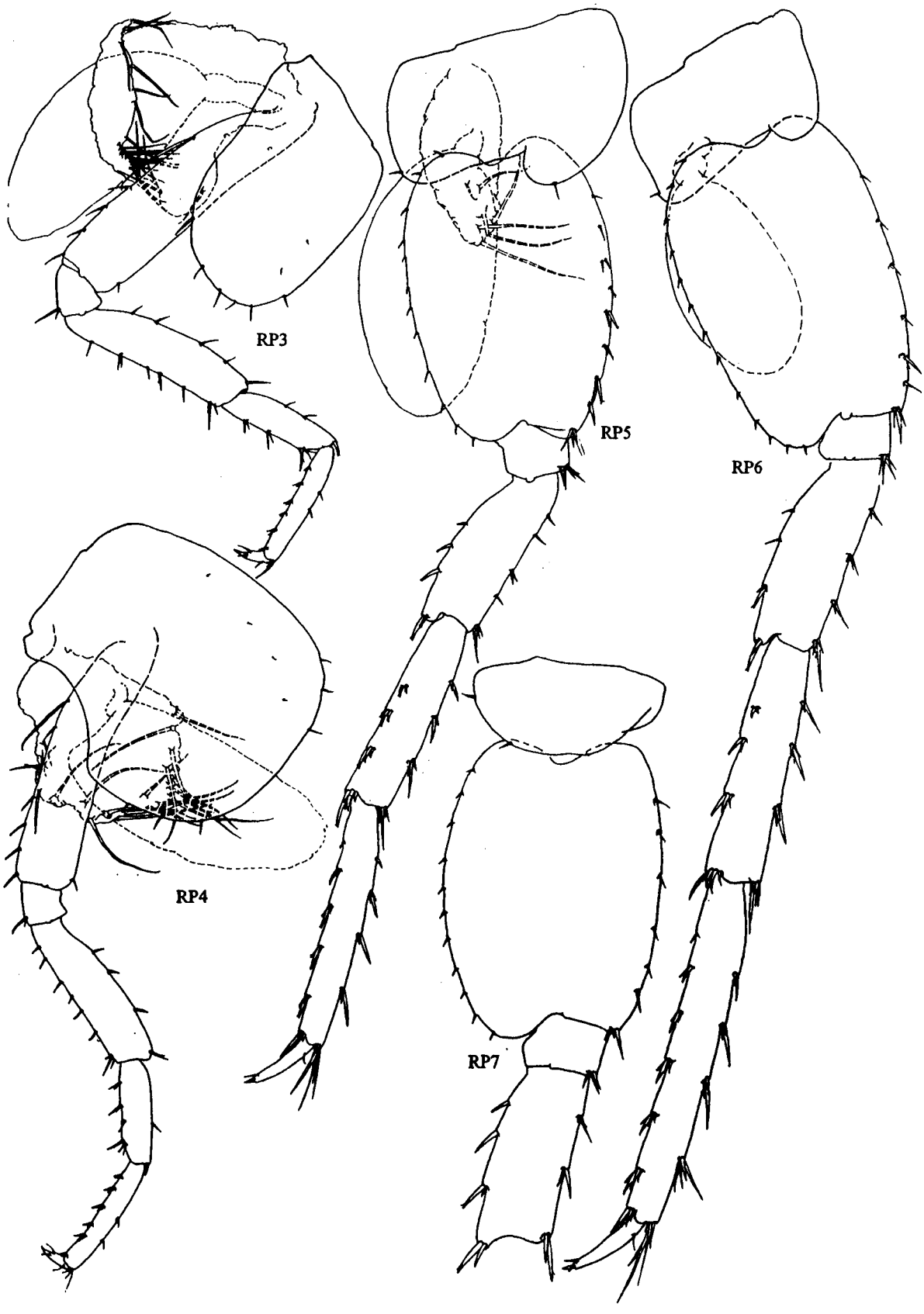

Fig. 3.38. *Chydaekata transversa* n. sp. allotype, female 'b' 7.5 mm. pereopods 3-7.

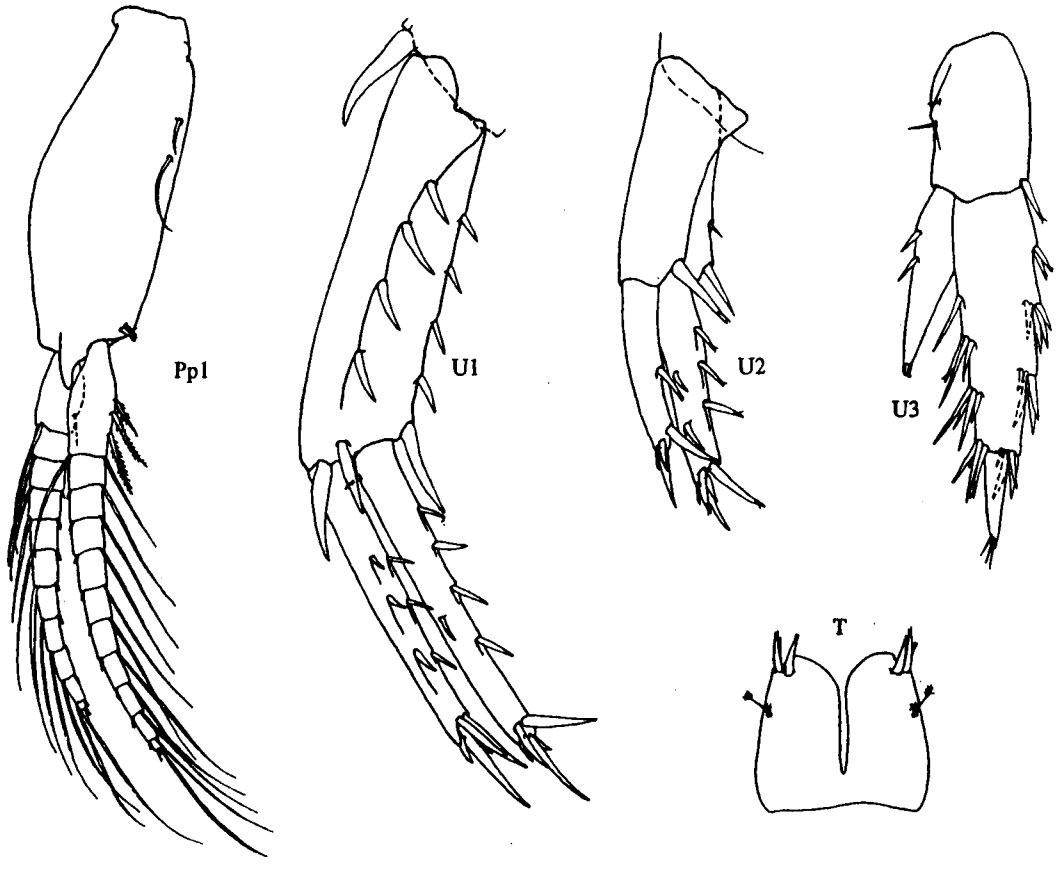

Fig. 3.39. *Chydaekata transversa* n. sp. holotype, male 'a' 7 mm. pleopod 1, uropods 1-3, telson.

facial, and 3 ventrofacial long strong setae basal to the dactyl, the apex moderately produced, setulate, with 2 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 5 anteroventral and 1 ventral setae; merus without posterior hump; carpus of moderate length, 1.6 x width, subtriangular, posterior margin strongly setose, with setae ranked in 5 transverse bands; propodus subrectangular, small, length 1.7 x width, posteroventral corner rounded, with 2 lateral and 1 medial robust setae, and 4 additional lateral elongate setae, palmar angle weakly oblique, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 3 anteroventral setae, and 1 ventral seta; carpus length 2.6 x width, trapezoidal, with posterior setae ranked in 7 transverse bands; propodus subrectangular, small, length 2 x width, with 2 lateral robust setae, 1 medial robust seta, and 2 additional lateral elongate setae, palmar angle transverse, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Pereopods*: third pereopod longer than the second gnathopod, coxa with 2 anterior setae, no long ventral setae, 2 short ventral setae, 1 seta at the posteroventral corner, carpus weakly setose posteriorly; pereopod 4 subequal in length with pereopod 3, coxa anteroventral margin with 1 seta, posteroventral margin with 3 setae, ventral margin with 2 setae, posterior margin moderately emarginate; carpus weakly setose posteriorly; coxa 5 bearing 1 seta on anterior lobe and 1 seta on the posterior lobe; basis of pereopod 5 with short slender posterior setae, bearing short robust and short slender anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing no setae on anterior lobe, basis moderately expanded, bearing short robust anterior setae, moderately lobate posteroventrally; bases of pereopods equally expanded. *Epimera*: first epimeron with 1 slender seta on the posterior margin; posterior margin straight, posteroventral corner rounded; second epimeron with 2 robust setae on the anteroventral margin, posterior margin straight, posteroventral corner rounded; third epimeron with 3 robust setae on the anteroventral margin, without slender setae on ventral margin, posterior margin straight, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 3 feeble setae, of pleonite 2 with 2 feeble setae, of pleonite 3 with 2 feeble setae, and no distolateral robust setae. *Pleopods*: first pleopod and second pleopods with 1 accessory retinacula, and third pleopod with no accessory retinacula. *Urosomites*: first urosomite bearing no distolateral slender setae and 1 distolateral robust seta;

second urosomite with no distolateral slender setae, and 3 distolateral robust setae. *First uropod*: peduncle length 1.3 x the length of the inner ramus, with a strong row of 4 dorsolateral robust setae, and 4 dorsomedial robust setae; outer ramus with 3 dorsolateral and 3 dorsomedial robust setae; inner ramus with 2 dorsolateral, 4 dorsomedial and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about 1.2 x length of inner ramus, with 1 apicolateral, 1 dorsomedial, and 1 apicomedial robust setae; inner ramus with 1 dorsolateral, 2 dorsomedial, and 5 apical robust setae; outer ramus with 2 dorsolateral, 3 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.8 x length of uropod 1; peduncle length 0.3 x outer ramus, shorter than, 0.9 x, urosomite three, with 1 apicolateral robust seta, and no apicolateral slender setae, no dorsomedial robust setae, and 2 dorsomedial slender setae, with no apicomedial robust setae, and no apicomedial slender setae, with 1 mediodistal robust seta; inner ramus length 0.4 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands or arranged medially singly with 3 lateral transverse bands of robust setae, 1 medial transverse band of robust setae, no medial transverse bands of mixed robust and small setae, 1 medial robust seta, 4 apicolateral robust setae, no apicolateral small setae, 4 apicomedial robust setae, no apicomedial small setae, and no apicomedial long slender setae; distal article short, with no apical robust setae and 3 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender seta. *Telson*: shorter than, 0.9 x, urosomite 3; cleft 79 %; shorter than broad, length 0.9 x breadth; apices rounded and laterally notched, 3 subapical robust setae, and no subapical slender setae, with 1 apical penicillate seta, and paired lateral penicillate setae at M0.6 from the telson base.

Description of the allotype (female 7.5mm.)

With the characteristics of the Holotype except. *Body*: length 7.5mm. *First gnathopod*: less robust than male; coxa bearing 1 extra marginal seta; propodus narrower than in male, bearing 3 mediofacial setal bands. *Second gnathopod*: coxa bearing an additional ventral and anterior setae, with a large, irregular, marginally setose oostegite, length about 0.9x coxal plate; carpus proportionally longer than the male, and bearing 8 posterior transverse setal bands; propodus with 5 posterior setal bands, but 4 medio-facial bands as in the male. *Pereopods*. Pereopod three: coxa bearing a large, ovate marginally setose and apically involute oostegite, length

about equal to the length of the coxal plate; with an additional anterior marginal seta. Pereopod four: coxa bearing a large, irregular, marginally setose oostegite, length about 0.8x coxal plate. Pereopod five: coxa with an additional seta on the ventral margin of the anterior lobe; bearing a moderately long, irregularly ovate, apically setose oostegite, length about 0.7x length of the coxal plate, about 0.9x length of oostegite of coxa 3. Pereopod seven; coxa bearing an additional posterior ventral seta.

Relationships

C. transversa differs from others of the genus in: second antenna flagellum bearing calceoli on 1 article only; left mandible accessory blade with 1 plumose inter-raker seta; right mandible accessory blade with 1 plumose interraker seta; maxilliped inner plate bearing small setules on the lateral margin and latero-proximal face; first gnathopod coxal plate with 5 anteroventral setae; pereopod coxa 7 bearing no setae on the posterior lobe; first uropod outer ramus with 3 dorsolateral robust setae, inner ramus with 4 dorsomedial robust setae.

3.1.4.6 *Chydaekata diagonalis* sp. nov. Figs. 3.40 - 3.43

Etymology

From the Latin 'diagonalus' (oblique), referring to the oblique palmar angle of the propodus of the first gnathopod.

Type locality

Newman bore field, WB23/4, 23°19'S, 117°51'E.

Material examined

Holotype (Western Australian Museum, C24664) male 'a' 6mm, Allotype (Western Australian Museum, C24665) female 'b' 8mm, 50 others in the type series, mainly juveniles, same data as the holotype (Western Australian Museum, C24666). Collection number BES 4839, taken with trap, W. F. Humphreys and S. M. Eberhard, 24/07/97.

Diagnosis

Second antenna: peduncle article 5 bearing 2 calceoli, flagellum 15 articulate, with calceoli on articles 1-8. Mandible: palp article 2 with a medio-distal row of 7 robust rastellate setae; article 3 with 13 D and 4 E setae apically. Left first maxilla: palp article 2 with 7 apical setae. Right first maxilla: palp apex with 3 articulated, and 2

fused broad based tooth setae. Maxilliped outer plate with a row of 5 slender naked, medial submarginal to disto-facial setae; a medial row of 8 submarginal to subapical robust, naked, tooth setae; 2 apicolateral setae. First gnathopod propodus: dactyl reaching to palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 7 transverse bands. Telson: cleft 78%, bearing 2 subapical robust setae.

Description of the holotype (male 'a' 6mm)

Body: urosomite 1 bearing 2 dorsolateral robust setae, urosomite 2 bearing 3 dorsolateral robust setae. *First antenna*: length 0.7 x body, 1.9 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 39 articles; accessory flagellum of 5 articles, reaching to article 7 of primary flagellum. *Second antenna*: length 0.4 x body; peduncle length subequal to flagellum, article 5 bearing 2 calceoli, article 4 subequal with article 5, articles 3-5 with sparse setation; flagellum 15 articulate, with sparse setation, bearing calceoli on articles 1-8. *Left mandible*: palp article 2 with a medio-distal row of 7 robust rastellate setae, article 3 with 13 D and 4 E setae, facially strongly setulose (pubescent); incisor with 5 teeth, lacinia mobilis with 4 teeth, and 4 plumose interraker setae; molar bearing pappose seta, with 2 penicillate hooked brushy basal setae. *Right mandible*: palp article 2 with a medio-distal row of 7 robust rastellate setae, article 3 with 11 D and 4 E setae; incisor with 5 teeth, and 2 plumose interraker setae; molar without penicillate hooked brushy basal setae, and few penicillate setules. *Left first maxilla*: palp article 2 with 4 apical and 1 subapical facial strong slender setae, with 1 apicomedial and 1 submarginal apicomedial setae; outer plate with 10 robust setae - 10 denticulate, none naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with 3 articulated and 2 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 4x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 2.5 x width, extending to M0.6 of the outer plate, bearing small setules on the lateral margin and medioproximal face, no facial pappose setae, no medial pappose setae, with a row of 5 submarginal to subapical pappose setae, extending to a row of 4 similar subapical, and 1 apical setae, with 1 apicomedial and 3 apical naked tooth setae; outer plate long, length 2 x width, distally setulose (pubescent), with a row of 5, slender naked, medial submarginal to distal facial

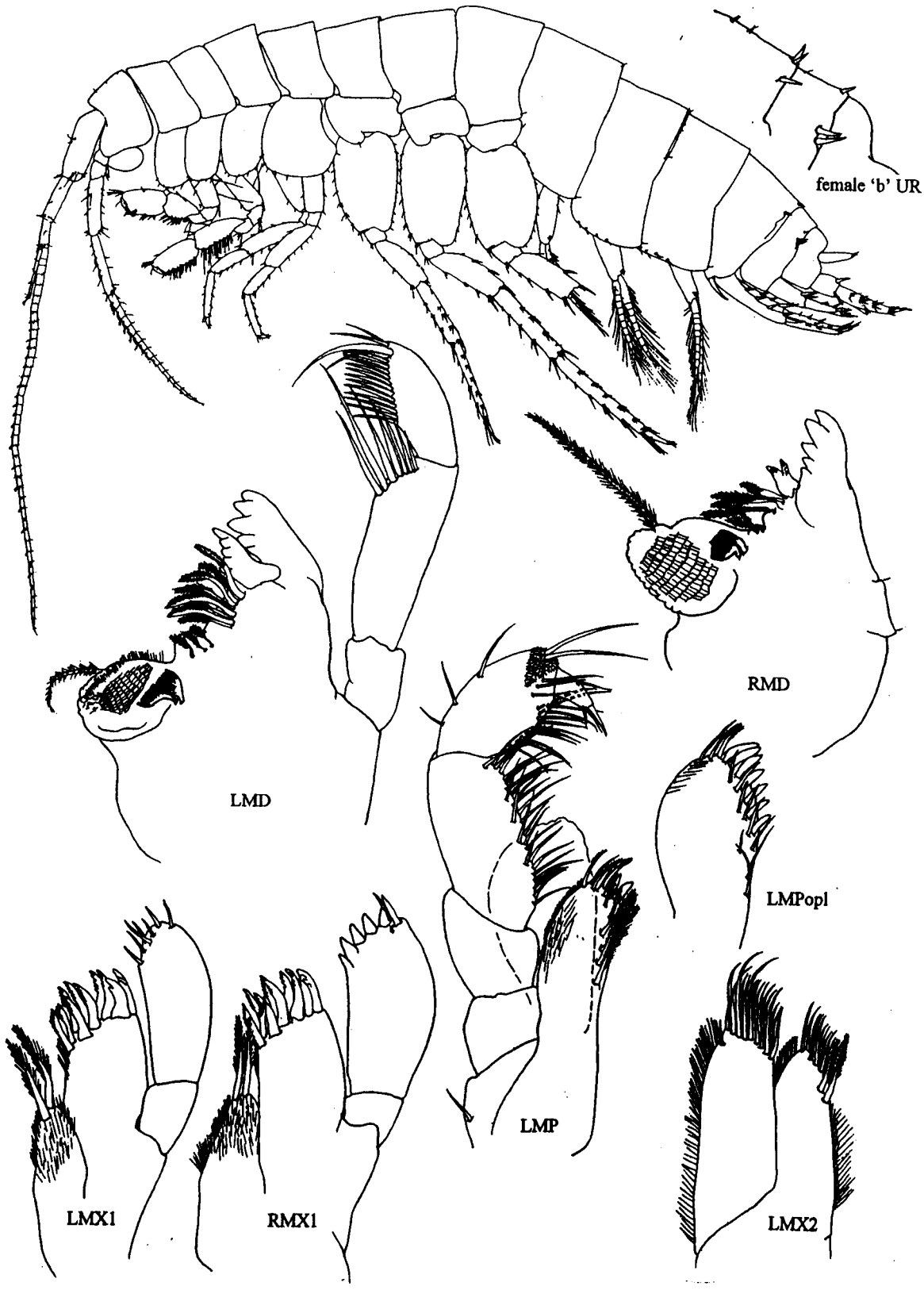

Fig. 3.40. *Chydaekata diagonalis* n. sp. holotype, male 'a' 6 mm., whole animal and mouthparts. Allotype female 'b' 8 mm. dorsal urosome.

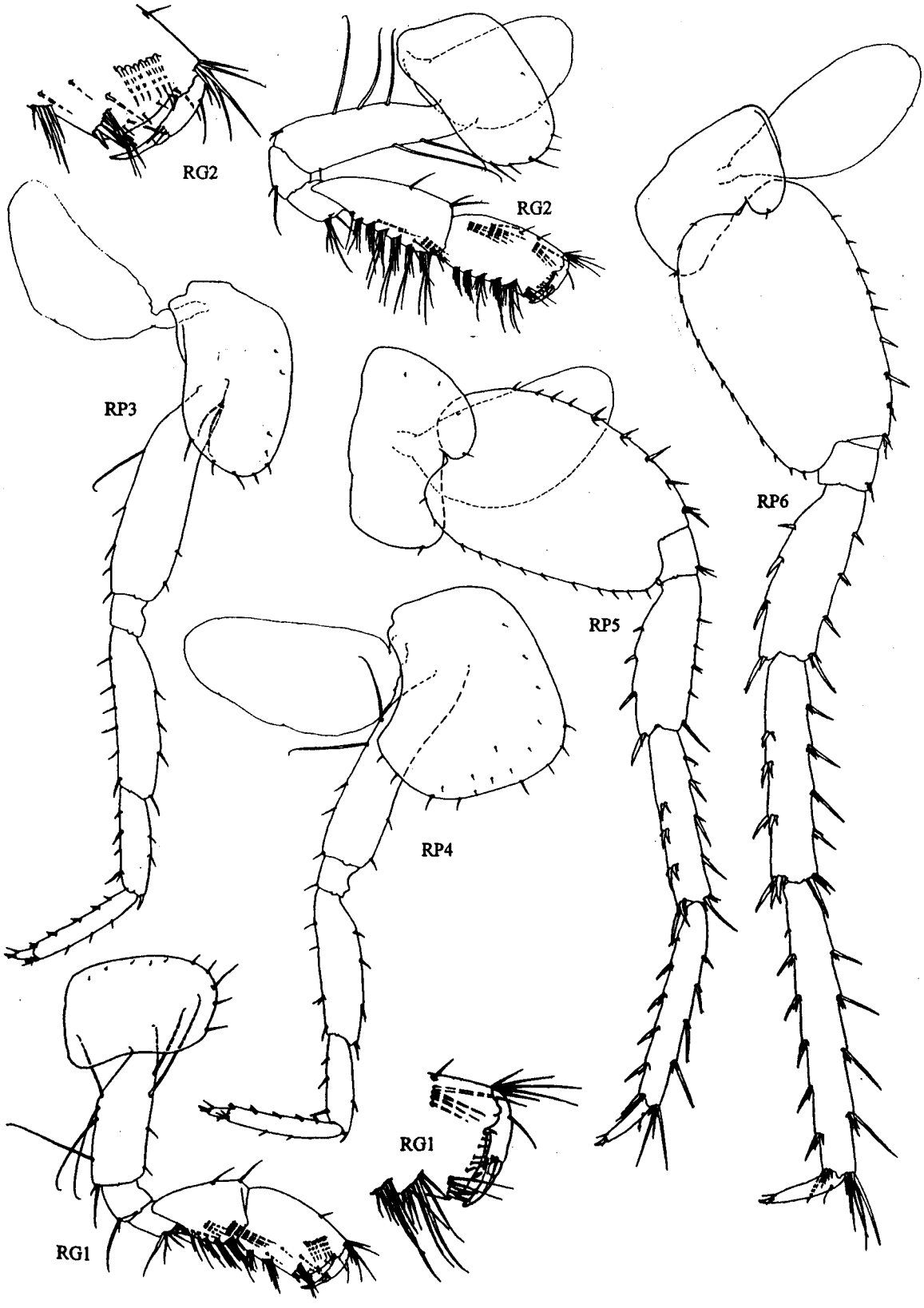

Fig. 3.41. *Chydaekata diagonalis* n. sp. holotype, male 'a' 6 mm., gnathopods 1-2 and pereopods 3-6.

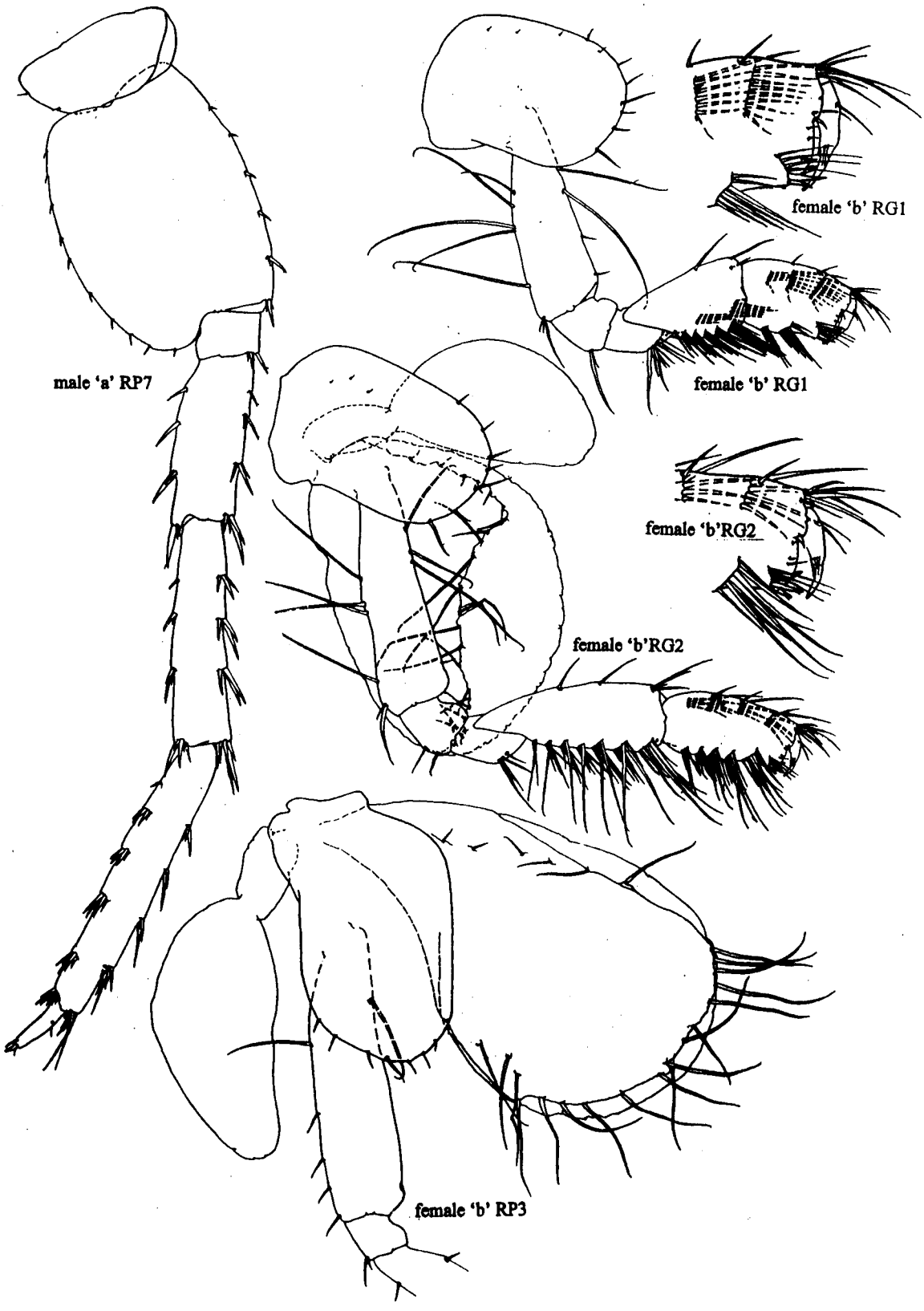

Fig. 3.42. *Chydaekata diagonalis* n. sp. holotype, male 'a' 6 mm., pereopod 7. Allotype female 'b' 8 mm, gnathopods 1-2 and coxa of pereopod 3.

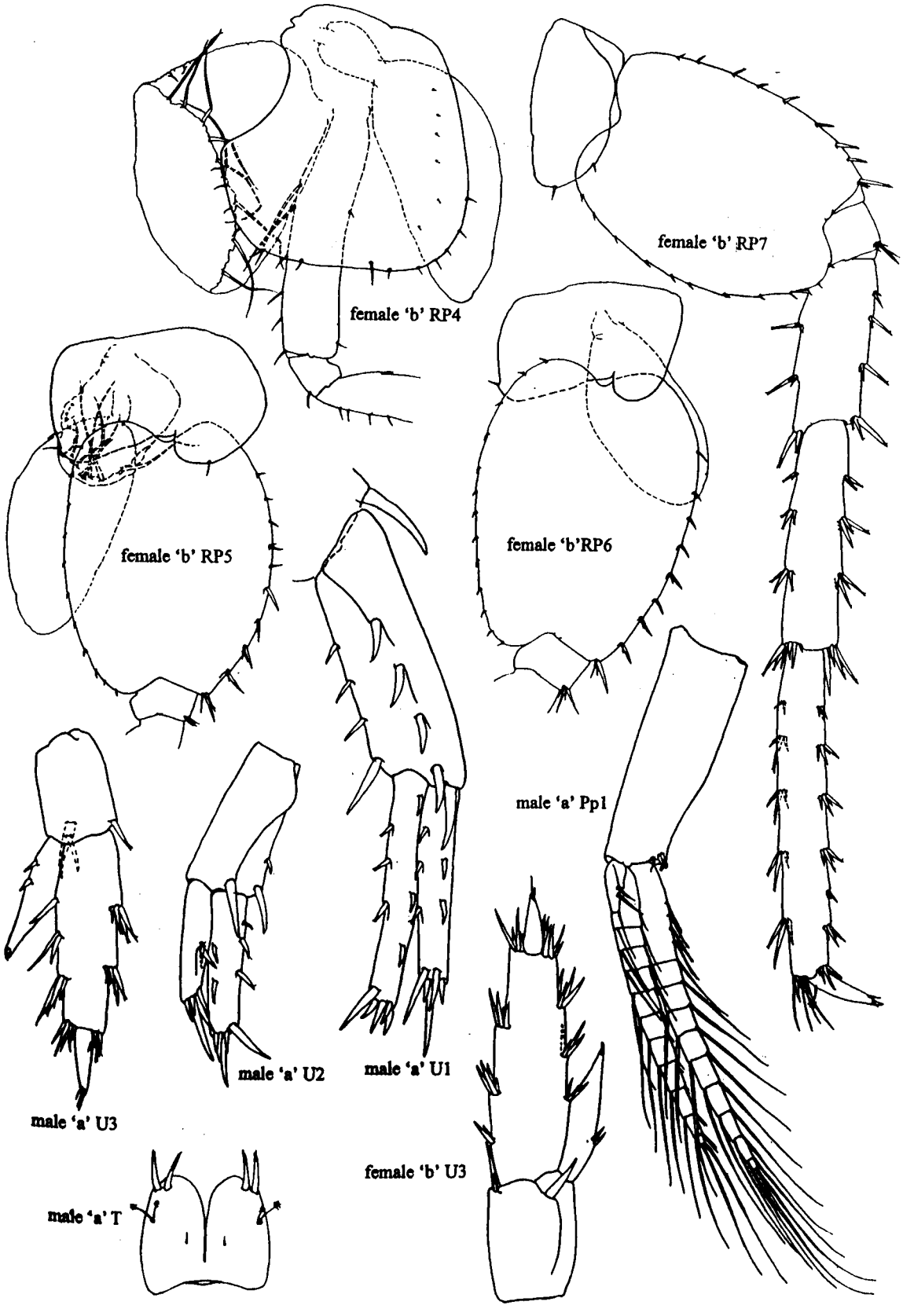

Fig. 3.43. *Chydaekata diagonalis* n. sp. holotype, male 'a' 6 mm., pleopod 1, uropods 1-3, telson. Allotype female 'b' 8 mm., coxae 4-6, pereopod 7.

setae, a medial row of 8 submarginal to subapical robust, naked, tooth setae, and 2 apicolateral setae - 1 naked, and 1 pappose; palp, second article strongly setose medially, third article sparsely setose laterally, moderately setose medially, with 3 facial, and 2 ventrofacial long strong setae basal to the dactyl, the apex moderately produced, setulate, with 2 long slender naked setae, and 1 dorsal accessory setae. *First gnathopod*: coxal plate with 3 anteroventral and 1 ventral setae; merus bearing posterior hump; carpus of moderate length, 1.6 x width, subtriangular, posterior margin with setae ranked in 5 transverse bands; propodus subrectangular, moderate size, length equal to width, posteroventral corner rounded, with 2 lateral and 1 medial robust setae, and 4 additional lateral elongate setae, palmar angle slightly oblique, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: subequal in size with first; coxal plate with 3 anteroventral and 1 ventral setae; carpus length 2.7 x width, trapezoidal, with posterior setae ranked in 7 transverse bands; propodus subrectangular, large, length 2.3 x width, with 2 lateral and 1 medial robust setae, and 3 additional lateral elongate setae, palmar angle weakly oblique, smooth, dactyl reaching beyond palmar corner, with a single recumbent inner tooth spine. *Pereopods*: pereopod 3 longer than the second gnathopod; coxa with 3 anterior setae, no long ventral setae, 1 short ventral seta, 1 seta at the posteroventral corner; carpus weakly setose posteriorly; pereopod 4: shorter than P3; coxa anteroventral margin with 3 setae, posteroventral margin with 4 setae, ventral margin with 2 setae, posterior margin moderately emarginate; carpus weakly setose posteriorly; coxa 5 bearing 2 setae on anterior lobe, and 1 seta on the posterior lobe; basis of pereopod 5 with short slender posterior setae, bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing 1 seta on anterior lobe; basis moderately expanded, bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 2 setae on the posterior lobe; basis bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally; bases of pereopods expanded unequally, basis of pereopod 7 most expanded, basis of pereopod 6 least expanded. *Epimera*: first epimeron with 1 slender seta on the posterior margin; posterior margin sinuous, posteroventral corner rounded; second epimeron with 4 robust setae on the anteroventral margin, posterior margin straight, posteroventral corner rounded; third epimeron with 4 robust setae on the

anteroventral margin, without slender setae on ventral margin, posterior margin straight, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 2 feeble setae of pleonite 2 with 5 feeble setae, of pleonite 3 with 4 feeble setae, and no distolateral robust setae. *Pleopods*: first pleopod, second pleopod and third pleopods with 1 accessory retinacula. *Urosomites*: first urosomite bearing 1 distolateral slender seta and 2 distolateral robust setae; second urosomite with no distolateral slender setae, and 3 distolateral robust setae. *First uropod*: peduncle length 1.3 x the length of the inner ramus, with a strong row of 3 dorsolateral robust setae, and 3 dorsomedial robust setae; outer ramus with 2 dorsolateral robust setae, and 2 dorsomedial robust setae; inner ramus with 2 dorsolateral robust setae, 3 dorsomedial robust setae, and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about equal to length of inner ramus, with 1 apicolateral, 1 dorsomedial, and 1 apicomedial robust setae; inner ramus with 1 dorsolateral, 1 dorsomedial, and 5 apical robust setae; outer ramus with 2 dorsolateral, 3 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.7 x length of uropod 1; peduncle length 0.4 x outer ramus, shorter than, 0.8 x, urosomite three, with 1 apicolateral robust seta and no apicolateral slender setae, with no dorsomedial robust setae, no dorsomedial slender setae, no apicomedial robust setae, no apicomedial slender setae, and with 1 mediodistal robust seta; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands or arranged medially singly with 2 lateral and 2 medial transverse bands of robust setae, 1 medial robust seta, 4 apicolateral robust setae, no apicolateral small setae, 5 apicomedial robust setae, no apicomedial small setae, and no apicomedial long slender setae; distal article short, with no apical robust setae, and 3 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender seta. *Telson*: shorter than, 0.8 x, urosomite 3, cleft 78 %, shorter than broad, length 0.9 x breadth; apices rounded and laterally notched, 2 subapical robust setae and no subapical slender setae; apical penicillate setae absent; paired lateral penicillate setae at M0. 6 from the telson base.

Description of the allotype (female 'b' 8mm)

With the characteristics of the Holotype except. *Body*: length 8mm. *First antenna*: without aesthetascs or calceoli. *Second antenna*: without calceoli. *First gnathopod*: coxa bearing additional ventral and anterior setae; carpus with 6 (ie an additional)

posterior transverse setal bands; propodus bearing 3 (ie. one additional) medio-facial setal bands, and 2 (versus 3) lateral robust setae at the palmar corner. *Second gnathopod*: coxa bearing 2 additional anterior setae, and a very large, ovate, marginally setate and involute oostegite, length about 1.4x length of coxal plate; carpus bearing 7 (versus 6) posterior transverse setal bands and a medio-facial band; propodus bearing 4 (versus 3) medio-facial setal bands. *Pereopods*. Pereopod three: coxa bearing additional ventral and anterior setae, and a very large, teardrop shaped, marginally setose and involute oostegite, length about 1.4x length of the coxal plate. Pereopod four: coxa bearing 5 additional marginal setae and large, ovate, marginally setose oostegite, length about equal to the coxal plate. Pereopod five: coxa bearing an additional posterior seta, with a moderately large, irregularly ovate, marginally setose, apically involute oostegite, length about 0.7x coxal plate, about 0.5x length of the oostegite of coxa 3. Pereopod six: coxa without a ventro-marginal seta on the anterior lobe. *Urosomites*. Urosomite four: bearing 2 robust dorsal setae (ie. 1 additional). Urosomite five: bearing 1 dorsal and 2 dorsolateral setae (versus no and 3). *Uropods*. Third uropod: outer ramus; proximal article bearing 3 (versus 2) translateral setal rows; distal article bearing 2 (versus 3) slender apical setae.

Relationships

C. diagonalis differs from others of the genus in: left mandible palp article 2 with a medio-distal row of 7 robust rastellate setae; right first maxilla right palp apex with 3 articulated tooth setae and 2 fused broad based tooth setae; first gnathopod propodus length less than 1.0 x width pereopod 4 shorter than P3 pereopod 5 coxa bearing 2 setae on anterior lobe; epimera 1 posterior margin sinuous; epimera 2 with 6 robust setae on the anteroventral margin; third uropod outer ramus proximal article with 5 apicomedial robust setae.

3.1.4.7 *Chydaekata carscutica* sp. nov. Figs. 3.44 - 3.47.

Etymology: from the Latin 'caritus' (lacking), and 'scutica' (whip), referring to the absence of a pappose seta on the molar of the left mandible.

Type locality

Newman bore field, WB23/4, 23°19'S, 117°51'E.

Material examined

Holotype (Western Australian Museum, C24667) male 'a' 5mm, Allotype (Western Australian Museum, C24668) female 'b' 7mm, male 'c' 6mm, about 60 others in the type series, same data as the holotype (Western Australian Museum, C24669). Collection number BES 4840, taken with trap, W. F. Humphreys and S. M. Eberhard, 24/07/97.

Diagnosis

Second antenna: peduncle article 5 bearing 3 calceoli, flagellum 14 articulate, with calceoli on articles 1-8. Mandible: palp article 2 with a medio-distal row of 5 robust rastellate setae; article 3 with 13 D and 4 E setae apically. Left first maxilla: palp article 2 with 7 apical setae. Right first maxilla: palp apex with no articulated, and 4 fused broad based tooth setae. Maxilliped outer plate with a row of 8 slender naked, medial submarginal to disto-facial setae; a medial row of 8 submarginal to subapical robust, naked, tooth setae; 3 apicolateral setae. First gnathopod propodus: dactyl reaching to palmar corner, with two recumbent inner tooth spines. Second gnathopod carpus: with posterior setae ranked in 6 transverse bands. Telson: cleft 66%, bearing 2 subapical robust setae.

Description of the holotype (male 'a' 5mm)

Body: urosomite 1 bearing 1 dorsolateral robust seta, urosomite 2 bearing 2 dorsolateral robust setae. *First antenna*: length 0.6 x body, 1.6 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 30 articles; accessory flagellum of 5 articles, reaching to article 7 of primary flagellum. *Second antenna*: length 0.4 x body; peduncle length greater than flagellum, article 5 bearing 3 calceoli, article 4 subequal with article 5, articles 3-5 with sparse setation; flagellum 14 articulate, with sparse setation, bearing calceoli on articles 1-8. *Left mandible*: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 13 D and 4 E setae, facially setulose (pubescent); incisor with 5 teeth, lacinia mobilis with 4 teeth, and 4 plumose interraker setae; molar without pappose seta, with 3 penicillate hooked brushy basal setae, and no penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 12 D and 4 E setae; incisor with 5 teeth, and 2 plumose interraker setae; molar, with 2 penicillate hooked brushy basal setae, and no penicillate setules. *Left first maxilla*: palp article 2 with 4 apical, and 1 subapical facial strong slender setae, with 1 apicomedial, 1 submarginal apicomedial setae; outer plate with 9 robust setae - 9 denticulate, none naked; inner plate subtriangular, facially and medially setulose

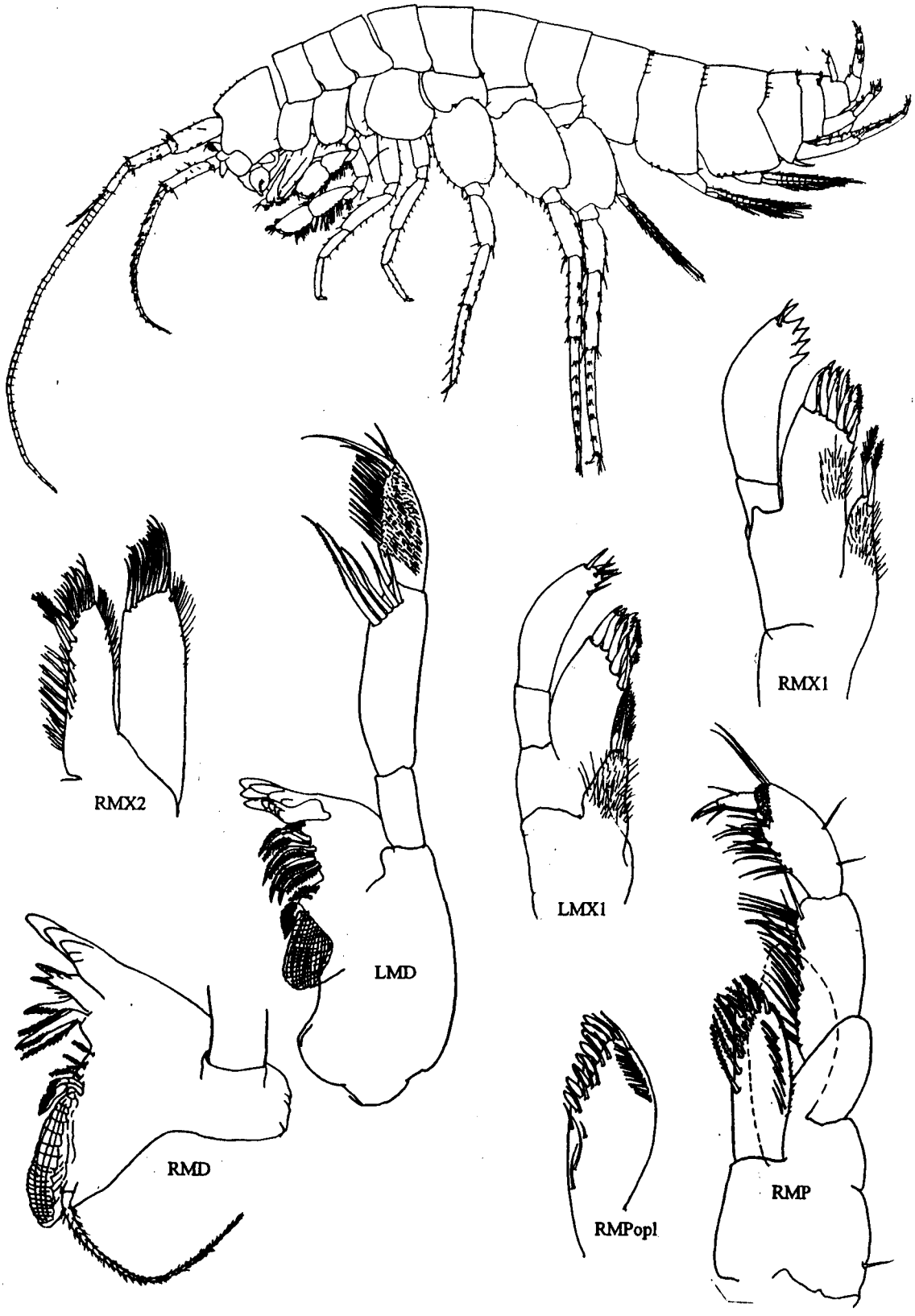

Fig. 3.44. *Chydaekata carscutica* n. sp. holotype, male 'a' 5 mm., mouth parts. Male 'c' 6 mm, whole animal.

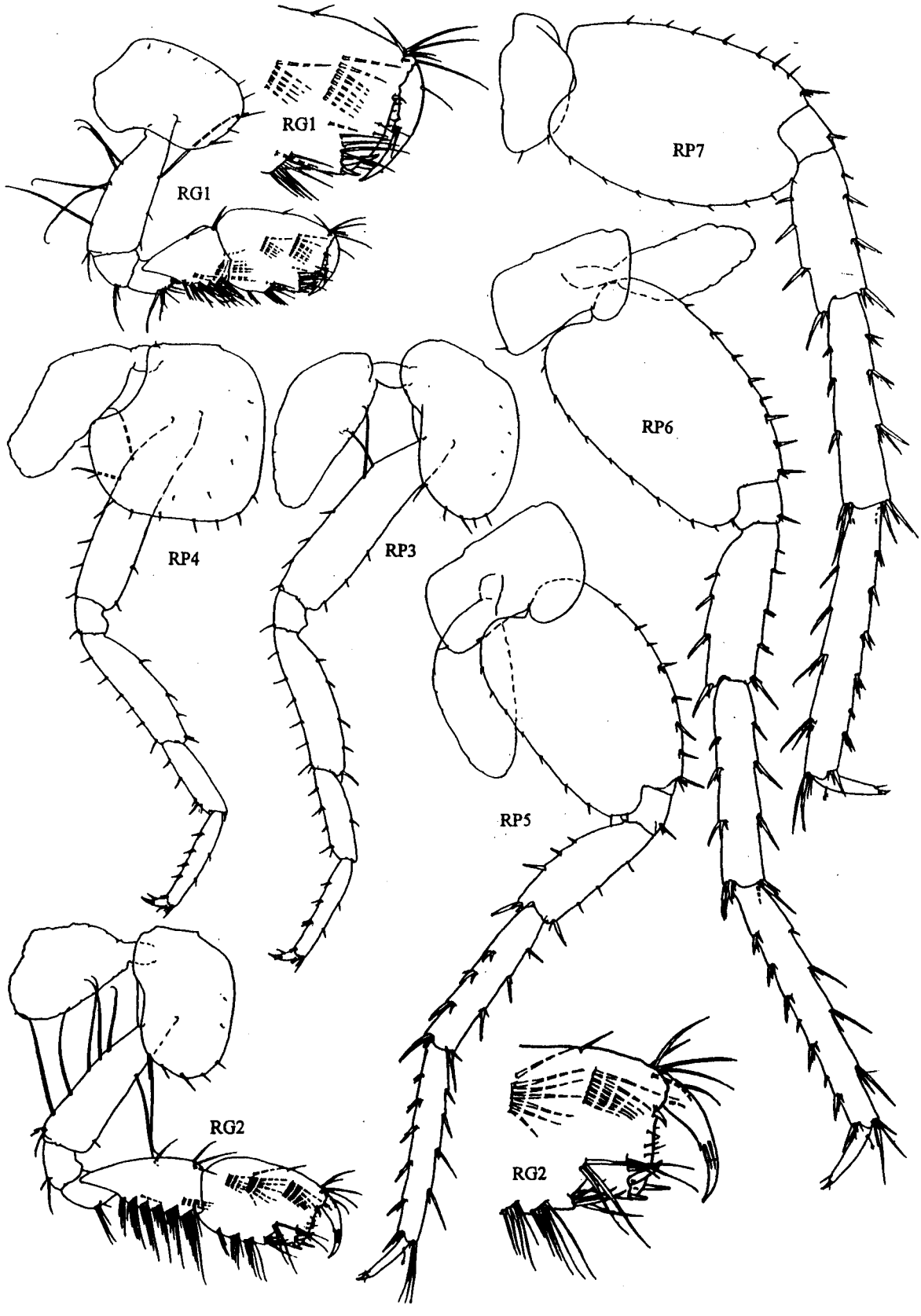

Fig. 3.45. *Chydaekata carscutica* n. sp. holotype, male 'a' 5 mm., Gnathopods 1-2 and pereopods 3-7.

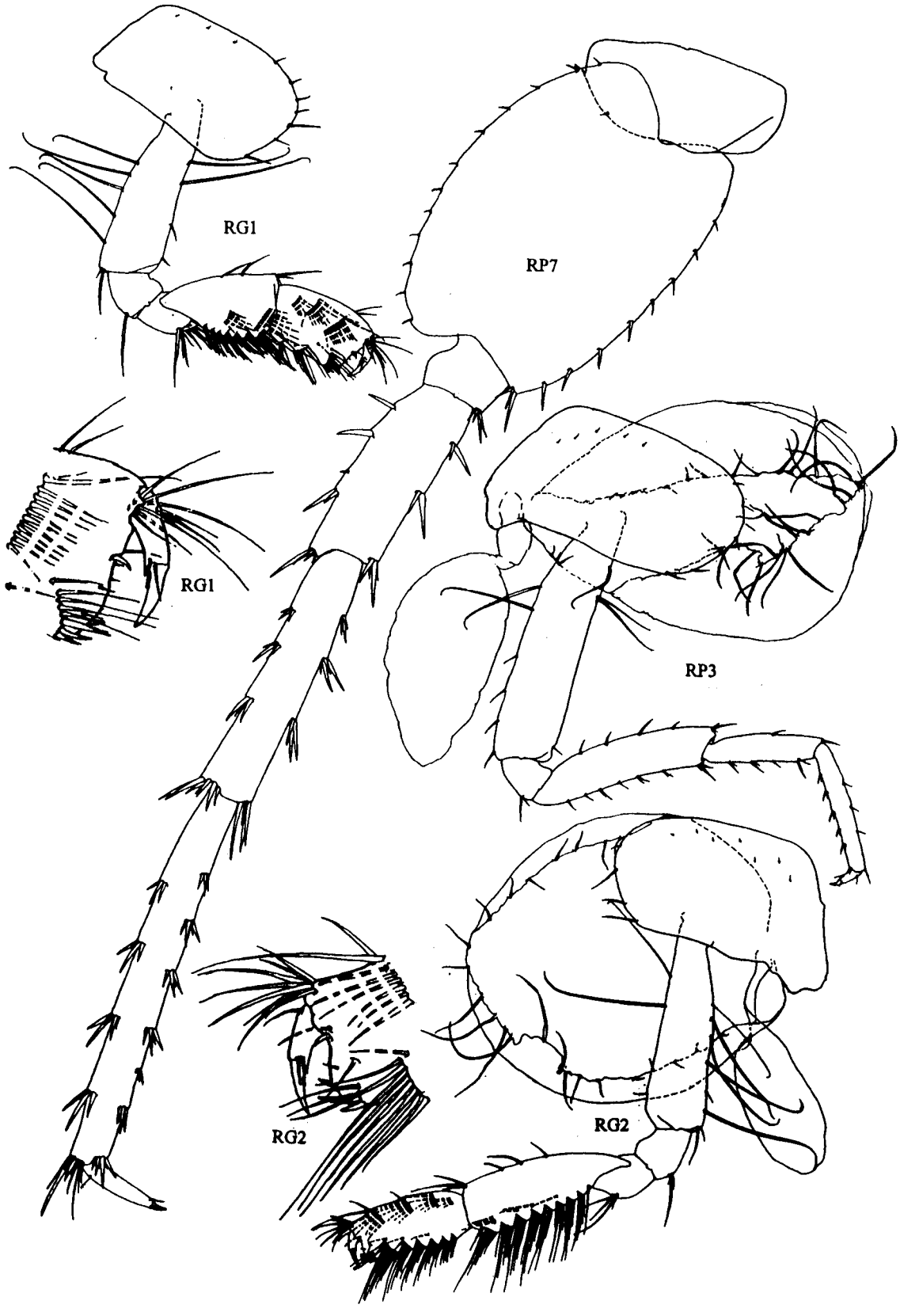

Fig. 3.46. *Chydaekata carscutica* n. sp. allotype, female 'b' 7 mm. Gnathopods 1-2 and pereopods 3 and 7.

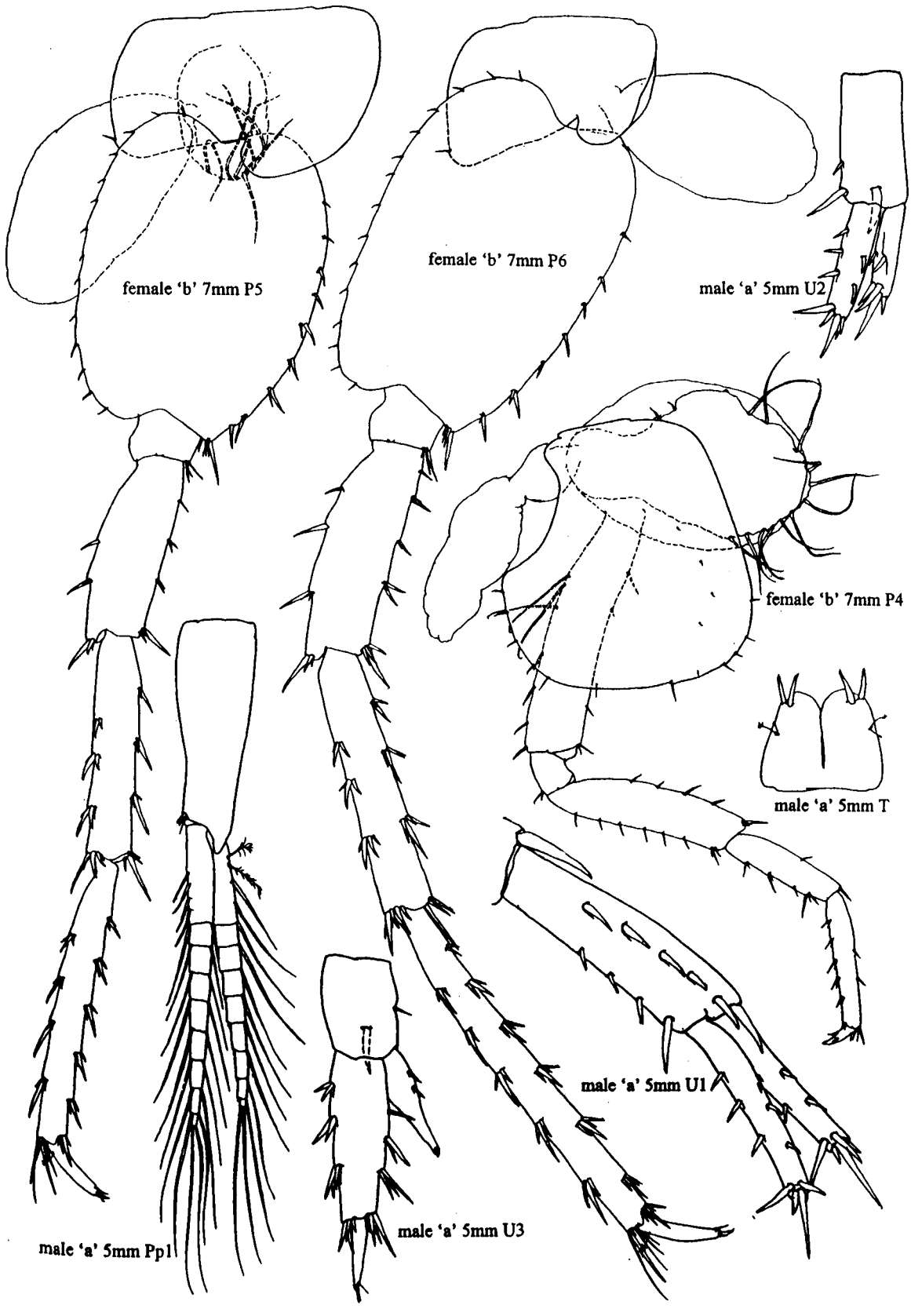

Fig. 3.47. *Chydaekata carscutica* n. sp. holotype, male 'a' 5 mm., pleopod 1, uropods 1-3, telson. Allotype female 'b' 7 mm. pereopods 4-6.

(pubescent). *Right first maxilla*: palp apex with no articulated and 4 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 3 x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 2.7 x width, extending to M0.7 of the outer plate, bearing small setules on the lateral margin and medioproximal face, no facial or medial pappose setae, with a row of 4 submarginal to subapical pappose setae, extending to a row of 4 similar subapical, and 1 apical setae, with 1 apicomedial, and 3 apical naked tooth setae; outer plate long, length 2.1 x width, distally naked, with a row of 8, slender naked, medial submarginal to distal facial setae, a medial row of 8 submarginal to subapical robust, naked, tooth setae, and 3 apicolateral setae - 1 naked, and 2 pappose; palp second article weakly setose medially, third article sparsely setose laterally, weakly setose medially, with 3 facial, and 3 ventrofacial long strong setae basal to the dactyl, the apex moderately produced, setulate, with 3 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 3 anteroventral setae and 1 ventral seta; merus bearing posterior hump; carpus of moderate length, 1.4 x width, subtriangular, posterior margin with setae ranked in 5 transverse bands; propodus ovate, small, length 1.7 x width, posteroventral corner rounded, with 2 medial and 1 lateral robust setae, and 4 additional lateral elongate setae, palmar angle weakly oblique, smooth, dactyl reaching to palmar corner, with two recumbent inner tooth spines. *Second gnathopod*: slightly larger than first; coxal plate with 2 anteroventral and 2 ventral setae; carpus length 2.2 x width, subtriangular, with posterior setae ranked in 6 transverse bands; propodus ovate, moderate size, length 1.6 x width, with 1 medial robust seta, 2 lateral robust setae, and 5 additional lateral elongate setae, palmar angle transverse, smooth, dactyl reaching to palmar corner, with two recumbent inner tooth spines. *Pereopods*: first pereopod longer than the second gnathopod; coxa with 3 anterior setae, no long ventral setae, 1 short ventral seta, 1 seta at the posteroventral corner; carpus weakly setose posteriorly; pereopod 4 subequal in length with pereopod 3, coxa anteroventral margin with 3 setae, posteroventral margin with 4 setae, ventral margin with 2 setae, posterior margin moderately emarginate, carpus weakly setose posteriorly; coxa 5 bearing 1 seta on anterior and posterior lobes; basis of pereopod 5 with short slender posterior setae, bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally; pereopod 6 coxa

bearing no setae on anterior lobe, basis moderately expanded, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 2 setae on the posterior lobe; basis bearing short and long robust anterior setae, moderately lobate posteroventrally; bases of periopods expanded unequally, basis of periopod 7 most expanded, basis of periopod 6 least expanded. *Epimera*: epimeron 1 with 1 slender seta on the posterior margin; posterior margin convex, posteroventral corner rounded; second epimeron with 2 robust setae on the anteroventral margin, posterior margin straight, posteroventral corner rounded; epimeron 3 with 3 robust setae on the anteroventral margin, without slender setae on ventral margin, posterior margin concave, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 3 feeble setae, of pleonite 2 with 5 feeble setae, of pleonite 3 with 4 feeble setae, and no distolateral robust setae. *Pleopods*: first and second pleopods with 1 accessory retinacula, and third pleopod with no accessory retinacula. *Urosomites*: first urosomite bearing 1 distolateral slender and 1 distolateral robust setae; second urosomite with 1 distolateral slender seta, and 2 distolateral robust setae. *First uropod*: peduncle length 1.3 x the length of the inner ramus with a strong row of 4 dorsolateral robust setae, and 3 dorsomedial robust setae; outer ramus with 2 dorsolateral robust setae, and 2 dorsomedial robust setae; inner ramus with 2 dorsolateral robust setae, 3 dorsomedial robust setae, and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about 1.2 x length of inner ramus with 1 apicolateral, 1 dorsomedial, and 1 apicomedial robust setae; inner ramus with 1 dorsolateral, 1 dorsomedial, and 5 apical robust setae; outer ramus with 2 dorsolateral, 3 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.7 x length of uropod 1; peduncle length 0.4 x outer ramus, shorter than, 0.9 x, urosomite three, with 1 apicolateral robust seta, and no apicolateral slender setae, 1 dorsomedial robust seta, and no dorsomedial slender setae, no apicomedial robust setae, and no apicomedial slender setae, and with 1 mediodistal robust seta; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands or arranged medially singly with 3 lateral transverse bands of robust setae, 2 medial transverse bands of robust setae, 1 medial robust seta, 4 apicolateral robust setae, no apicolateral small setae, 4 apicomedial robust setae, 1 apicomedial small seta and, no apicomedial long slender setae; distal article short,

with no apical robust setae, and 3 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender seta. *Telson*: longer than, 1.1 x, urosomite 3, cleft 66 %, as long as broad; apices rounded and laterally notched with 2 subapical robust setae and no subapical slender setae, with 1 apical penicillate seta and paired lateral penicillate setae at M0.7 from the telson base.

Description of the allotype (female 'b' 7mm)

With the characteristics of the holotype, except: *Body*: length 7mm. *First antenna*: without aesthetascs or calceoli. *Second antenna*: without calceoli. *First gnathopod*: coxa bearing 2 additional anterior setae; carpus elongate, much longer than the male, bearing 7 (versus 2) posterior transverse setal bands; propodus less robust than the male, narrower, with 3 (versus 2) medio-facial setal bands, 3 (versus 2) lateral robust palmar corner setae and 5 (versus 4) elongate lateral accessory setae. *Second gnathopod*: coxa bearing 4 (versus 5) marginal setae, with huge round/ovate marginally setose and involute oostegite, length about 1.5x coxal plate; carpus elongate, longer than the male, bearing 8 (versus 6) posterior transverse setal bands and additional medio-facial setae; propodus much narrower, longer and less robust than the male, tapering apically, bearing 6 (versus 3) posterior translateral bands of setae and 4 (versus 3) medio-facial bands, palms and dactyl similar to the male. *Pereopods* (Figs. 27 and 28). Pereopod three: coxa longer than the male, with 7 (versus 5) marginal setae, bearing a huge, ovate, marginally setose, apically and posteriorly involute oostegite, length about 1.4x coxal plate. Pereopod four: coxa bearing 11 marginal and submarginal setae (versus 9), and a large, ovate marginally setose and involute oostegite. Pereopod five: coxa bearing a moderate to small, marginally setose oostegite. Pereopods six and seven similar to the male.

Description of male 'c' 6mm)

With the characters of the holotype except. *Body*: length 6mm. *First antenna*: flagellum of 41 articles, accessory flagellum of 6 articles. *Second antenna*: flagellum of 14 articles, calceoli present on articles 1-7. *Pleon*. Dorsolateral margin of pleonite 1 with 5 feeble setae and no robust setae, of pleonite 2 with 4 feeble setae, of pleonite 3 with 7 feeble setae. *Urosome*: first urosomite with 2 dorso-distal slender setae, 1 robust and 1 slender distolateral setae; second urosomite bearing 1 dorsodistal and 2 distolateral robust setae; third urosomite without setae. *Uropods*. First uropod; peduncle with 3 dorsolateral, 2 apicolateral, 3 dorsomedial and 1 apicomedial robust setae.

Relationships

C. carscutica differs from others of the genus in: second antenna flagellum 14 articulate; maxillipedal palp, second article weakly setose medially; second gnathopod propodus ovate; third uropod peduncle with 1 dorsomedial robust seta, outer ramus proximal article with 1 apicomedial small seta.

3.1.4.8 *Chydaekata gyraspis* sp. nov. Figs. 3.48 - 3.51.

Etymology: from the Greek 'gyros' (circle), and 'aspis' (shield), referring to the rounded posteroventral corner of the second epimeron.

Type locality

Newman bore field, K27 monitoring bore, 23°20'S, 117°51'E.

Material examined

Holotype (Western Australian Museum, C24670) male 'a' 6mm, Allotype (Western Australian Museum, C24671) female 'b' 8mm, 11 others in the type series, same data as the holotype (Western Australian Museum, C24672). Collection number BES 4824, taken with haul net, W. F. Humphreys and S. M. Eberhard, 23/07/97.

Diagnosis

Second antenna: peduncle article 5 bearing 2 calceoli, flagellum 12 articulate, with calceoli on articles 1-8. Mandible: palp article 2 with a medio-distal row of 5 robust rastellate setae; article 3 with 12 D and 4 E setae apically. Left first maxilla: palp article 2 with 7 apical setae. Right first maxilla: palp apex with no articulated, and 4 fused broad based tooth setae. Maxilliped outer plate with a row of 8 slender naked, medial submarginal to disto-facial setae; a medial row of 9 submarginal to subapical robust, naked, tooth setae; 3 apicolateral setae. First gnathopod propodus: dactyl reaching to palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 6 transverse bands. Telson: cleft 75%, bearing 2 subapical robust setae.

Description of the holotype (male 'a' 6mm.)

Body: urosomite 1 bearing 1 dorsolateral robust seta; urosomite 2 bearing 2 dorsolateral robust setae. *First antenna*: length 0.6 x body, 1.4 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 31 articles; accessory flagellum of 5 articles, reaching to article 7 of primary flagellum. *Second antenna*: length 0.5 x body; peduncle length less than flagellum, article 5 bearing 2

calceoli, article 4 subequal with article 5, articles 3-5 with sparse setation; flagellum 12 articulate, with sparse setation, bearing calceoli on articles 1 to 8. *Left mandible*: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 12 D and 4 E setae, facially strongly setulose (pubescent); incisor with 6 teeth, lacinia mobilis with 5 teeth, and 3 plumose interraker setae; molar bearing pappose seta, with 2 penicillate hooked brushy basal setae, and no penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 12 D and 3 E setae; incisor with 6 teeth, and 2 plumose interraker setae; molar , with 4 penicillate hooked brushy basal setae, and no penicillate setules. *Left first maxilla*: palp article 2 with 3 apical, and 1 subapical facial strong slender setae, with 3 apicomedial, no submarginal apicomedial, and no ventrofacial apicomedial strong slender setae; outer plate with 10 robust setae, 10 denticulate, no naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with no articulated, and 4 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 4.2 x width, bearing distal long, curved rastellate setae or naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 2.4 x width, extending to M0.6 of the outer plate, bearing small setules on the lateral margin and medioproximal face, 1 facial pappose seta at M0. 9 of its length, 1 medial pappose seta, with a row of 3, submarginal pappose setae, extending to a row of 4 similar subapical, and 2 apical setae, and 3 apical naked tooth setae; outer plate broad, length 1.7 x width, distally setulose (pubescent), with a row of 8, slender naked, medial submarginal to distal facial setae, a medial row of 9 submarginal to subapical robust, naked, tooth setae, and 3 apicolateral setae - none naked, 3 pappose; palp, second article strongly setose medially; third article sparsely setose laterally, moderately setose medially, with 3 facial, and 2 ventrofacial long strong setae basal to. the dactyl, the apex moderately produced, setulate, with 2 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 3 anteroventral setae, and 1 ventral seta; merus bearing posterior hump; carpus of moderate length, 1.3 x width, subtriangular, posterior margin strongly setose, with setae ranked in 4 transverse bands; propodus subrectangular, moderate size, length 1.7 x width, posteroventral corner subquadrate, with 2 lateral robust setae, and 4 additional lateral elongate setae, palmar angle transverse, smooth, dactyl reaching to palmar corner, with a single

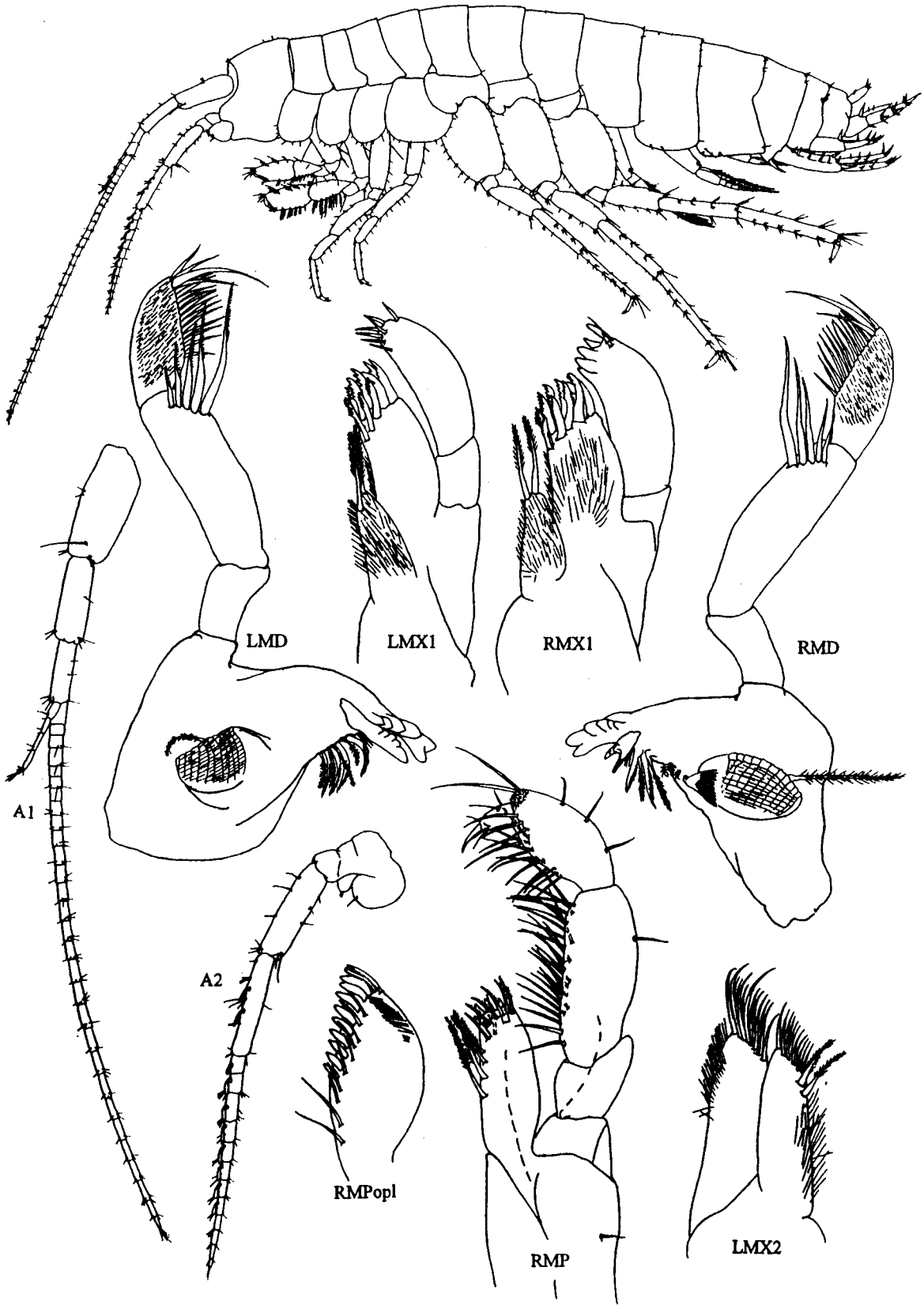

Fig. 3.48. *Chydaekata gyraspis* n. sp., holotype, male 'a' 6 mm. Whole animal, antenna 1 and mouthparts.

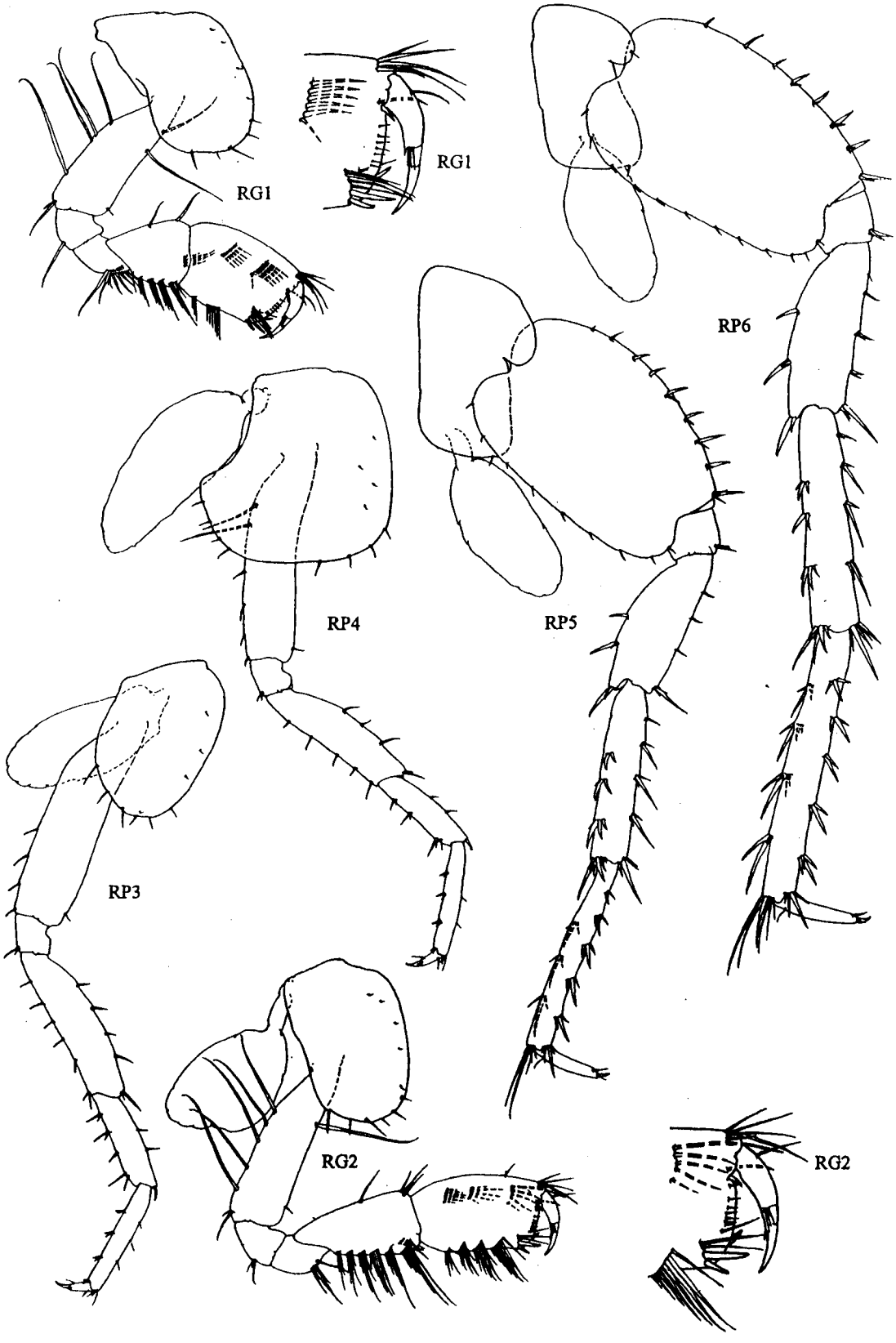

Fig. 3.49. *Chydaekata gyraspis* n. sp., holotype, male 'a' 6 mm., gnathopods and pereopods.

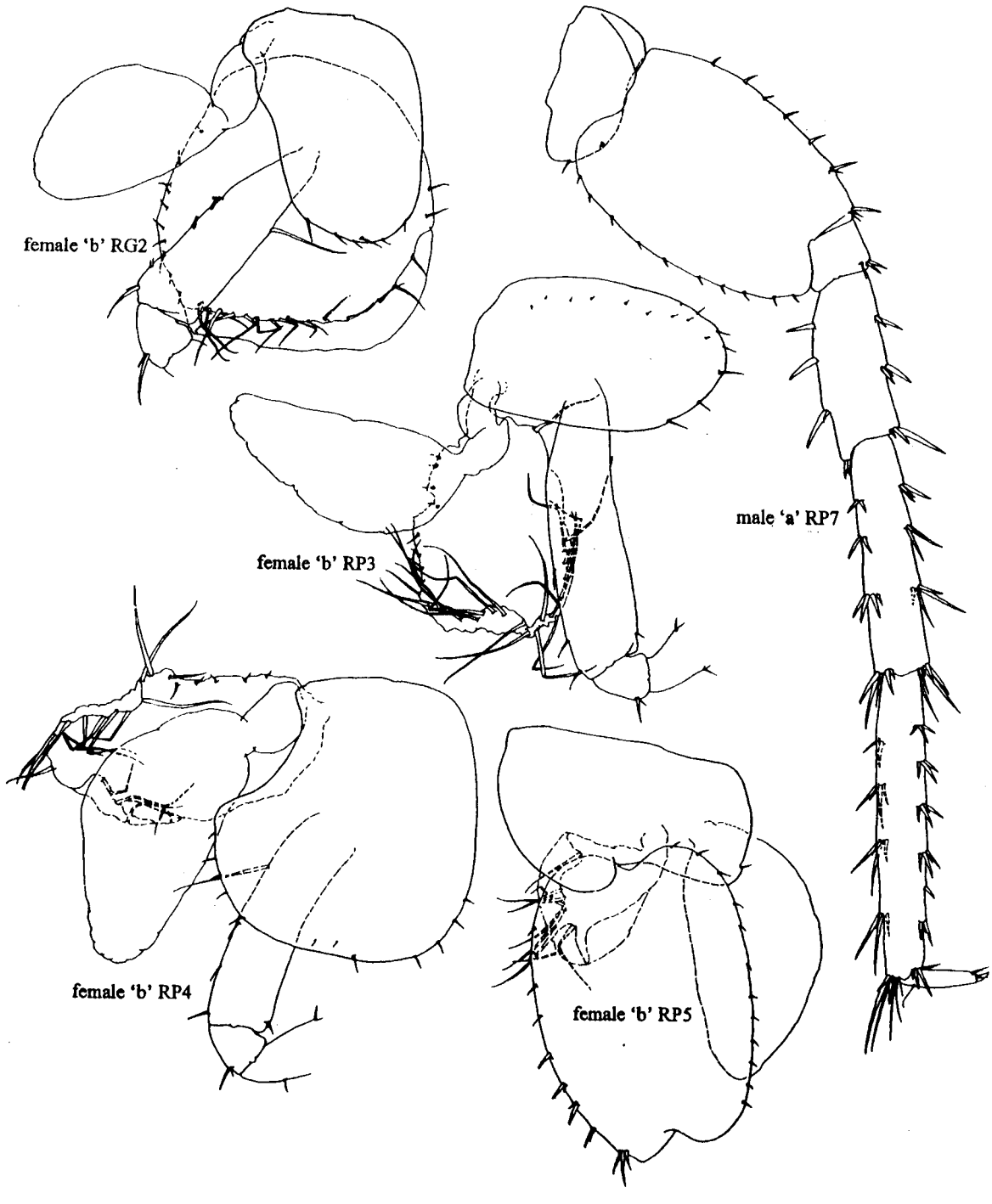

Fig. 3.50. *Chydaekata gyraspis* n. sp., holotype male 'a' 6 mm., pereopod 7. Allotype, female 'b' 8 mm., coxae of gnathopod 2 and pereopods 3-5.

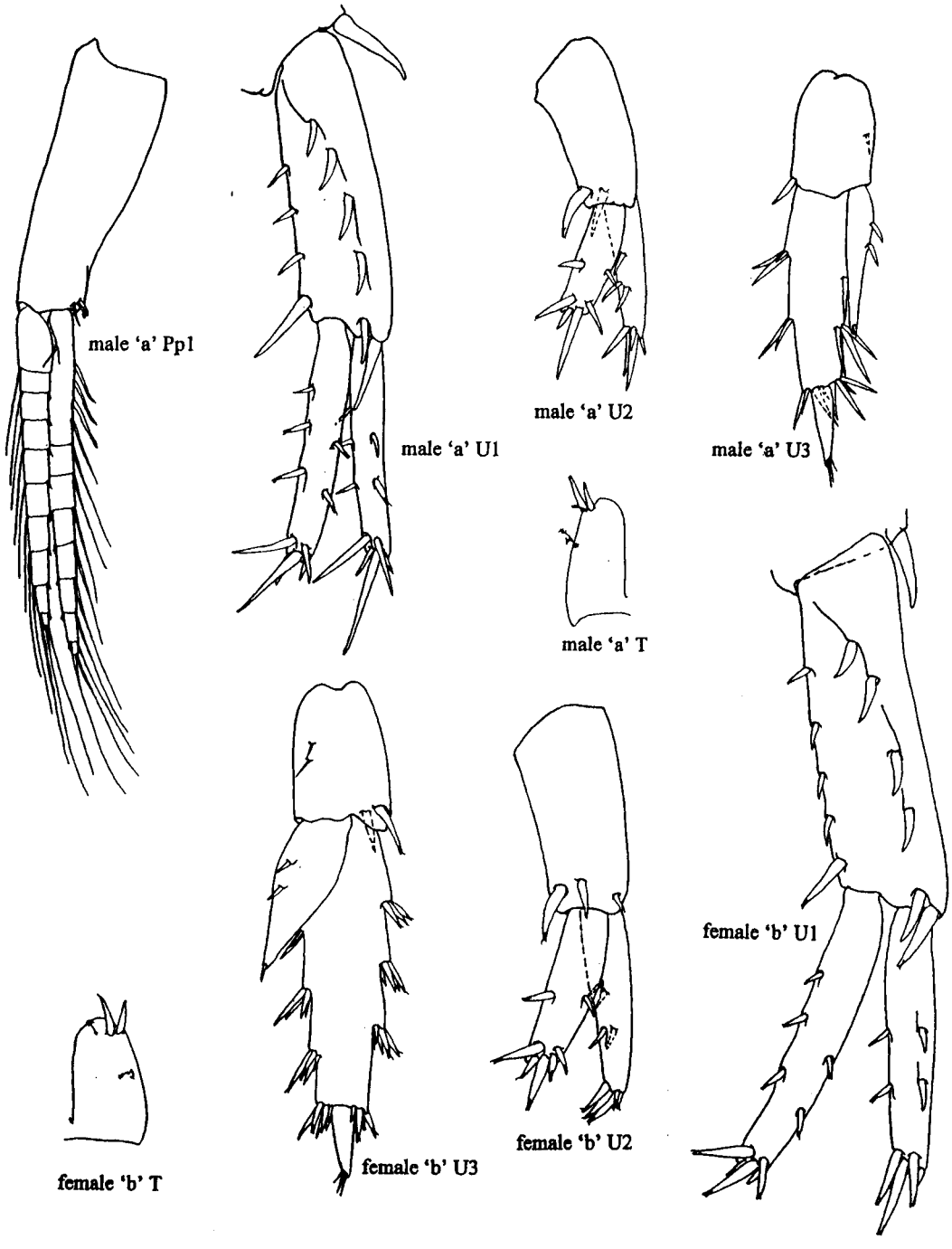

Fig. 3.51. *Chydaekata gyraspis* n. sp., holotype male 'a' 6 mm., pleopod 1, uropods 1-3, telson. Allotype female 'b' 8 mm. uropods 1-3, telson.

recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 3 anteroventral setae, and 2 ventral setae; carpus length 2.2 x width, subtriangular, with setae ranked in 6 transverse bands; propodus subrectangular, moderate size, length 2.2 x width, with 2 lateral robust setae, 1 medial robust seta and 2 additional lateral elongate setae, palmar angle transverse, smooth, dactyl reaching to palmar corner, with no recumbent inner tooth spine. *Pereopods*: pereopod 1 subequal in length to the second gnathopod; coxa with 3 anterior setae, 2 long ventral setae, no short ventral setae, 1 seta at the posteroventral corner; carpus weakly setose posteriorly; pereopod 4 subequal in length with pereopod 3, coxa anteroventral and posteroventral margins with 4 setae, ventral margin with no setae, posterior margin strongly emarginate, carpus weakly setose posteriorly; pereopods 5-7, coxa 5 bearing 1 seta on anterior and posterior lobes, basis of pereopod 5 with slender posterior setae, bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing 1 seta on anterior lobe; basis moderately expanded, bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 2 setae on the posterior lobe, basis bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally, bases of periopods equally expanded. *Epimera*: first epimeron with 1 slender seta on the posterior margin; posterior margin straight, posteroventral corner rounded; epimeron 2 with 2 robust setae on the anteroventral margin posterior margin straight, posteroventral corner rounded; epimeron 3 with 4 robust setae on the anteroventral margin, without slender setae on the ventral margin, posterior margin sinuous, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 5 feeble setae; of pleonite 2 with 7 feeble setae; of pleonite 3 with 3 feeble setae and no distolateral robust setae. *Pleopods*: first pleopod and second pleopods each with 1 accessory retinacula, third pleopod with no accessory retinacula. *Urosomites*: urosomite 1 bearing 2 distolateral slender setae, and 1 distolateral robust setae; urosomite 2: with 1 distolateral slender seta, and 2 distolateral robust setae. *First uropod*: peduncle length 1.3 x the length of the inner ramus, with a strong row of 4 dorsolateral robust setae and 3 dorsomedial robust setae; outer ramus with 2 dorsolateral robust setae, and 3 dorsomedial robust setae; inner ramus with 2 dorsolateral robust setae, 3 dorsomedial robust setae, and 5 apical robust setae. *Second uropod*: 0.5 x length of

uropod 1; peduncle about 1.3 x length of inner ramus, with 1 apicolateral, 1 dorsomedial, and 1 apicomedial robust setae; inner ramus with 1 dorsolateral, 1 dorsomedial, and 5 apical robust setae; outer ramus with 1 dorsolateral, 2 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.7 x length of uropod 1; peduncle length 0.4 x outer ramus, shorter than, 0.8 x urosomite three, with 1 apicolateral robust seta, and no apicolateral slender setae, with no dorsomedial robust setae, and 1 dorsomedial slender seta, with 1 apicomedial robust seta, no apicomedial slender setae, and no mediodistal robust setae; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands or arranged medially singly with, with 2 lateral transverse bands of robust setae, with 1 medial transverse band of robust setae, with no medial transverse bands of mixed robust and small setae, 1 medial robust seta, 4 apicolateral robust setae, no apicolateral small setae, 4 apicomedial robust setae, no apicomedial small setae, no apicomedial long slender setae; distal article short, with no apical robust setae, and 3 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender seta. *Telson*: shorter than, 0.9 x, urosomite 3; cleft 75 %; as long as broad; apices rounded and laterally notched; 2 subapical robust setae, and no subapical slender setae; with 1 apical penicillate seta; and paired lateral penicillate setae at M0. 7 from the telson base.

Description of the allotype (female 'b' 8mm.)

Similar to the holotype except in the following. *Body*: length 8mm. *Second gnathopod*; coxa bearing very large ovate, almost round, marginally setose and involute oostegite, length about 1.6x coxal plate. *Pereopods*: Third pereopod; coxa bearing large, irregular ovate, marginally setose, apically inturned oostegite, length about 1.0x coxal plate. Fourth pereopod; coxa strongly excavate, bearing 2 more marginal setae than the holotype; with a large, irregular paddle shaped, marginally setose oostegite; length about 0.9x coxal plate. Fifth pereopod; coxa bearing moderate length irregularly shaped apically and posteriorly setose oostegite; length about 0.6x coxal plate, about 0.5x length of the oostegite of coxa 2. *Uropods*. First uropod: peduncle bearing 4 dorsomedial robust setae; outer ramus with 2 dorsomedial setae. Second uropod: peduncle bearing 1 dorso-distal robust seta; inner ramus bearing 2 dorsolateral setae; outer ramus with 5 apical robust setae.

Third uropod; peduncle with 2 small setae dorsomedially and 2 apicolateral robust setae; inner ramus bearing 3 medial and 3 lateral transverse bands of robust setae.

Relationships

C. gyraspis differs from others of the genus in: second antenna flagellum 12 articulate; maxilliped inner plate length 2.0-2.4 x width , with 1 medial pappose seta; first gnathopod: propodus posteroventral corner subquadrate, palmar angle transverse; pereopod 3 coxa bearing 2 long ventral setae; dorsolateral margin of pleonite 3 with 3 feeble setae.

3.1.4.9 *Chydaekata simulata* sp. nov. Figs. 3.52 - 3.55.

Etymology

From the Latin 'simulo' (imitate), referring to equal extensions of the propodal dactylus and palmar corner of the first gnathopod.

Type locality

Newman bore field, WP96, 23°20'S, 117°51'E.

Material examined

Holotype (Western Australian Museum, C24673) male 'a' 5mm, Allotype (Western Australian Museum, C24674) female 'b' 6mm, male 4.5mm, about 55 others in the type series, same data as the holotype (Western Australian Museum, C24675). Collection number BES 4832, taken with haul net, W. F. Humphreys and S. M. Eberhard, 23/07/97.

Diagnosis

Second antenna: peduncle article 5 bearing 1 calceolus, flagellum 11 articulate, with calceoli on articles 1-7. Mandible: palp article 2 with a medio-distal row of 4 robust rastellate setae; article 3 with 9 D and 3 E setae apically. Left first maxilla: palp article 2 with 6 apical setae. Right first maxilla: palp apex with 1 articulated, and 4 fused broad based tooth setae. Maxilliped outer plate with a pair of slender naked, medial submarginal to disto-facial setae; a medial row of 7 submarginal to subapical robust, naked, tooth setae; 3 apicolateral setae. First gnathopod propodus: dactyl reaching to palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 5 transverse bands. Telson: cleft 83%, bearing 2 subapical robust setae.

Description of the holotype (male 'a' 5mm)

Body: urosomites 1 and 2 without dorsolateral robust setae. *First antenna*: length 0.6 x body, 1.6 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 27 articles; accessory flagellum of 5 articles, reaching to article 5 of primary flagellum. *Second antenna*: length 0.4 x body; peduncle length greater than flagellum, article 5 bearing 1 calceolus, article 4 subequal with article 5, articles 3-5 with sparse setation; flagellum 11 articulate, with sparse setation, bearing calceoli on articles 1 - 7. *Left mandible*: palp article 2 with a medio-distal row of 4 robust rastellate setae, article 3 with 9 D and 3 E setae, facially setulose (pubescent); incisor with 5 teeth, lacinia mobilis with 4 teeth, and 4 plumose interraker setae; molar without pappose seta, with 2 penicillate hooked brushy basal setae, and no penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 4 robust rastellate setae, article 3 with 9 D and 3 E setae; incisor with 4 teeth, and 2 plumose interraker setae; molar without penicillate hooked brushy basal setae, and few penicillate setules. *Left first maxilla*: palp article 2 with 4 apical and 1 subapical facial strong slender setae, and 1 submarginal apicomedial seta; outer plate with 9 robust setae - 9 denticulate, none naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with 1 articulated and 4 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 4.3 x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 3 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 2.5 x width, extending to M0.7 of the outer plate, bearing small setules on the lateral margin, no facial or medial pappose setae, with a row of 5 submarginal to subapical pappose setae, but not extending to a row of similar subapical or apical setae, with no apicomedial or mediodistal setae, and 3 apical naked tooth setae; outer plate broad, length 2.3 x width, distally naked, with a row of 2 slender naked, submarginal setae, a medial row of 7 submarginal to subapical robust, naked, tooth setae, and 3 apicolateral setae - 1 naked, and 2 pappose; palp second article strongly setose medially; third article sparsely setose laterally, moderately setose medially, with 3 facial, and 2 ventrofacial long strong setae basal to the dactyl, the apex moderately produced, setulate, with 2 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 3 anteroventral but no ventral setae; merus bearing posterior hump; carpus of moderate length, 1.5 x width, subtriangular, posterior

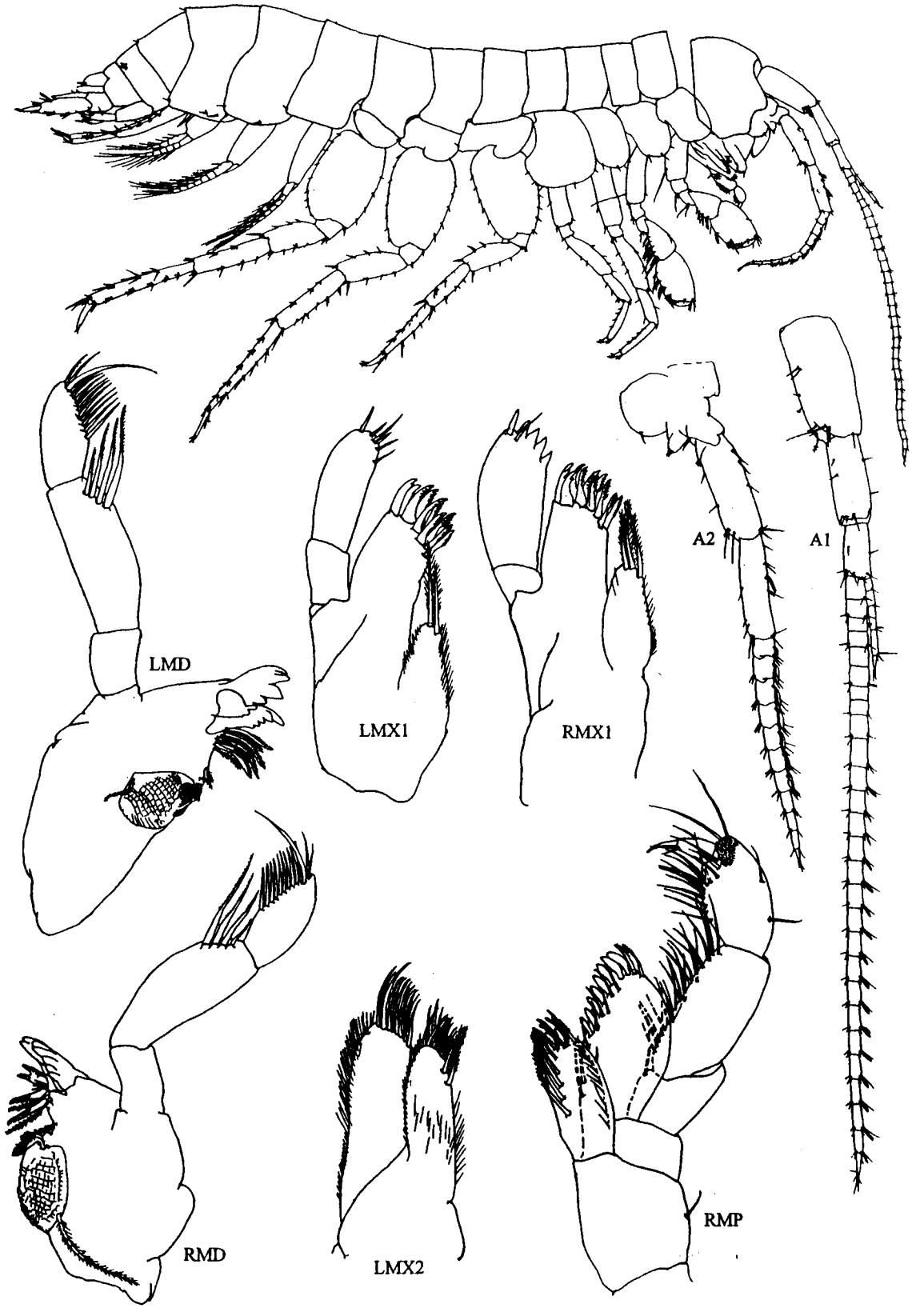

Fig. 3.52. *Chydaekata simulata* n. sp., holotype male 'a' 5 mm., antennae and mouthparts. Male 4.5 mm. whole animal.

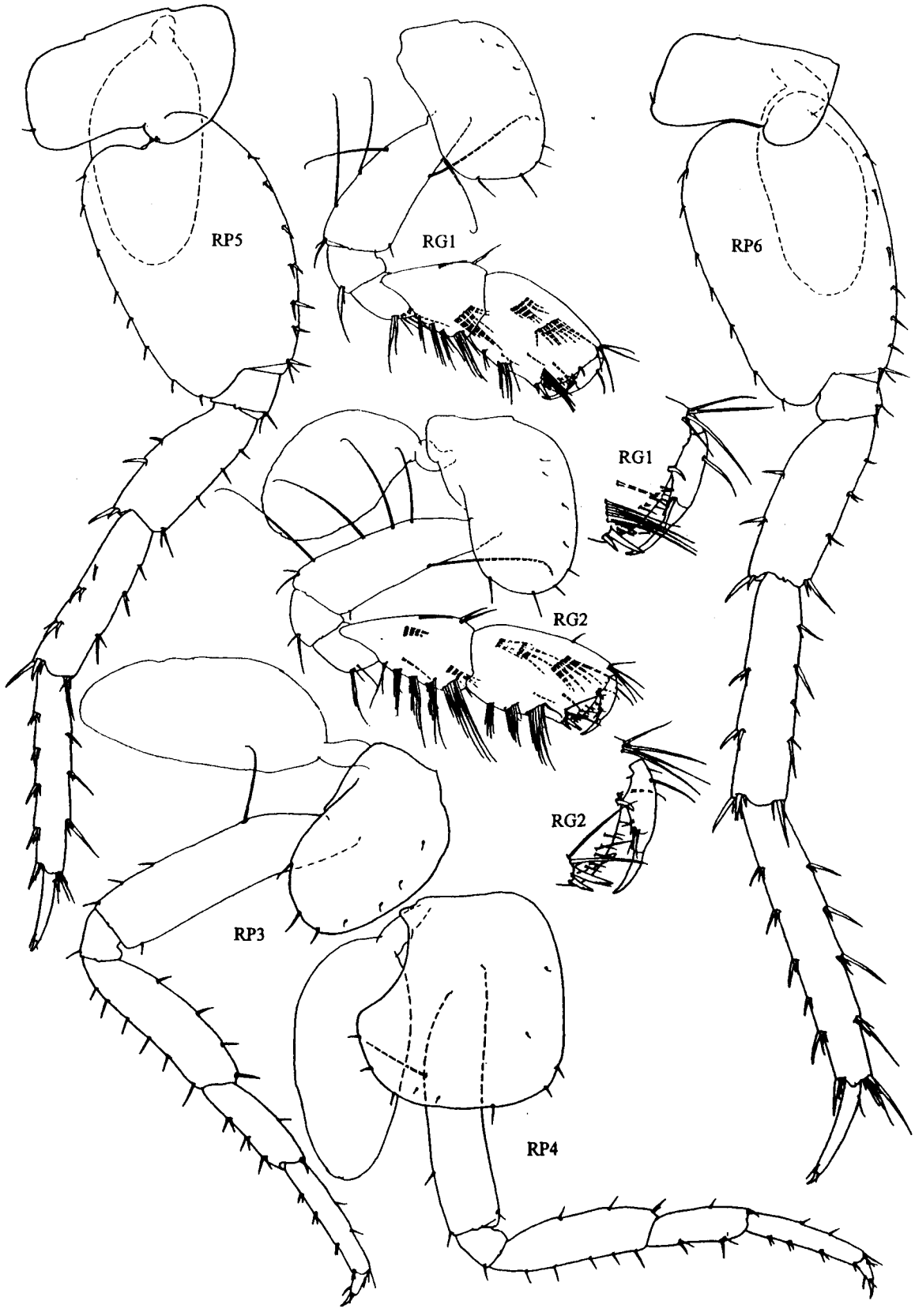

Fig. 3.53. *Chydaekata simulata* n. sp., holotype male 'a' 5 mm., gnathopods 1-2 and pereopods 3-6.

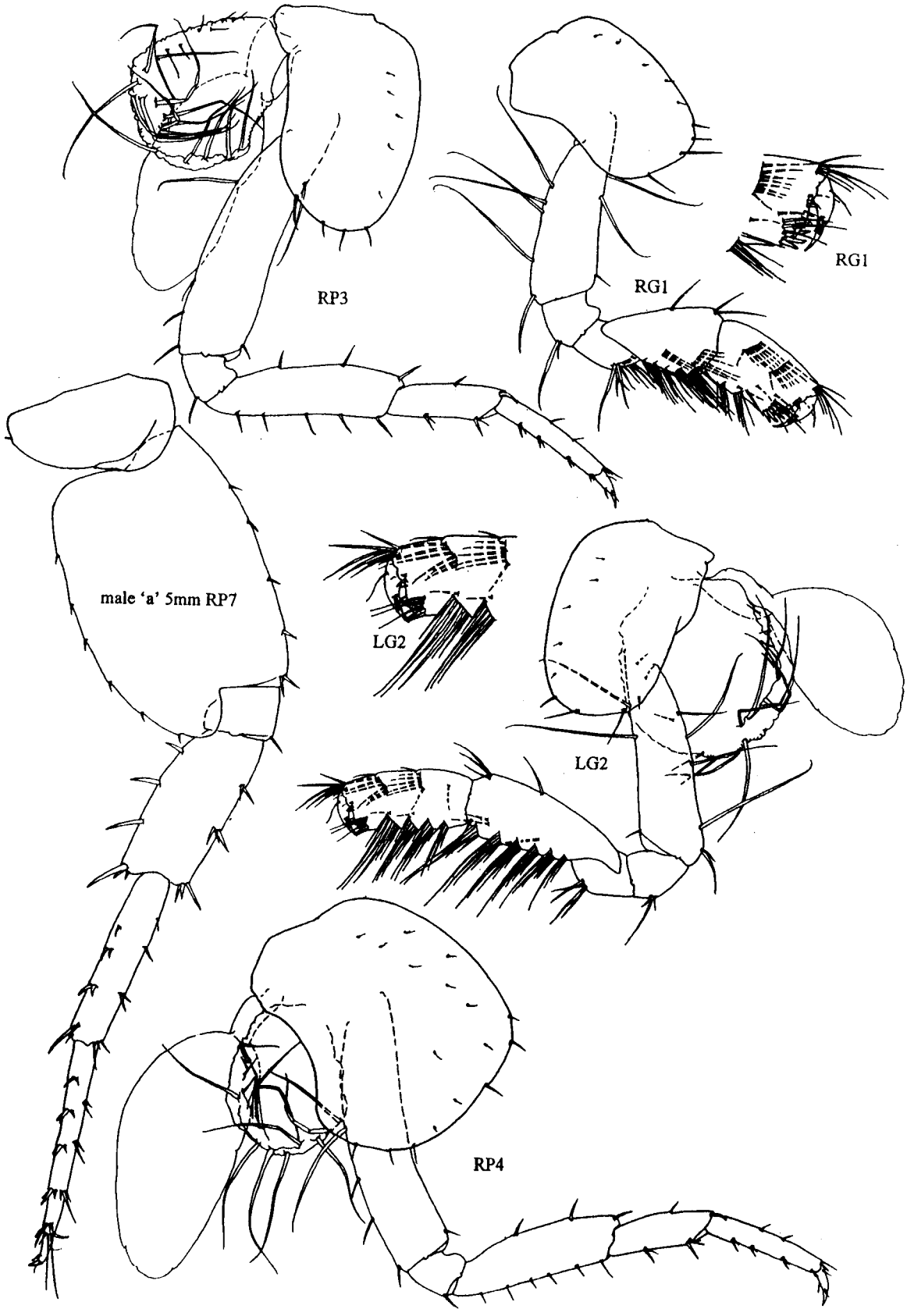

Fig. 3.54. *Chydaekata simulata* n. sp., allotype female 'b' 6 mm., gnathopods 1-2, pereopods 3-4. Holotype male 'a' 5 mm., pereopod 7.

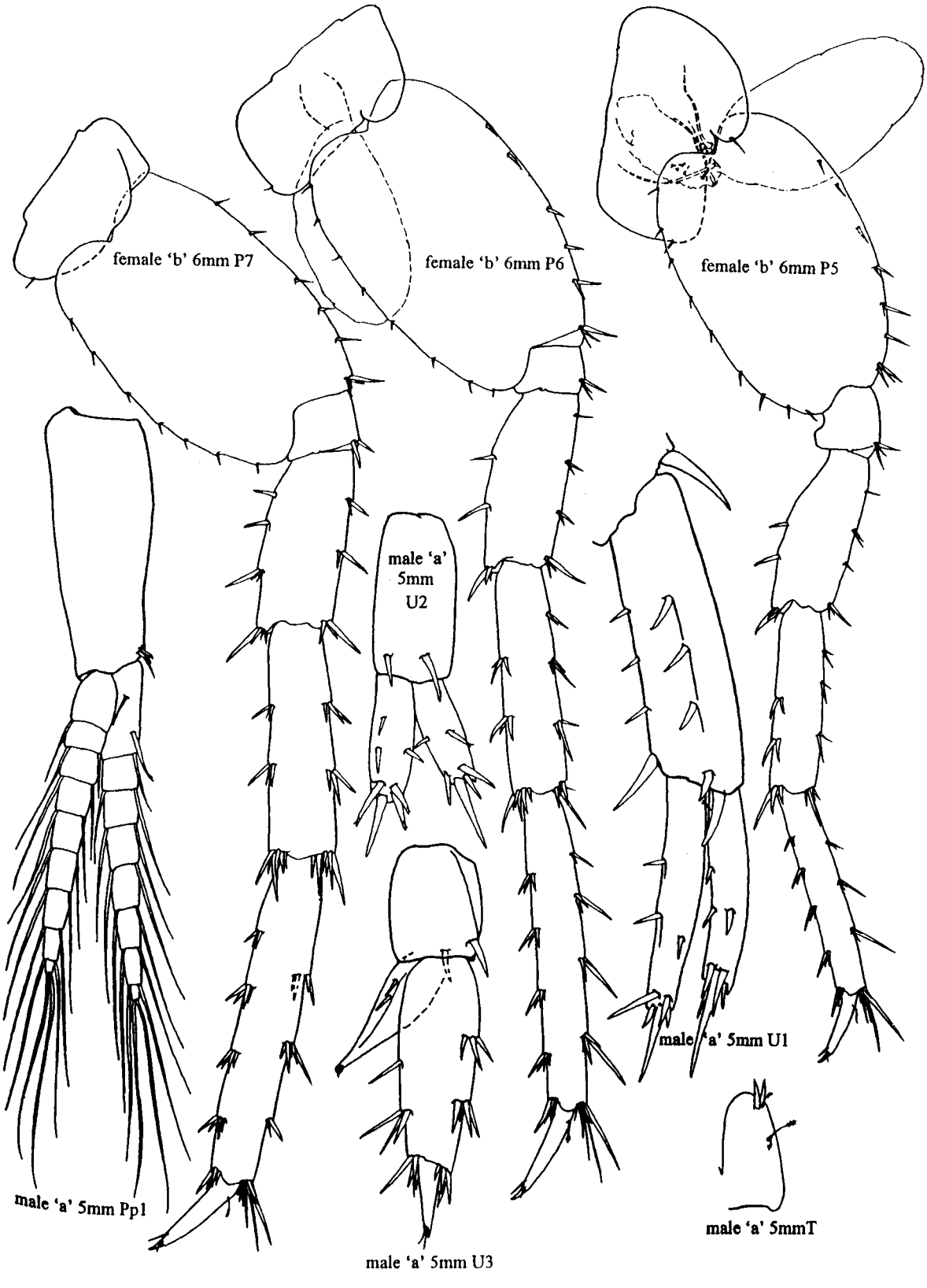

Fig. 3.55. *Chydaekata simulata* n. sp., holotype male 'a' 5 mm., pleopod 1, uropods 1-3, telson. Allotype female 'b' 6 mm. pereopods 5-7.

margin with setae ranked in 4 transverse bands; propodus subrectangular, small, length 1.7 x width, posteroventral corner rounded, with 2 lateral and 1 medial robust setae, and 4 additional lateral elongate setae, palmar angle slightly oblique, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 3 anteroventral setae, and no ventral setae; carpus length 2.1 x width, subtriangular, with posterior setae ranked in 5 transverse bands; propodus subrectangular, small, length 2 x width, with 2 medial robust setae, 1 lateral robust seta, and 2 additional lateral elongate robust setae, palmar angle weakly oblique, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Pereopods*: pereopod 3 longer than the second gnathopod, coxa with 2 anterior setae, no long or short ventral setae, 1 seta at the posteroventral corner, carpus weakly setose posteriorly; pereopod 4 subequal in length with pereopod 3, coxa anteroventral margin with 2 setae, posteroventral margin with 3 setae, ventral margin with 1 seta, posterior margin moderately emarginate, carpus weakly setose posteriorly; coxa 5 bearing 1 seta on anterior lobe, and 1 seta on the posterior lobe; basis of periopod 5 with short slender posterior setae, bearing short robust and slender anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing no setae on anterior lobe, basis moderately expanded, bearing short robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 1 seta on the posterior lobe; basis bearing short robust anterior setae, moderately lobate posteroventrally; bases of pereopods equally expanded. *Epimera*: first epimeron with 1 slender seta on the posterior margin, posterior margin straight, posteroventral corner rounded; epimeron 2 with 1 robust seta on the anteroventral margin; posterior margin straight, posteroventral corner rounded; epimeron 3 with 2 robust setae on the anteroventral margin, without slender setae on ventral margin, posterior margin straight, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 1 feeble setae; of pleonites 2 and 3 with 2 feeble setae, with no distolateral robust setae on pleonite 3. *Pleopods*: first pleopod with 1 accessory retinacula, second and third pleopods with no accessory retinacula. *Urosomites*: urosomite 1 bearing 2 distolateral slender setae, and no distolateral robust seta; urosomite 2 with 1 distolateral slender setae, and 1 distolateral robust setae. *First uropod*: peduncle length 1.3 x the length of the inner ramus, with a strong row of 3 dorsolateral robust setae, and 3 dorsomedial robust setae; outer ramus with 1 dorsolateral robust seta,

and 2 dorsomedial robust setae; inner ramus with 1 dorsolateral robust seta, 2 dorsomedial robust setae, and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about 1.3 x length of inner ramus, with 1 apicolateral, no dorsomedial, and 1 apicomedial robust setae; inner ramus with 1 dorsolateral, 1 dorsomedial, and 4 apical robust setae; outer ramus with 1 dorsolateral, 2 dorsomedial, and 4 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.7 x length of uropod 1; peduncle length 0.4 x outer ramus, shorter than, 0.8 x, urosomite three, with 1 apicolateral robust seta and no apicolateral slender setae, no dorsomedial robust setae, no dorsomedial slender setae, with no apicomedial robust setae, no apicomedial slender setae, and with 1 mediodistal robust seta; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands and medially singly with 2 lateral transverse bands of robust setae, with 1 medial transverse band of robust setae, 1 medial robust seta, 4 apicolateral robust setae, no apicolateral small setae, 4 apicomedial robust setae, no apicomedial small setae, no apicomedial long slender setae; distal article short, with no apical robust setae, and 2 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 2 apical slender setae. *Telson*: shorter than, 0.9 x, urosomite 3, cleft 83 %, shorter than broad, length 0.9 x breadth; apices rounded and laterally notched with 2 subapical robust setae, 1 apical penicillate seta, and paired lateral penicillate setae at M0.6 from the telson base.

Description of the allotype (female 'b' 6mm)

With the characteristics of the holotype except. *Body*: length 6mm. *First antenna*: without aesthetascs or calceoli. *Second antenna*. without calceoli. *First gnathopod*: carpus narrower, more elongate than male but nevertheless subtriangular, bearing 5 (versus 4) posterior translateral setal bands, and 2 (versus 1)medio-facial bands; propodus smaller, less robust than male, narrower and tapering apically though similarly armed. *Second gnathopod*: coxa bearing fewer marginal setae, with large, round, posteriorly setose and involute, length about equal to coxal plate; carpus elongate and narrower than male, bearing 6 (versus 5) posterior translateral setal bands but 1 (versus 2) medio-facial band; propodus less robust than male, narrower, tapering apically, bearing 4 (versus 3) posterior translateral setal bands and 2 (versus 3) medio-facial bands; palm and dactyl similarly armed. *Pereopods*. Third pereopod: coxa with an extra marginal seta,

bearing a moderately large, paddle shaped, marginally setose and involute oostegite, length about 0.8x coxal plate. Pereopod four: coxa similarly armed marginally, but bearing many facial setules, also with a moderately long, ovate, marginally setose and involute oostegite, length about 0.6x coxal plate. Pereopod five: coxa bearing a small, ovate, apically setose oostegite, length about 0.6x coxal plate, about 0.8x oostegite of coxa 2. Pereopods six and seven: similar to male.

Relationships

C. simulata differs from others of the genus in: right first maxilla palp apex with 1 articulated tooth seta; second maxilla apicomedial corner of inner plate with 3 weakly submarginal thick plumose/pappose setae; maxilliped inner plate setae without a row of similar subapical setae, outer plate with a row of 2 slender naked submarginal setae; second pleopod with no accessory retinacula; second uropod outer ramus with 4 apical robust setae; third uropod inner ramus with 2 apical slender setae; telson cleft 83%.

3.1.4.10 *Chydaekata tetraspis* sp. nov. Figs. 3.56 - 3.59

Etymology

From the Greek 'tetra' (four) and 'aspis' (shield), referring to the sub-quadrate posteroventral corner of the second epimeron.

Type locality

Ebathacalby Well, Fortescue Valley, 22°15'S, 118°45E.

Material examined

Holotype (Western Australian Museum, C24676) male 'a' 5.5mm, Allotype (Western Australian Museum, C24677) female 'b' 6.5mm. Collection number BES 4847, taken with haul net, W. F. Humphreys and S. M. Eberhard, 25/07/97.

Diagnosis

Second antenna: flagellum 13 articulate. Mandible: palp article 2 with a medio-distal row of 4 robust rastellate setae; article 3 with 10 D and 4 E setae apically. Left first maxilla: palp article 2 with 5 apical setae. Right first maxilla: palp apex with no articulated, and 4 fused broad based tooth setae. Maxilliped outer plate with a row of 8 slender naked, medial submarginal to disto-facial setae; a medial row of 4 submarginal to subapical robust, naked, tooth setae; 2 apicolateral setae. First gnathopod propodus: dactyl not reaching to palmar corner, with a single

recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 6 transverse bands. Telson: cleft 76%, bearing 2 subapical robust setae.

Description of the holotype (male 'a' 5.5mm)

Body: urosomite 1 bearing 1 dorsolateral robust seta, urosomite 2 bearing 2 dorsolateral robust setae. *First antenna*: length 0.7 x body, 2 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 40 articles; accessory flagellum of 7 articles, reaching to article 10 of primary flagellum. *Second antenna*: length 0.3 x body; peduncle length subequal to flagellum, article 4 longer than article 5, articles 3-5 with sparse setation; flagellum 17 articulate, with sparse setation. *Left mandible*: palp article 2 with a medio-distal row of 4 robust rastellate setae, article 3 with 10 D and 4 E setae, facially setulose (pubescent); incisor with 5 teeth, lacinia mobilis with 5 teeth, and 4 plumose interraker setae; molar bearing pappose seta, with 2 penicillate hooked brushy basal setae and no penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 3 robust rastellate setae, article 3 with 9 D and 4 E setae; incisor with 5 teeth and 2 plumose interraker setae; molar, with 3 penicillate hooked brushy basal setae, and no penicillate setules. *Left first maxilla*: palp article 2 with 3 apical and 1 subapical facial strong slender setae, with 1 apicomedial seta; outer plate with 10 robust setae - 10 denticulate, none naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with no articulated and 4 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 2.4 x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 1 weakly submarginal thick plumose/pappose seta. *Maxilliped*: inner plate length 4.2 x width, extending to M0. 8 of the outer plate, bearing small setules on the lateral margin and medioproximal face, no facial pappose setae, no medial pappose setae, with a row of 3 submarginal pappose setae, extending to a row of 4 similar subapical, and 2 apical setae, with 1 apicomedial mediodistal, and 3 apical naked tooth setae; outer plate broad, length 1.7 x width, distally setulose (pubescent), with a row of 4, slender naked, medial submarginal to distal facial setae, a medial row of 8 submarginal to subapical robust, naked, tooth setae, and 2 apicolateral setae - 1 naked, and 1 pappose; palp, second article strongly setose medially; third article sparsely setose laterally, strongly setose medially, with 3 facial, and no ventrofacial long strong setae basal to the dactyl, the apex moderately produced, setulate, with 2 long slender naked setae, and 1 dorsal

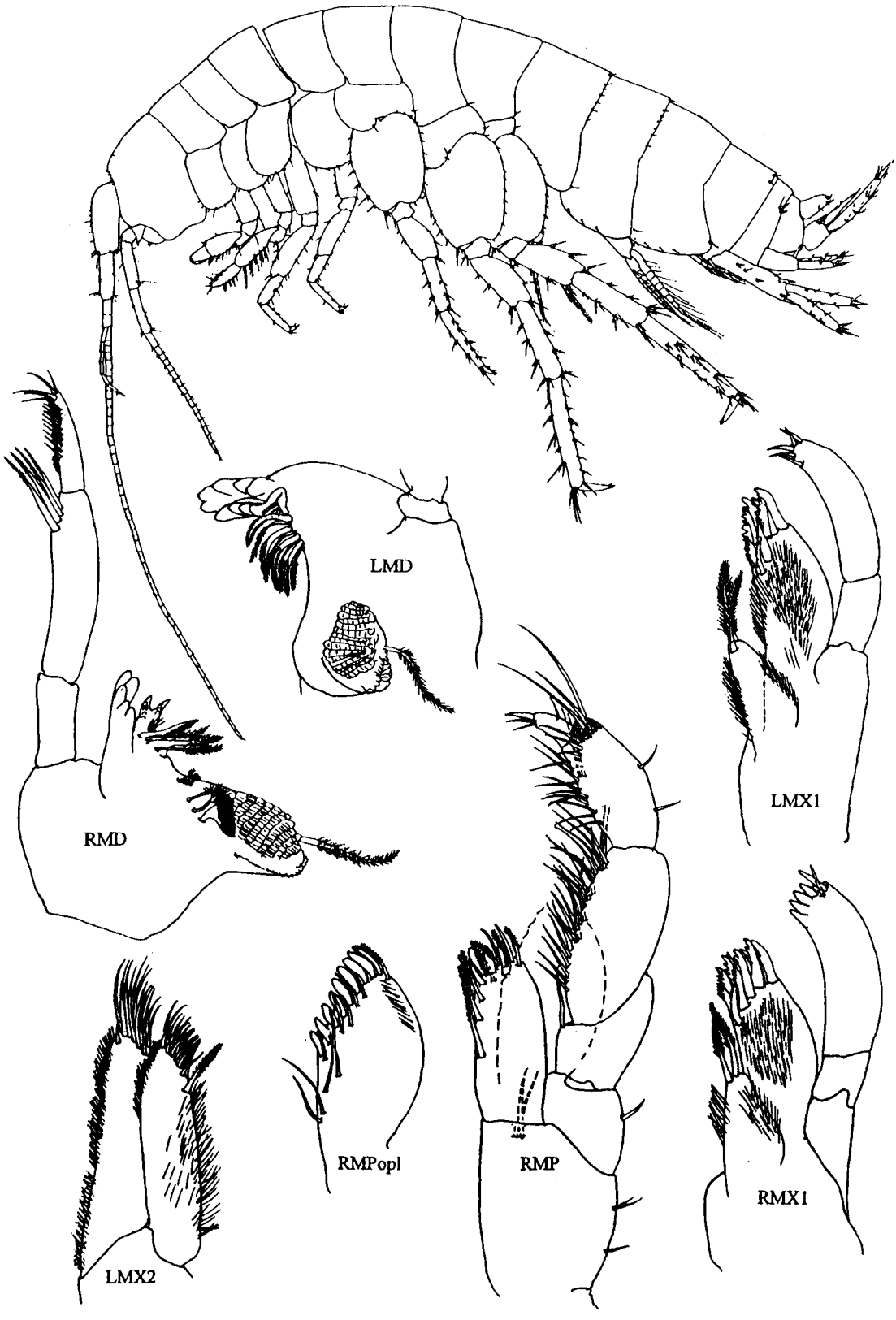

Fig. 3.56. *Chydaekata tetraspis* n. sp., holotype male 'a' 5.5 mm., whole animal and mouthparts.

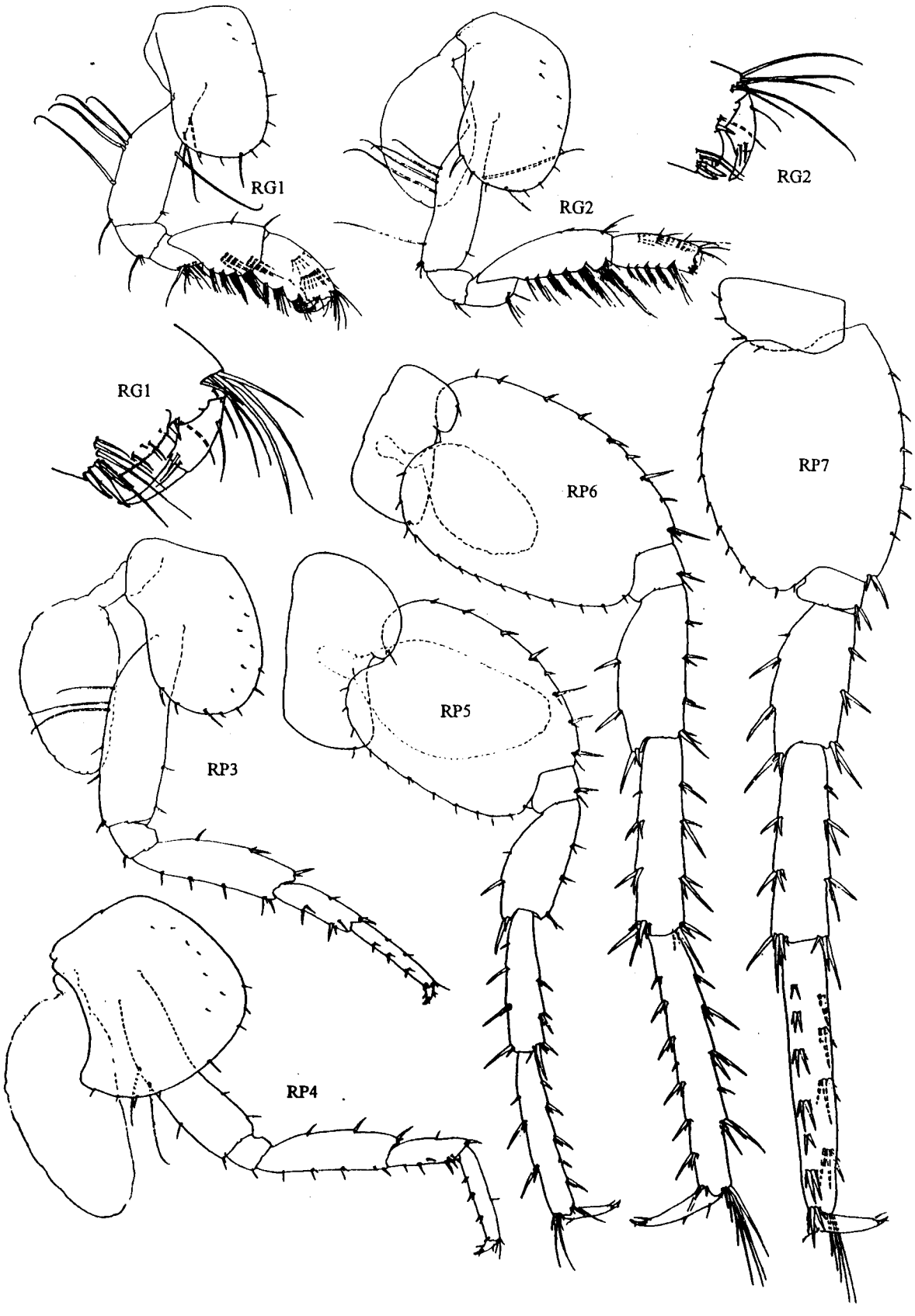

Fig. 3.57. *Chydaekata tetraspis* n. sp., holotype male 'a' 5.5 mm., gnathopods and pereopods.

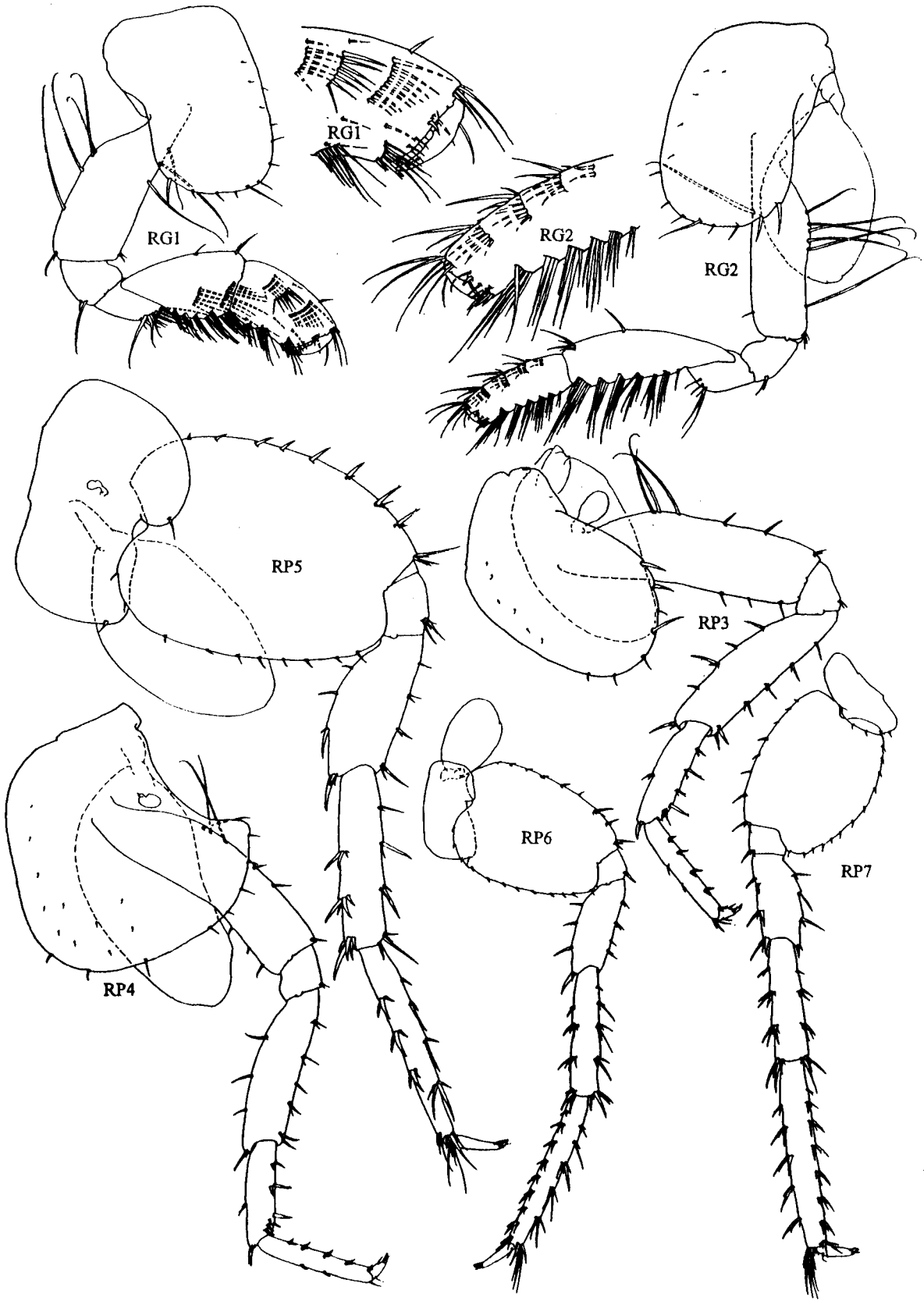

Fig. 3.58. *Chydaekata tetraspis* n. sp., allotype female 'b' 6.5 mm., gnathopods and pereopods (pereopods 6-7 shown half scale).

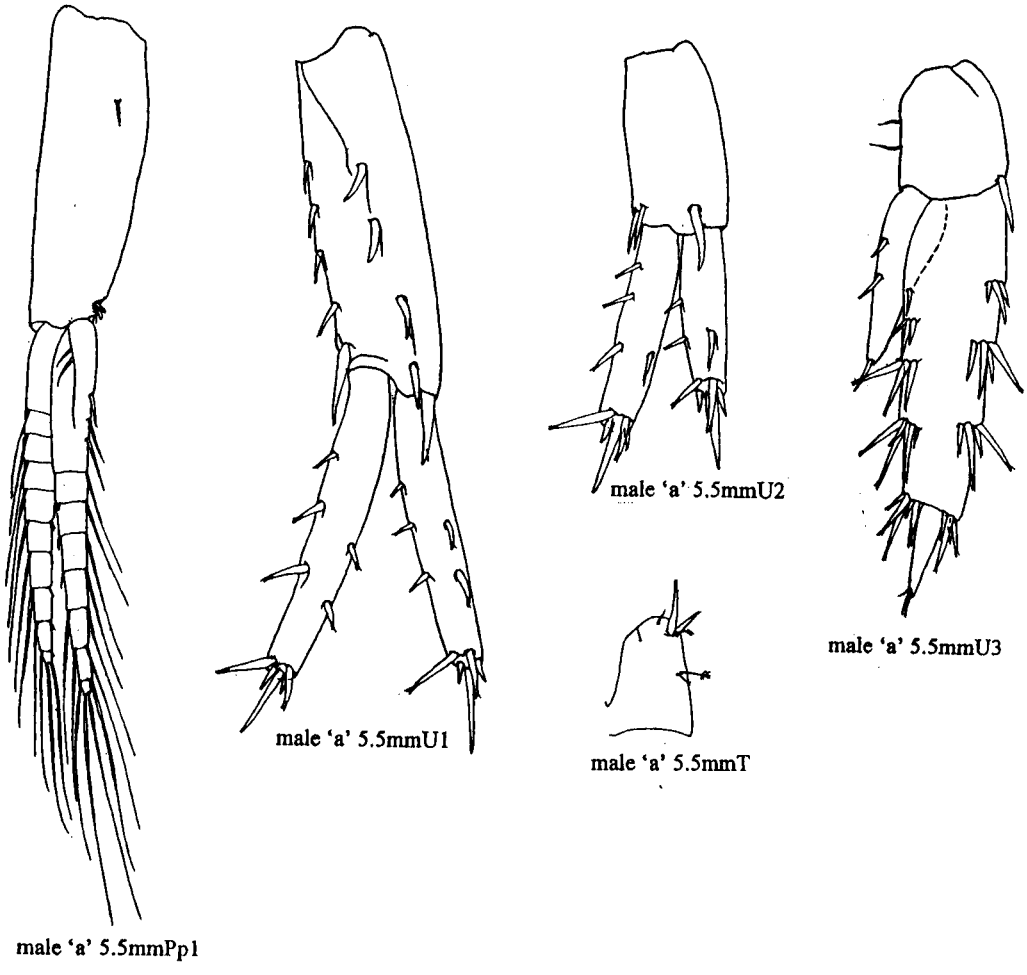

Fig. 3.59. *Chydaekata tetraspis* n. sp., holotype male 'a' 5.5 mm., pleopod 1, uropods 1-3, telson.

accessory seta. *First gnathopod* coxal plate with 4 anteroventral setae, and 3 ventral setae; merus without posterior hump; carpus long, 1.8 x width, ovate, posterior margin with setae ranked in 5 transverse bands; propodus subrectangular, small, length 1.4 x width, posteroventral corner rounded, with 2 lateral and 1 medial robust setae, and 3 additional lateral elongate setae, palmar angle weakly oblique, bearing fine marginal teeth, dactyl not reaching to palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: subequal in size with first gnathopod; coxal plate with 4 anteroventral setae, and 3 ventral setae; carpus length 3.6 x width, subrectangular, with posterior setae ranked in 6 transverse bands; propodus subrectangular, small, length 2 x width, with 2 lateral and 1 medial robust setae, and 2 additional lateral elongate setae, palmar angle transverse, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Pereopods*: pereopod 3 longer than the second gnathopod; coxa with 3 anterior setae, no long ventral setae, 3 short ventral setae, 2 setae at the posteroventral corner; carpus weakly setose posteriorly; pereopod 4 subequal in length with pereopod 3; coxa anteroventral margin with 3 setae, posteroventral margin with 4 setae, ventral margin with 1 seta, posterior margin moderately emarginate; carpus moderately setose posteriorly; coxa 5 bearing 1 seta on anterior lobe, and 1 seta on the posterior lobe; basis of periopod 5 with short slender posterior setae, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing 1 seta on anterior lobe; basis moderately expanded, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 4 setae on the posterior lobe; basis bearing short and long robust anterior setae, moderately lobate posteroventrally; bases of periopods equally expanded. *Epimera*: first epimeron with 1 slender seta on the posterior margin; posterior margin convex, posteroventral corner rounded; second epimeron with 3 robust setae on the anteroventral margin, posterior margin sinuous, posteroventral corner subquadrate; third epimeron with 4 robust setae on the anteroventral margin, without slender setae on ventral margin, posterior margin sinuous, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 4 feeble setae, of pleonite 2 with 5 feeble setae and of pleonite 3 with 1 feeble seta, and no distolateral robust setae. *Pleopods*: first, second, and third pleopods with 1 accessory retinacula. *Urosomites*: first urosomite bearing no distolateral slender setae, and 2 distolateral robust setae; urosomite 2 with 1 distolateral slender seta and

2 distolateral robust setae. *First uropod*: peduncle length 1.2 x the length of the inner ramus, with a strong row of 4 dorsolateral robust setae and 4 dorsomedial robust setae; outer ramus with 2 dorsolateral robust setae and 3 dorsomedial robust setae; inner ramus with 2 dorsolateral robust setae 3 dorsomedial robust setae and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about 0.9 x length of inner ramus, with no apicolateral, no dorsomedial, and 2 apicomedial robust setae; inner ramus with 1 dorsolateral, 2 dorsomedial, and 5 apical robust setae; outer ramus with 1 dorsolateral, 3 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.9 x length of uropod 1; peduncle length 0.3 x outer ramus, subequal in length to urosomite 3, with 2 apicolateral robust setae, and 2 apicolateral slender setae, with no dorsomedial robust setae, and no dorsomedial slender setae, with no apicomedial robust setae, and no apicomedial slender setae, and with 1 mediodistal robust seta; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands, with 3 lateral transverse bands of robust setae, 3 medial transverse bands of robust setae, with no medial transverse bands of mixed robust and small setae, 4 apicolateral robust setae, 1 apicolateral small seta, 4 apicomedial robust setae, no apicomedial small setae, no apicomedial long slender setae, distal article short, with no apical robust setae, and 3 apical slender setae; inner ramus with 2 medial robust setae, 1 apical robust seta, and no apical slender setae. *Telson*: subequal in length to urosomite 3; cleft 76 %, shorter than broad, length 0.7 x breadth; apices rounded, with 2 subapical robust setae and 1 subapical slender seta, with 1 apical penicillate setae; paired lateral penicillate setae at M0.5 from the telson base.

Description of the allotype (female 'b' 6.5mm)

With the characteristics of the Holotype except. *Body*: length 6.5mm. *First antenna*: flagellum of 47 (versus 42) articles, accessory flagellum of 9 (versus 7) articles; without aesthetascs or calceoli. *Second antenna*: flagellum of 21 (versus 17) articles; peduncle and flagellum without calceoli. *First gnathopod*: coxa bearing an additional marginal seta (9 versus 8); carpus of similar proportions to male, but bearing 5 (versus 4) posterior translateral setal bands; propodus shorter than male, tapering apically, bearing 3 (versus 2) medio-facial setal bands, otherwise similarly armed. *Second gnathopod*: coxa (bearing ovate oostegite), with 3 (versus 4) anterior setae; carpus longer and narrower than male, with 7 (versus 6)

posterior translateral setal bands; propodus longer and narrower than in the male, bearing 6 (versus 7) posterior trans lateral setal bands and 4 (versus 3) medio-facial bands. *Pereopods*. Third pereopod: similar to male except for the presence on the coxa of a small ovate (immature) oostegite attached adjacent the basis. Fourth pereopod; coxa bearing a tiny ovate (immature) oostegite attached adjacent the basis. Fifth pereopod; similar to the male except for the presence on the coxa of a small bud possibly an immature oostegite near the attachment of the basis. Sixth pereopod: coxa without 1 ventro-marginal seta on the anterior lobe, otherwise similar to the male. Seventh pereopod: similar to the male. *Uropods*. First uropod: peduncle bearing 3 lateral and 2 apicolateral, 4 medial and 1 apicomedial robust setae; outer ramus 3 lateral, 5 medial and 5 apical robust setae; inner ramus bearing 3 lateral, 3 medial and 4 apical robust setae. Second uropod: peduncle bearing no lateral and 1 apicolateral, 1 medial and 2 apicomedial robust setae; outer ramus bearing 2 lateral, 2 medial and 5 apical robust setae; inner ramus bearing 2 lateral, 4 medial and 5 apical robust setae. Third uropod: peduncle bearing 1 apico-dorso-lateral, 2 apico-ventro-lateral, 2 apico-ventral robust setae, and 1 slender dorsomedial seta; outer ramus, first article bearing 3 trans lateral bands and 4 distolateral, 4 transmedial bands and 5 distomedial bands of robust setae, the second article bearing 3 short, slender setae; inner ramus bearing 2 lateral robust and 1 apical slender setae. *Telson*: bearing a small apicolateral notch, with 1 left and 2 right robust setae and a single penicillate seta on both lobes; with paired penicillate setae submarginal at M0.6 and several dorsal setules on both lobes; cleft 80%.

Relationships

C. tetraspis differs from others of the genus in: first antenna accessory flagellum of 7 articles reaching to article 10 of primary flagellum; second maxilla outer plate length less than 2.4 x width, apicomedial corner of inner plate with 1 weakly submarginal thick plumose/pappose seta; maxilliped inner plate length 3.6-4.5 x width, outer plate with a row of 4 slender naked medial submarginal to disto facial setae, palp third article without ventrofacial setae basal to the dactyl; first gnathopod carpus ovate; second gnathopod propodus posteroventral corner lateral without medial robust setae; pereopod 3 coxa with 2 setae at the posteroventral corner; pereopod 7 coxa bearing 4 setae on the posterior lobe; epimera 2 posterior margin sinuous, posteroventral corner subquadrate; second uropod peduncle bearing 2 apicomedial robust setae; third uropod peduncle with 2 apicolateral robust setae,

peduncle with 2 apicolateral slender setae, outer ramus proximal article with 1 apicolateral small seta; telson apices rounded each with 1 subapical slender seta.

3.1.4.11 *Chydaekata ovatosetosa* sp. nov. Figs. 3.60 - 3.63.

Etymology

From the Latin 'ovatus' (egg shaped), and 'setosus' (bristly), referring to the facially setose, ovate inner plate of the first maxilla.

Type locality

Newman bore field, WI11, 23°20'S, 117°51'E.

Material examined

Holotype (Western Australian Museum, C24678) male 'c' 6mm, Allotype (Western Australian Museum, C24679) female 'd' 7mm, female 'a' 6mm, about 50 others in the type series, same data as the holotype (Western Australian Museum, C24680). Collection number BES 4811, taken with haul net, W. F. Humphreys and S. M. Eberhard, 22/07/97.

Diagnosis

Second antenna: peduncle article 5 bearing 1 calceolus, flagellum 9 articulate, with calceoli on articles 1-5. Mandible: palp article 2 with a medio-distal row of 3 robust rastellate setae; article 3 with 7 D and 3 E setae apically. Left first maxilla: palp article 2 with 6 apical setae. Right first maxilla: palp apex with no articulated, and 4 fused broad based tooth setae. Maxilliped outer plate with no medial submarginal to disto-facial setae; a medial row of 7 submarginal to subapical robust, naked, tooth setae; 2 apicolateral setae. First gnathopod propodus: dactyl reaching beyond the palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 4 transverse bands. Telson: cleft 68%, bearing 2 subapical robust setae.

Description of the holotype (male 'c' 6mm)

Body: urosomite 1 without dorsolateral robust setae, urosomite 2 bearing 1 dorsolateral robust seta. *First antenna*: length 0.6 x body, 1.8 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 25 articles; accessory flagellum of 4 articles, reaching to article 6 of primary flagellum. *Second antenna*: length 0.3 x body; peduncle length greater than flagellum, article 5 bearing 1 calceolus, article 4 subequal with article 5, articles 3-5 with sparse setation;

flagellum 9 articulate, with sparse setation, bearing calceoli on articles 1-5. *Left mandible*: palp article 2 with a medio-distal row of 3 robust rastellate setae, article 3 with 7 D and 3 E setae, facially setulose (pubescent); incisor with 6 teeth, lacinia mobilis with 5 teeth, and 2 plumose interraker setae; molar without pappose seta, without penicillate hooked brushy basal setae, and few penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 4 robust rastellate setae, article 3 with 7 D and 3 E setae; incisor with 5 teeth, and 2 plumose interraker setae; molar with 2 penicillate hooked brushy basal setae, and few penicillate setules. *Left first maxilla*: palp article 2 with 4 apical and 1 subapical facial strong slender setae, with 1 apicomedial, no submarginal apicomedial, and no ventrofacial apicomedial strong slender setae; outer plate with 10 robust setae, all denticulate, none naked; inner plate ovate, facially setulose (pubescent). *Right first maxilla*: palp apex with no articulated, 4 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 3 x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 2 x width, extending to M0.6 of the outer plate, bearing small setules on the lateral margin, no facial pappose setae, no medial pappose setae, with a row of 3 submarginal pappose setae, extending to a row of 1 similar subapical, and 3 apical setae, with 3 apicomedial and 1 mediodistal naked tooth setae; outer plate long, length 2 x width, distally naked, a medial row of 7 submarginal to subapical robust, naked, tooth setae, and 2 apicolateral setae - 1 naked, and 1 pappose; palp second article strongly setose medially, third article sparsely setose laterally, weakly setose medially, with no facial, and 2 ventrofacial long strong setae basal to the dactyl, the apex not produced, naked, with 2 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 2 anteroventral and no ventral setae; merus without posterior hump; carpus of moderate length, 1.3 x width, subtriangular, posterior margin strongly setose, with setae ranked in 4 transverse bands; propodus subrectangular, small, length 1.7 x width, posteroventral corner rounded, with 2 lateral and 1 medial robust setae, and 3 additional lateral elongate setae, palmar angle weakly oblique, smooth, dactyl reaching beyond palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 3 anteroventral setae and no ventral setae; carpus length 2 x width, subtriangular, with posterior setae ranked in 4 transverse bands; propodus

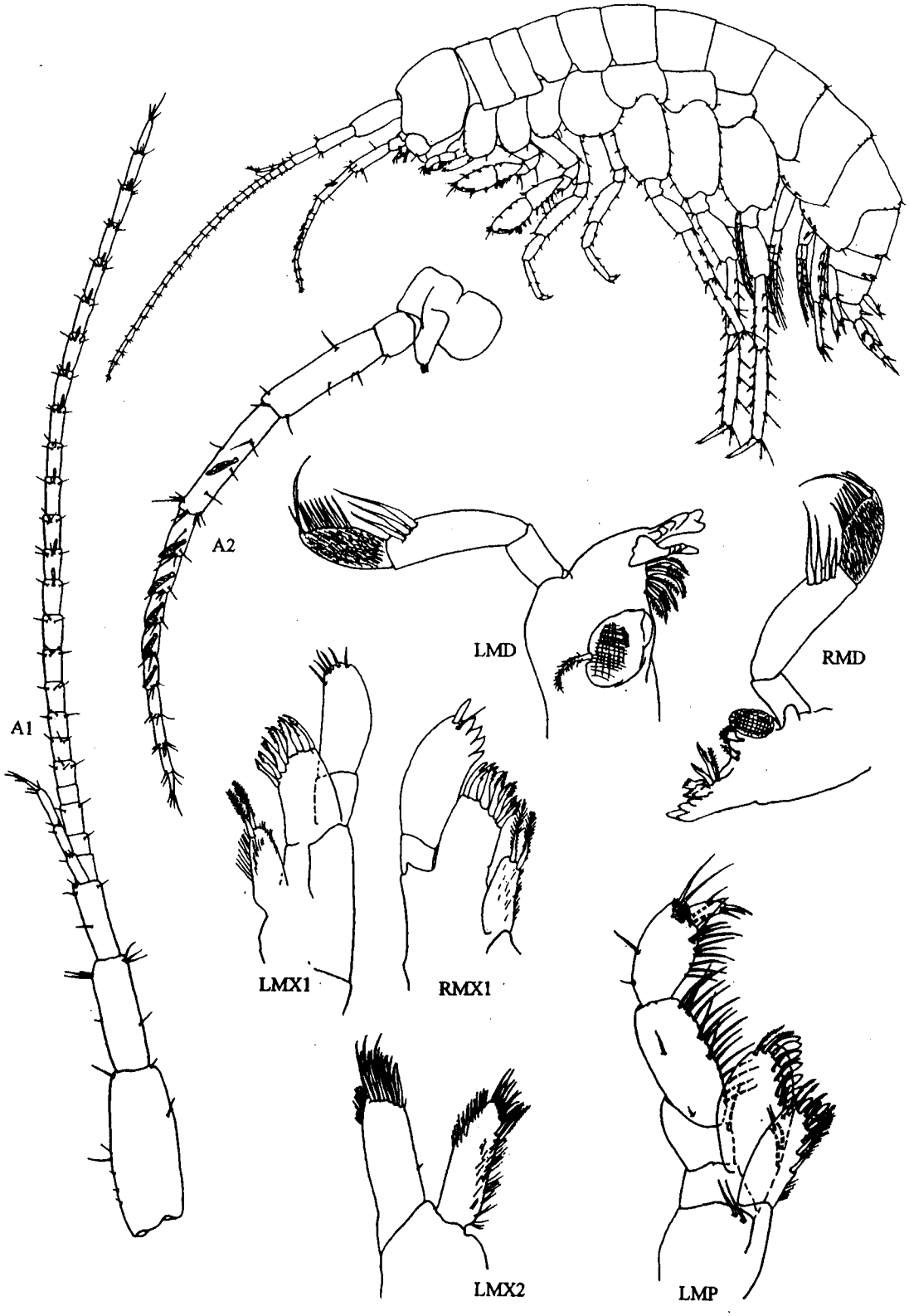

Fig. 3.60. *Chydaekata ovatosetosa* n. sp., holotype male 'c' 6 mm., whole animal, antennae and mouthparts.

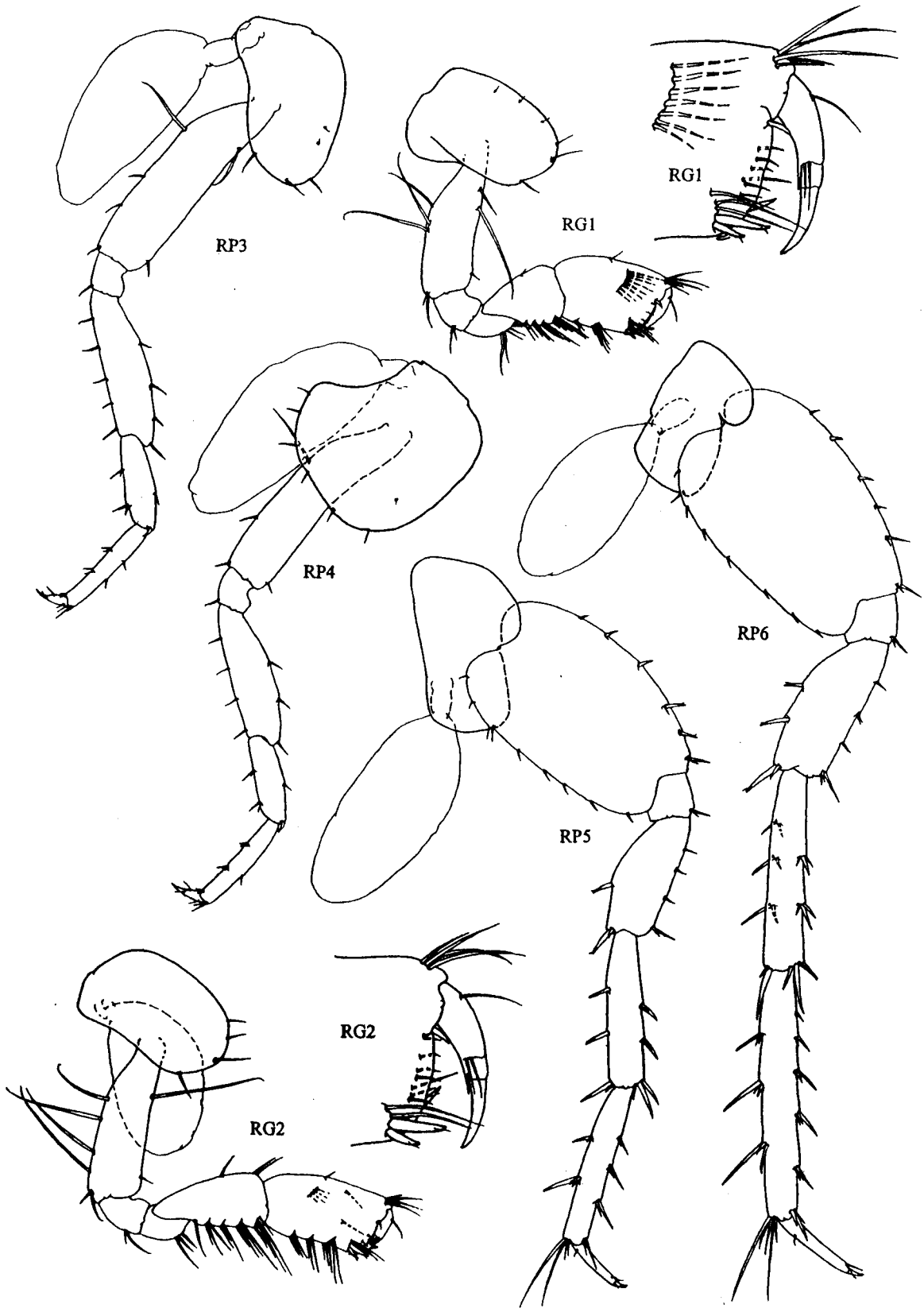

Fig. 3.61. *Chydaekata ovatosetosa* n. sp., holotype male 'c' 6 mm., gnathopods 1-2 and pereopods 3-6

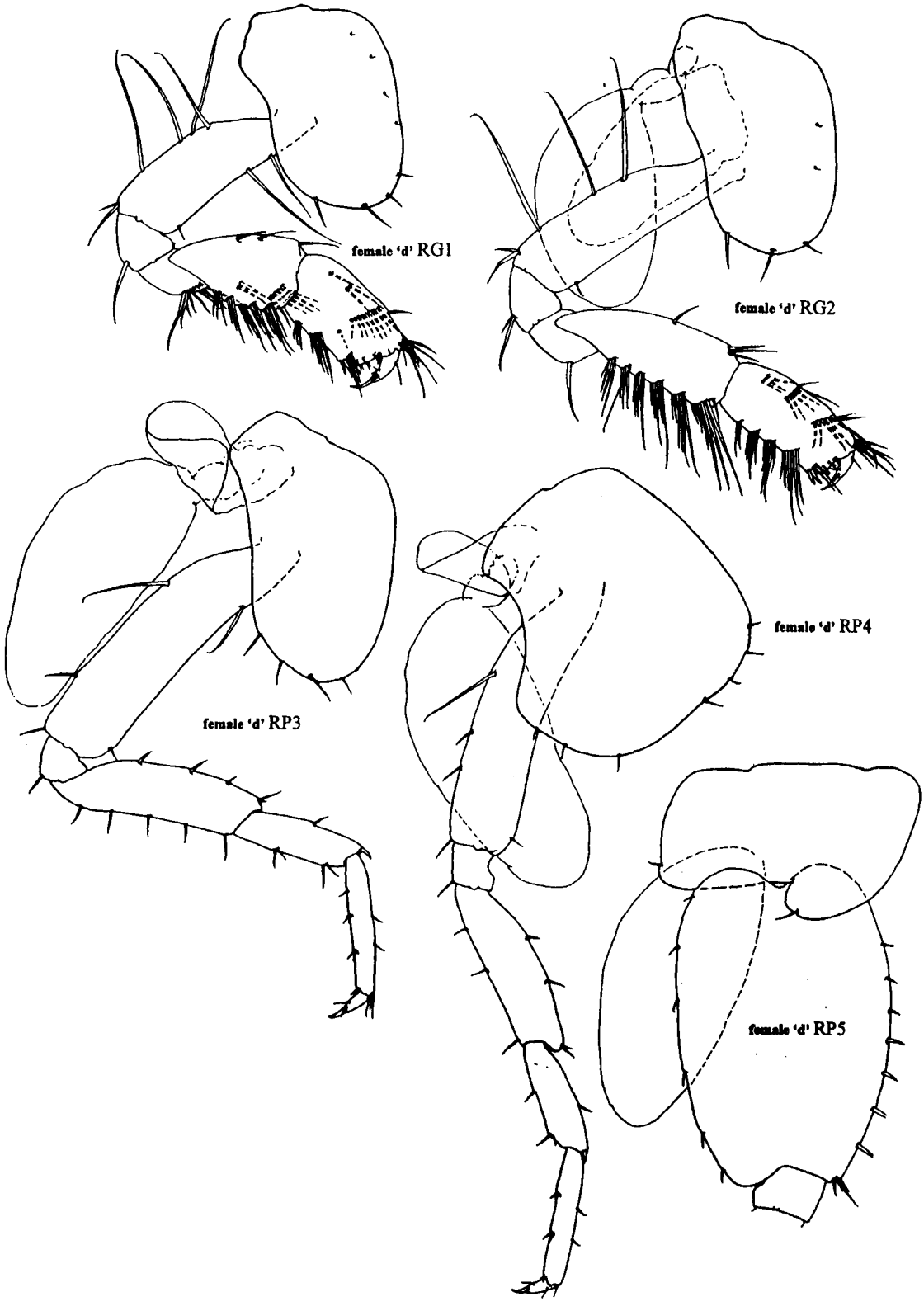

Fig. 3.62. *Chydaekata ovatosetosa* n. sp., allotype female 'd' 7 mm., gnathopods 1-2 and pereopods 3-5.

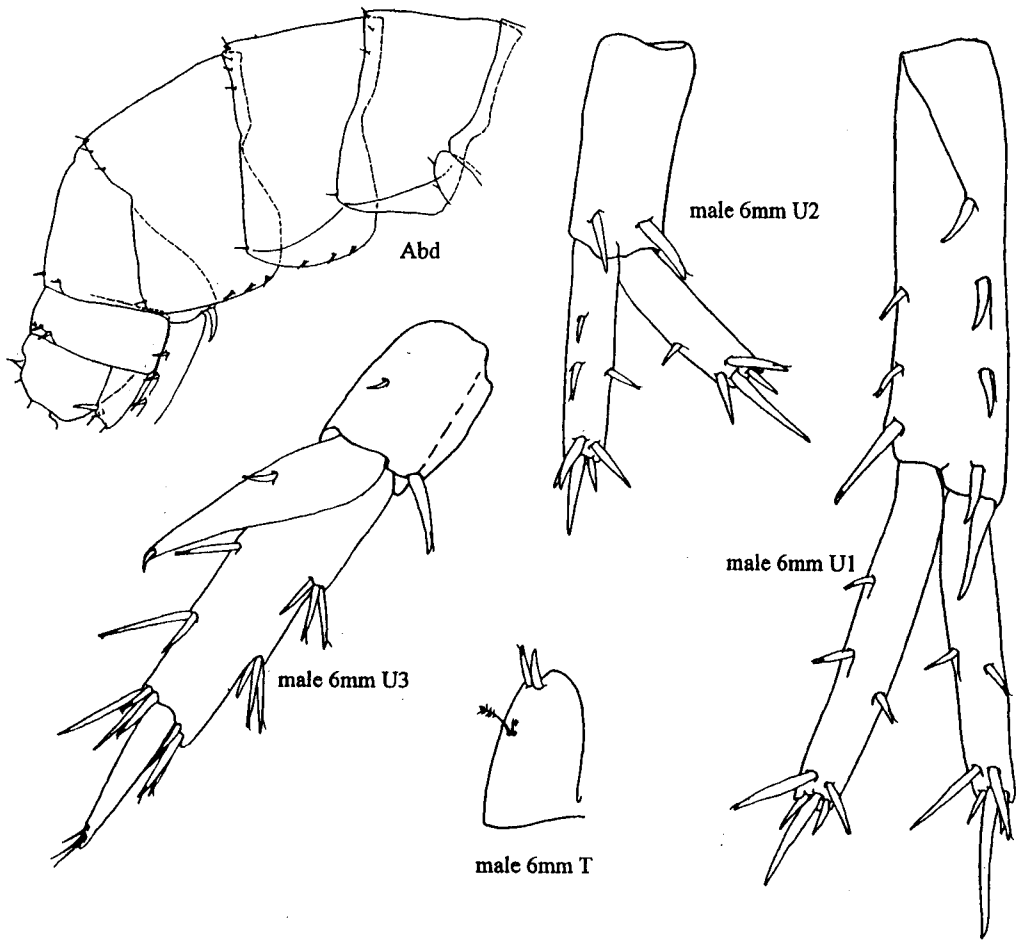

Fig. 3.63. *Chydaekata ovatosetosa* n. sp., holotype male 'c' 6 mm., abdomen, uropods 1-3, telson.

subrectangular, small, length 2 x width, with 2 medial robust setae, 1 lateral robust seta, and 2 additional lateral elongate setae, palmar angle transverse, smooth, dactyl reaching beyond palmar corner, with a single recumbent inner tooth spine. *Pereopods*: longer than the second gnathopod; coxa with 2 anterior setae, no long ventral setae, no short ventral setae, 1 seta at the posteroventral corner; carpus weakly setose posteriorly; pereopod 4 longer than pereopod 3, coxa anteroventral margin with 2 setae, posteroventral margin with 3 setae, ventral margin with 1 setae, posterior margin moderately emarginate, carpus weakly setose posteriorly; coxa 5 bearing 1 seta on anterior and posterior lobes, basis of pereopod 5 with short slender posterior setae, bearing short robust anterior setae or bearing short slender anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing no setae on anterior lobe, basis moderately expanded, bearing short robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 1 seta on the posterior lobe; basis bearing short robust anterior setae, moderately lobate posteroventrally; bases of pereopods equally expanded. *Epimera*: first epimeron without slender setae on posterior margin; posterior margin straight, posteroventral corner subquadrate; second epimeron without robust setae on anteroventral margin; posterior margin straight, posteroventral corner rounded; third epimeron with 2 robust setae on the anteroventral margin, without slender setae on ventral margin, posterior margin convex, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 and 2 with 1 feeble seta, of pleonite 3 with 2 feeble setae, and no distolateral robust setae. *Pleopods*: first pleopod with 1 accessory retinacula, second pleopod with 1 accessory retinacula, and third pleopod with no accessory retinacula. *Urosomites*: first urosomite bearing 2 distolateral slender setae and no distolateral robust setae; second urosomite with no distolateral slender setae and 1 distolateral robust seta. *First uropod*: peduncle length 1.3 x the length of the inner ramus, with a strong row of 3 dorsolateral robust setae and 2 dorsomedial robust setae; outer ramus with 1 dorsolateral and 1 dorsomedial robust setae; inner ramus with 1 dorsolateral and 2 dorsomedial robust setae, and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about 1 x length of inner ramus, with 1 apicolateral, no dorsomedial, and 1 apicomedial robust setae; inner ramus with no dorsolateral, 1 dorsomedial, and 5 apical robust setae; outer ramus with 1 dorsolateral, 2 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.8 x length of uropod 1;

peduncle length 0.3 x outer ramus, subequal in length to urosomite 3, with 1 apicolateral robust seta and no apicolateral slender setae, no dorsomedial robust setae and no dorsomedial slender setae, with no apicomedial robust setae and 1 apicomedial slender seta, and with no mediodistal robust setae; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands or arranged medially singly with 2 lateral transverse bands and 1 medial transverse band of robust setae, with no medial transverse bands of mixed robust and small setae, 1 medial robust seta, 4 apicolateral robust setae, no apicolateral small setae, 4 apicomedial robust setae, no apicomedial small or long slender setae; distal article short, with no apical robust setae and 3 apical slender setae; inner ramus with 1 medial robust seta, no apical robust setae, and 1 apical slender seta. *Telson*: subequal in length to urosomite 3, cleft 68 %, shorter than broad, length 0.9 x breadth; apices rounded and laterally notched with 2 subapical robust setae and no subapical slender setae, with 1 apical penicillate seta; and paired lateral penicillate setae at M0.6 from the telson base.

Description of the allotype (female 'd' 7mm.)

With the characteristics of the Holotype except. *Body*: length 7mm. *First antenna*: without aesthetascs or calceoli. *Second antenna*: without calceoli. *First gnathopod*: coxa bearing an additional anterior seta; carpus bearing 5 posterior transverse setal bands, and 2 medio-facial setal bands; propodus bearing 3 medio-facial setal bands. *Second gnathopod*: coxa with 1 fewer marginal setae; bearing large, naked, ovate oostegite, length about 1.0x coxal plate; carpus longer than male, bearing 6 posterior transverse setal bands; propodus bearing 4 posterior transverse setal bands and 3 mediofacial bands. *Pereopods*. Third pereopod; coxa with 1 additional marginal seta; bearing moderate sized, naked, ovate oostegite, length about 0.7x coxal plate. Fourth pereopod; coxa bearing additional marginal seta; with small to moderate sized ovate, naked oostegite, length about 0.5x coxal plate. Fifth pereopod; bearing a ventro-marginal seta on the anterior lobe; without oostegite.

Description of female 6mm.

With the characteristics of the holotype, except. *Body*: length 6mm. *Pereopods*. Pereopod 5 and pereopod 6 each bearing a ventral seta on the anterior lobe of the coxa; coxa 7 bearing an additional post-ventral seta.

Relationships

C. ovatosetosa differs from others of the genus in: second antenna: flagellum 9 articulate; left mandible: palp article 2 with a medio-distal row of 3 robust rastellate setae, article 3 with 7 D setae; left first maxilla inner plate ovate, inner plate facially setose (pubescent); maxilliped inner plate setae extending to a row of 1 similar subapical setae, inner plate with3 similar apical setae and 3 apicomedial naked tooth setae; outer plate without facial, submarginal or medial marginal setae; palp third article without facial long strong setae basal to the dactyl, facially naked; second gnathopod carpus with strong posterior rastellate setae ranked in 4 transverse bands; pereopod 4 longer than P3; epimera 1 with no slender setae on the posterior margin, posteroventral corner subquadrate; first uropod peduncle bearing 2 dorsomedial robust setae; first uropod peduncle bearing 1 apicomedial slender seta, inner ramus with 1 medial robust seta.

3.1.4.12 *Chydaekata anophelma* sp. nov. Figs. 3.64 - 3.66.

Etymology

From the Greek 'an' (not), and 'ophelma' (broom), referring to the absence of brushy basal setae on the molar of the left mandible.

Type locality

Newman bore W129, 23°14'S, 119°53'E.

Material examined

Holotype (Western Australian Museum, C24681) male 'a' 5mm, Allotype (Western Australian Museum, C24682) female 'b' 5mm, male 'c' 6mm, 57 others in the type series, same data as the holotype (Western Australian Museum, C24683), collection number BES 3539, S.Eberhard, 12/11/98.

Diagnosis

Second antenna: peduncle article 5 bearing 2 calceoli, flagellum 11 articulate, with calceoli on articles 1-7. Mandible: palp article 2 with a medio-distal row of 4 robust rastellate setae; article 3 with 10 D and 4 E setae apically. Left first maxilla: palp article 2 with 6 apical setae. Right first maxilla: palp apex with no articulated, and 3 fused broad based tooth setae. Maxilliped outer plate with a row of 9 slender naked, medial submarginal to disto-facial setae; a medial row of 8 submarginal to subapical robust, naked, tooth setae; 3 apicolateral setae. First gnathopod propodus:

dactyl not reaching to palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 5 transverse bands. Telson: cleft 72%, bearing 2 subapical robust setae.

Description of the holotype (male 'a' 5mm)

Body: urosomite 1 bearing 1 dorsolateral robust setae; urosomite 2 bearing 2 dorsolateral robust setae. *First antenna*: length 0.6 x body, 1.7 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 27 articles; accessory flagellum of 5 articles, reaching to article 6 of primary flagellum. *Second antenna*: length 0.3 x body; peduncle length greater than flagellum, article 5 bearing 2 calceoli, article 4 subequal with article 5, articles 3-5 with sparse setation; flagellum 11 articulate, with sparse setation, bearing calceoli on articles 1 - 7. *Left mandible*: palp article 2 with a medio-distal row of 4 robust rastellate setae, article 3 with 10 D and 4 E setae, facially setulose (pubescent); incisor with 5 teeth, lacinia mobilis with 5 teeth, and 4 plumose interraker setae; molar without pappose seta, without penicillate hooked brushy basal setae, and few penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 4 robust rastellate setae, article 3 with 10 D and 4 E setae; incisor with 4 teeth, and 2 plumose interraker setae; molar without penicillate hooked brushy basal setae, and no penicillate setules. *Left first maxilla*: palp article 2 with 4 apical and 1 subapical facial strong slender setae, with 1 apicomedial seta; outer plate with 10 robust setae - 10 denticulate, none naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: with 5 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 3.6 x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 3.3 x width, extending to M0.7 of the outer plate, bearing small setules on the lateral margin and medioproximal face, no facial pappose setae, with a row of 5 submarginal to subapical pappose setae, extending to a row of 4 similar subapical, 1 mediodistal, and 3 apical naked tooth setae; outer plate broad, length 2.3 x width, distally setulose (pubescent), with a row of 9 slender naked, medial submarginal to distal facial setae, a medial row of 8 submarginal to subapical robust, naked, tooth setae, and 3 apicolateral setae - none naked, 3 pappose; palp second article strongly setose medially; third article sparsely setose laterally, moderately setose medially, with 3 facial and 3 ventrofacial long strong setae basal to the dactyl, the apex moderately

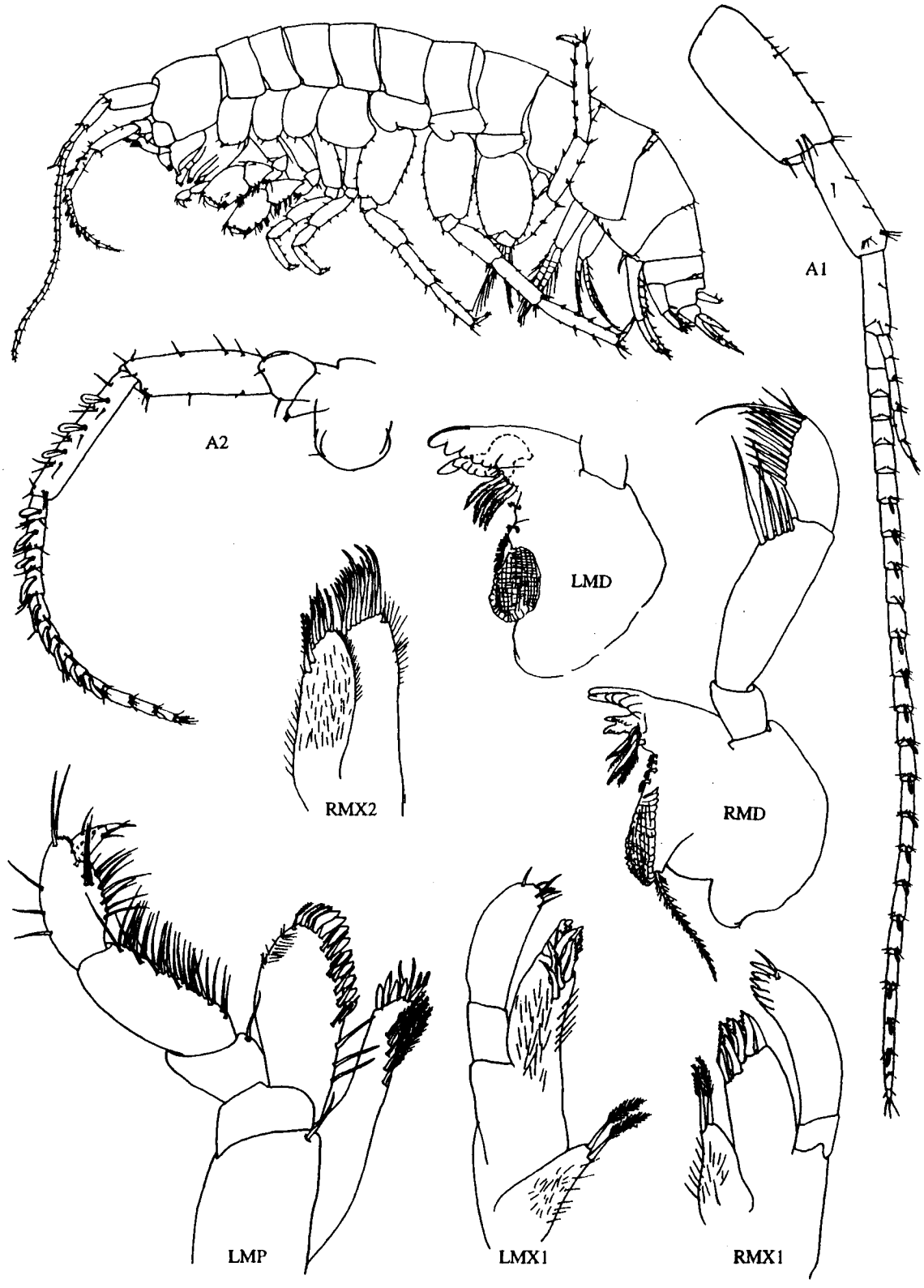

Fig. 3.64. *Chydaekata anophelma* n. sp., holotype male 'a' 5 mm., whole animal, antennae and mouthparts.

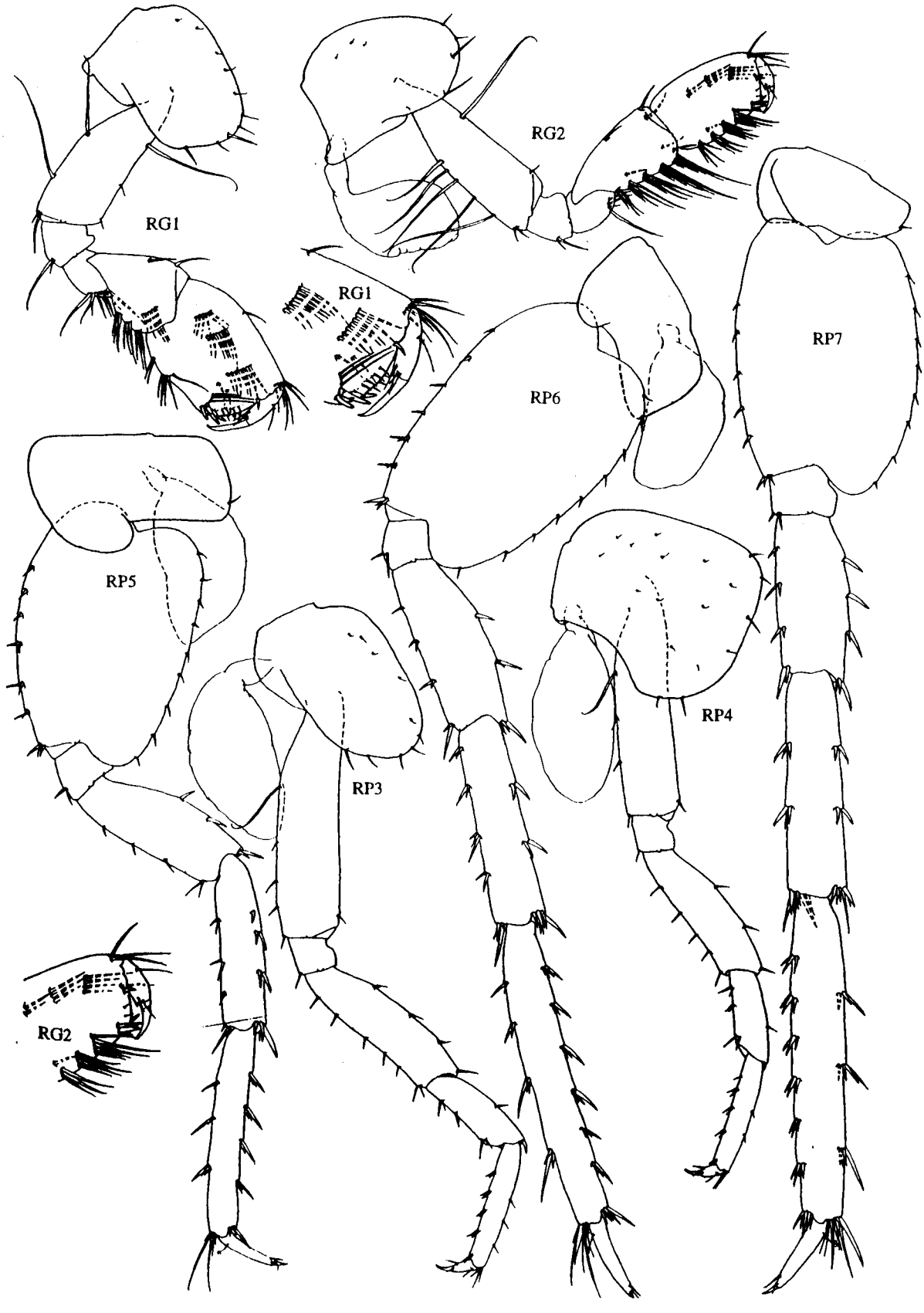

Fig. 3.65. *Chydaekata anophelma* n. sp., holotype male 'a' 5 mm., gnathopods and pereopods.

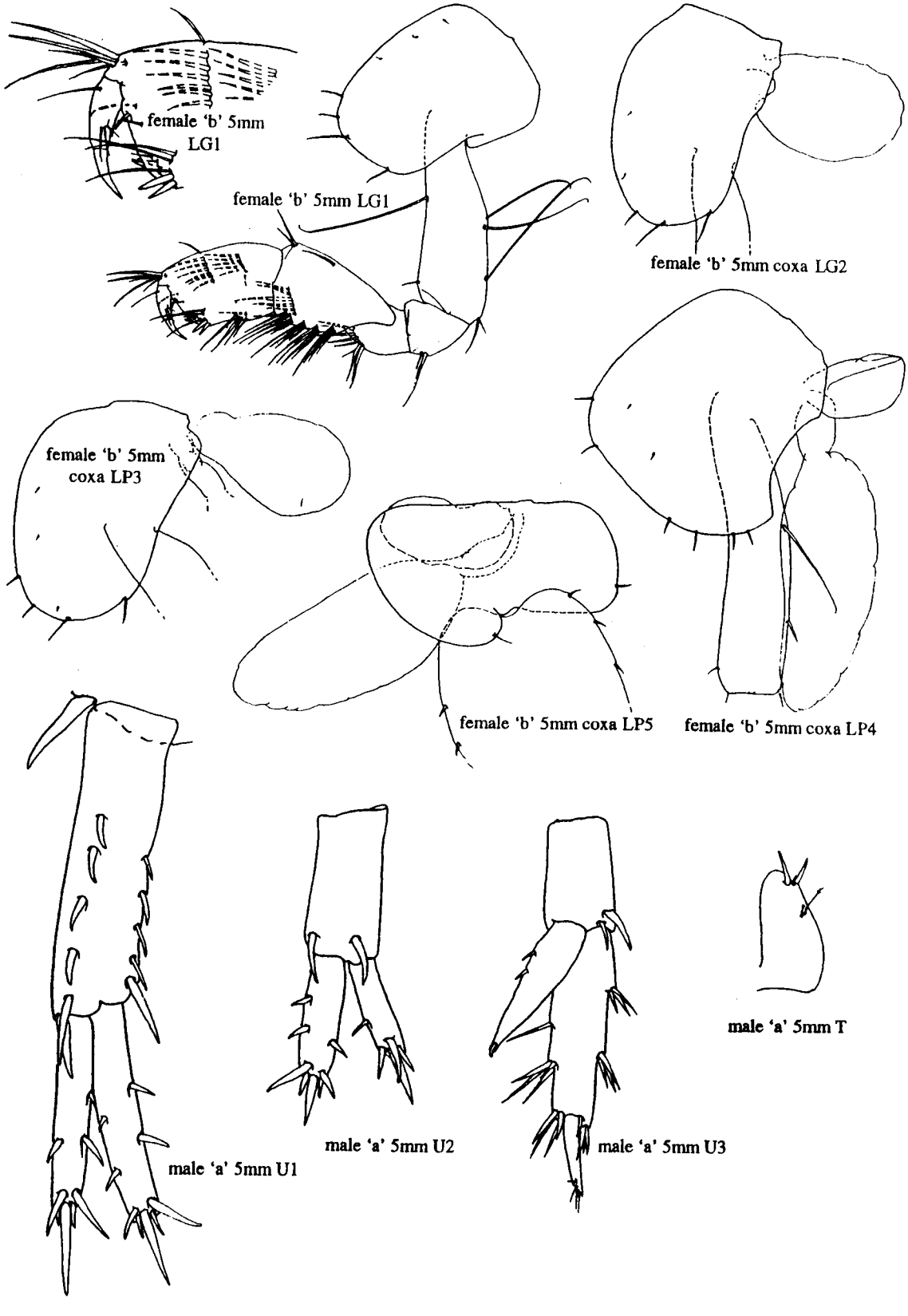

Fig. 3.66. *Chydaekata anophelma* n. sp., holotype male 'a' 5 mm., uropods 1-3, telson. Allotype female 'b' 5 mm., coxae 2-5.

produced, setulate, with 2 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 3 anteroventral setae, and no ventral setae; merus bearing posterior hump; carpus of moderate length, 1.5 x width, subtriangular, posterior margin with setae ranked in 4 transverse bands; propodus subrectangular, small, length 1.8 x width, posteroventral corner rounded, with 2 lateral and 1 medial robust setae, and 2 additional lateral elongate setae, palmar angle slightly oblique, smooth, dactyl not reaching to palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 2 anteroventral setae and 1 ventral seta; carpus length 2.1 x width, subtriangular, with setae ranked in 5 transverse bands; propodus subrectangular, moderate size, length 2 x width, with 2 lateral robust setae, 1 medial robust seta, and 1 additional lateral elongate seta, palmar angle transverse, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Pereopods*: pereopod 3 longer than the second gnathopod; coxa with 1 anterior seta, 2 short ventral setae, 1 seta at the posteroventral corner; carpus weakly setose posteriorly; pereopod 4 subequal in length with pereopod 3, coxa anteroventral and posteroventral margins with 3 setae, ventral margin with no setae, posterior margin moderately emarginate, carpus weakly setose posteriorly; coxa 5 bearing no setae on anterior lobe, and 1 seta on the posterior lobe; basis of periopod 5 with short slender posterior setae, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing no setae on anterior lobe, basis moderately expanded, bearing short robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 2 setae on the posterior lobe; basis bearing short and long robust anterior setae, moderately lobate posteroventrally; bases of periopods equally expanded. *Epimera*: epimeron 1 with 1 slender seta on the posterior margin, posterior margin convex, posteroventral corner rounded; epimeron 2 with 2 robust setae on the anteroventral margin, posterior margin convex, posteroventral corner rounded; epimeron 3 with 3 robust setae on the anteroventral margin, without slender setae on ventral margin, posterior margin convex, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 2 feeble setae, of pleonite 2 with 3 feeble setae, of pleonite 3 with 4 feeble setae and no distolateral robust setae. *Pleopods*: first pleopod with no accessory retinacula, second pleopod with 1 accessory retinacula, and third pleopod with no accessory retinacula. *Urosomites*: first urosomite bearing no distolateral slender setae, and 1 distolateral robust seta;

urosomite 2 with no distolateral slender setae, and 2 distolateral robust setae. *First uropod*: peduncle length 1.2 x the length of the inner ramus with a strong row of 3 dorsolateral robust setae, and 3 dorsomedial robust setae; outer ramus with 1 dorsolateral robust setae, and 2 dorsomedial robust setae; inner ramus with 1 dorsolateral robust seta, 3 dorsomedial robust setae, and 5 apical robust setae. *Second uropod*: 0.8 x length of uropod 1, peduncle about 2 x length of inner ramus; with 1 apicolateral, no dorsomedial, and 1 apicomedial robust setae; inner ramus with 1 dorsolateral, 1 dorsomedial, and 5 apical robust setae; outer ramus with 1 dorsolateral, 3 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.8 x length of uropod 1; peduncle length 0.6 x outer ramus, subequal in length to urosomite 3, with 1 apicolateral robust seta, and no apicolateral slender setae, with no dorsomedial robust setae, and no dorsomedial slender setae, no apicomedial robust setae, no apicomedial slender setae, and with 1 mediodistal robust seta; inner ramus length 0.6 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands and arranged medially singly with 3 lateral transverse bands of robust setae, 1 medial transverse band of robust setae, with no medial transverse bands of mixed robust and small setae, 1 medial robust seta, 3 apicolateral robust setae, no apicolateral small setae, 3 apicomedial robust setae, no apicomedial small setae, no apicomedial long slender setae; distal article short, with no apical robust setae, and 3 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender seta. *Telson*: shorter than, 0.8 x, urosomite 3; cleft 72 %, as long as broad; apices rounded, with 2 subapical robust setae, and no subapical slender setae; apical penicillate setae absent, with paired lateral penicillate setae at M0.6 from the telson base.

Description of the allotype (female 'b' 5mm)

With the characteristics of the Holotype except. *Body*: length 5mm. *First antenna*: without aesthetascs or calceoli. *Second antenna*: without calceoli. *First gnathopod*: smaller than the male; coxa bearing 4 (versus 5) marginal setae; carpus more elongate than the male, bearing 4 (versus 3) posterior translateral setal bands; propodus less robust than male, bearing 1 (versus 2) posteriro translateral setal bands and 2 (versus 3) medio-facial bands. *Second gnathopod*: coxa bearing 3 (versus 4) marginal setae, and (naked, ovate oostegite). *Pereopods*. Pereopod three: bearing 4 (versus 5) marginal setae and (naked, ovate oostegite). Pereopod

four: bearing 6 (versus 5) marginal setae and a small, naked, ovate oostegite, length about 0.4x coxal plate. Pereopod five: coxa bearing 1 ventro-marginal seta (versus none) on the anterior lobe, and a small/moderate length naked, ovate oostegite, length about 0.5x coxal plate. Pereopods six and seven: similar to the holotype.

Description of male 'c' 6mm)

With the characteristics of the Holotype except. *Body*: length 6mm. *First antenna*: primary flagellum of 22articles, the accessory flagellum of 4. *Second antenna*: flagellum of 9 articles, bearing prominent calceoli on articles 1, 3-6.

Relationships

C. anophelma differs from others of the genus in: first gnathopod propodus posteroventral corner bearing 2 additional elongate setae on the lateral face; second gnathopod propodus posteroventral corner with 1 additional lateral elongate seta; pereopods 5 coxa bearing no setae on anterior lobe; epimera 2 posterior margin convex; first pleopod with no accessory retinacula; second uropod 0.7-1.0 x length of uropod 1, peduncle length 1.4-2.5x length of inner ramus; third uropod outer ramus proximal article with 3 apicomedial robust setae.

3.1.4.13 *Chydaekata scopula* sp. nov. Figs. 3.67 - 3.70.

Etymology

From the Latin 'scopa' (broom), referring to the presence of brushy basal setae on the molar of the left mandible.

Type locality

Newman bore field, PZ13S, 23°19'S, 117°51'E.

Material examined

Holotype (Western Australian Museum, C24684) male 'a' 5.5mm, Allotype (Western Australian Museum, C24685) female 'b' 6.5mm, 7 others in the type series, same data as the holotype (Western Australian Museum, C24686). Collection number BES 4843, taken with haul net, W. F. Humphreys and S. M. Eberhard, 24/07/97.

Diagnosis

Second antenna: peduncle article 5 bearing 2 calceoli, flagellum 13 articulate, with calceoli on articles 1-7. Mandible: palp article 2 with a medio-distal row of 4 robust rastellate setae; article 3 with 10 D and 4 E setae apically. Left first maxilla: palp

article 2 with 6 apical setae. Right first maxilla: palp apex with no articulated, and 4 fused broad based tooth setae. Maxilliped outer plate with a row of 9 slender naked, medial submarginal to disto-facial setae; a medial row of 8 submarginal to subapical robust, naked, tooth setae; 2 apicolateral setae. First gnathopod propodus: dactyl reaching to palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 6 transverse bands. Telson: cleft 71%, bearing 3 subapical robust setae.

Description of the holotype (male 'a' 5.5mm)

Body: urosomites 1 and 2 bearing 2 dorsolateral robust setae. *First antenna*: length 0.5 x body, 1.6 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 31 articles; accessory flagellum of 5 articles, reaching to article 5 of primary flagellum. *Second antenna*: length 0.3 x body; peduncle length greater than flagellum, article 5 bearing 2 calceoli, article 4 subequal with article 5, articles 3-5 with sparse setation; flagellum 13 articulate, with sparse setation, bearing calceoli on articles 1 - 7. *Left mandible*: palp article 2 with a medio-distal row of 4 robust rastellate setae, article 3 with 10 D and 4 E setae, facially setulose (pubescent); incisor with 5 teeth, lacinia mobilis with 5 teeth, and 4 plumose interraker setae; molar bearing pappose seta, with 1 penicillate hooked brushy basal seta. *Right mandible*: palp article 2 with a medio-distal row of 3 robust rastellate setae, article 3 with 9 D and 4 E setae; incisor with 5 teeth, and 2 plumose interraker setae; molar with 3 penicillate hooked brushy basal setae. *Left first maxilla*: palp article 2 with 4 apical, with 1 apicomedial, and 1 ventrofacial apicomedial strong slender setae; outer plate with 10 robust setae - 10 denticulate, none naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with no articulated and 4 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 3.9 x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 3.3 x width, extending to M0.7 of the outer plate, bearing small setules on the lateral margin and medioproximal face, with a row of 4 submarginal pappose setae, extending to a row of 5 similar subapical, and 2 apical setae, and 3 apical naked tooth setae; outer plate broad, length 1.8 x width, distally setulose (pubescent), with a row of 9, slender naked, medial submarginal to distal facial setae, a medial row of 8 submarginal to subapical robust, naked, tooth setae, and 2 apicolateral setae -

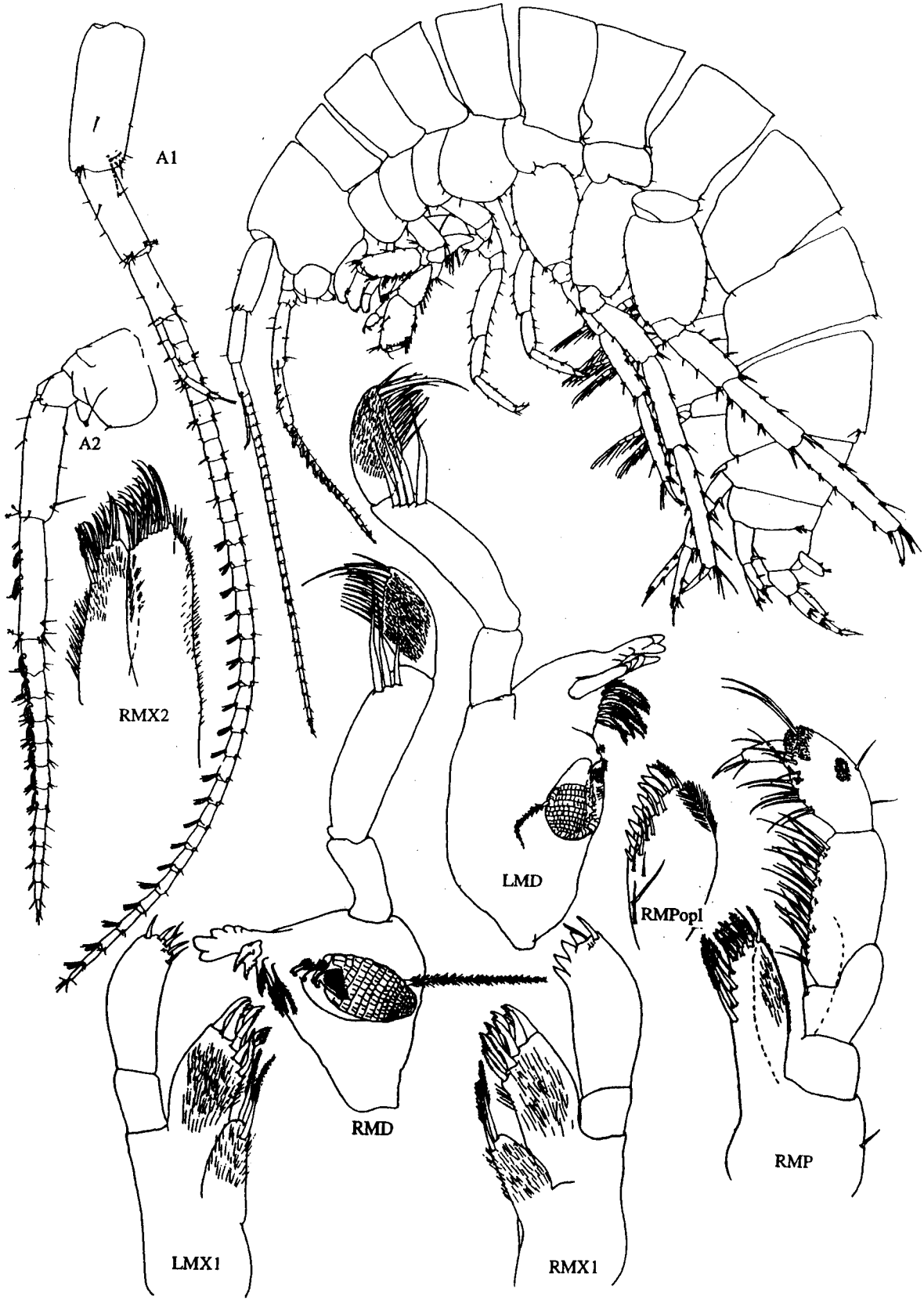

Fig. 3.67. *Chydaekata scopula* n. sp., holotype male 'a' 5.5 mm., whole animal, antennae and mouthparts.

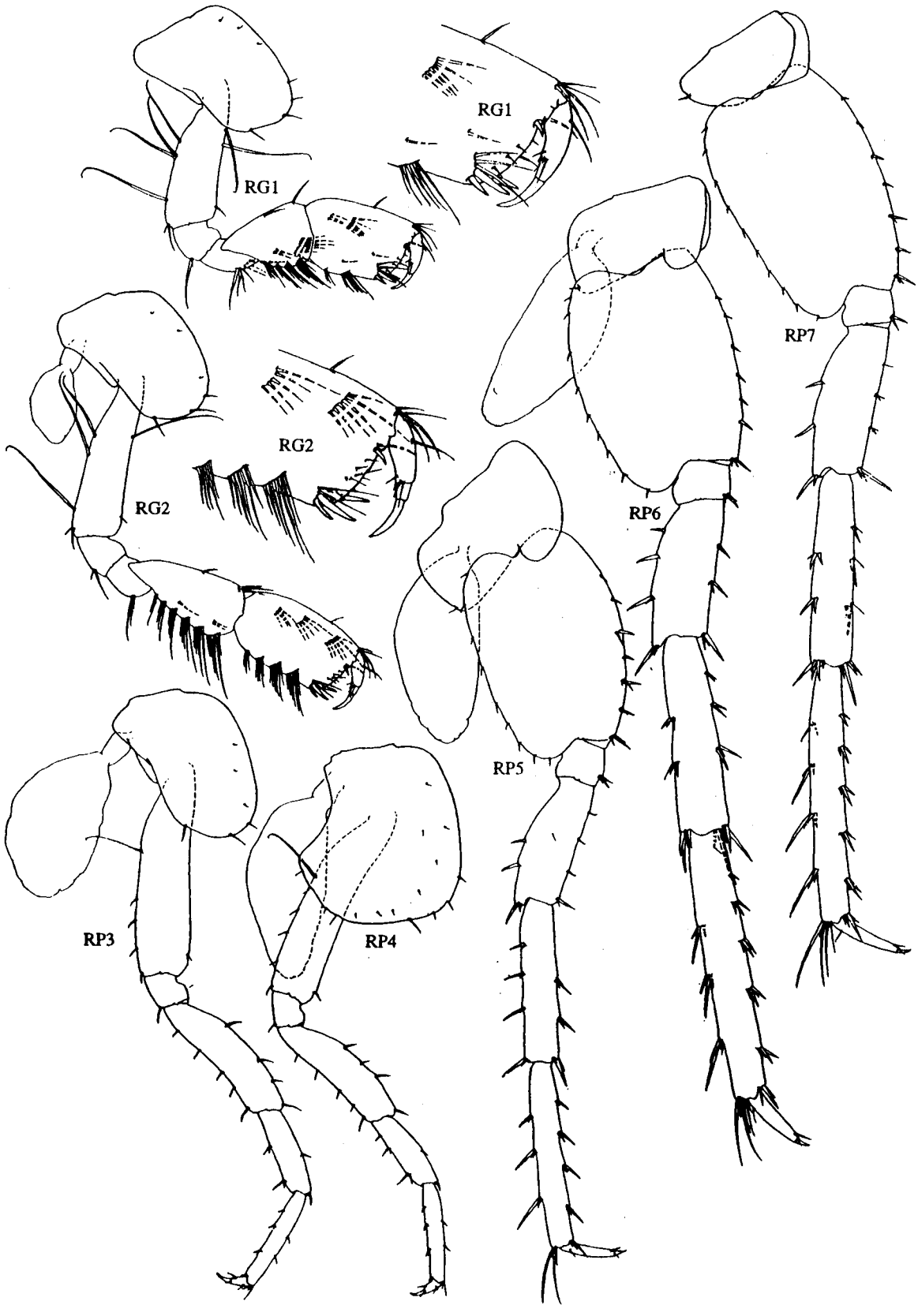

Fig. 3.68. *Chydaekata scopula* n. sp., holotype male 'a' 5.5 mm., gnathopods and pereopods.

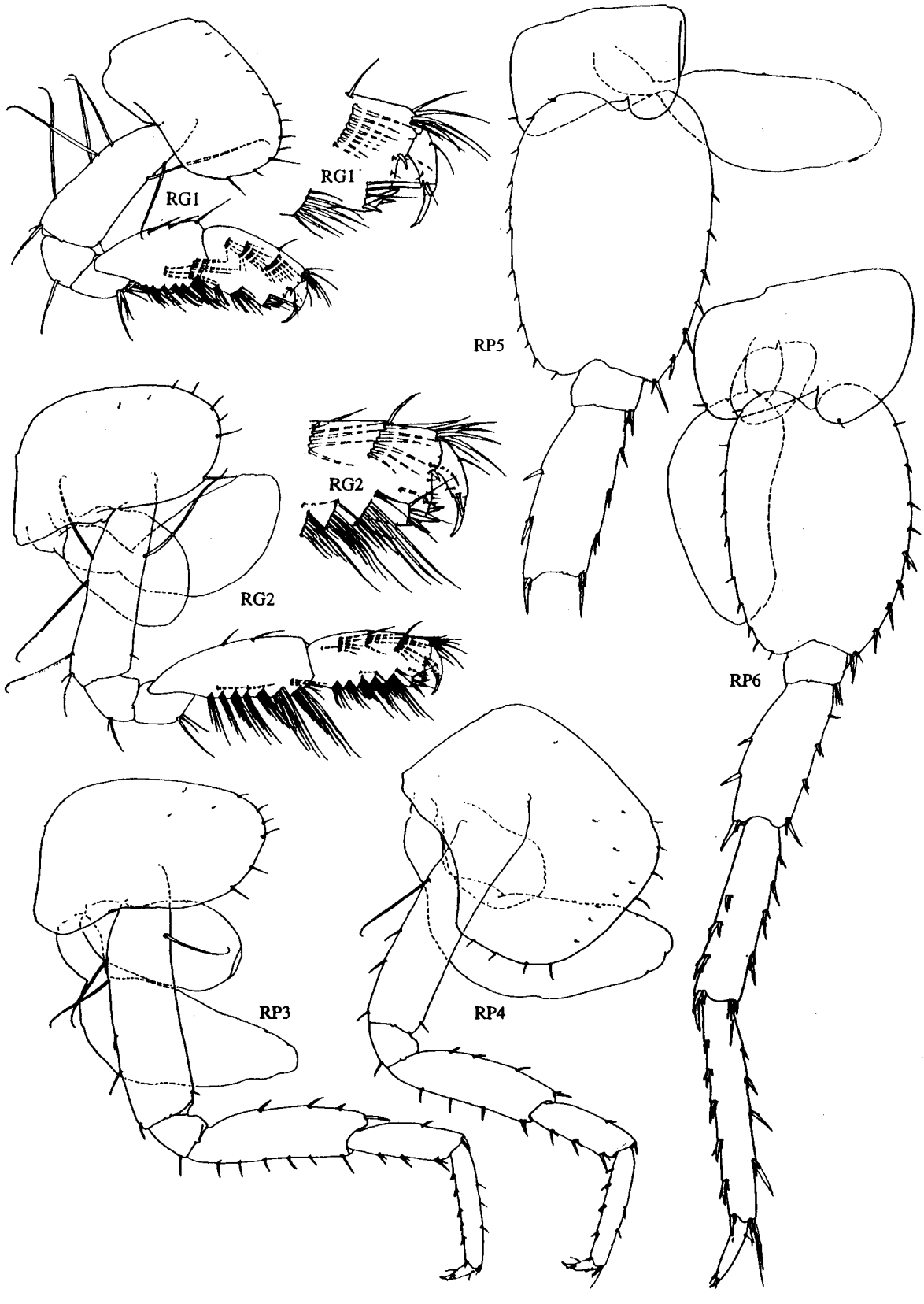

Fig. 3.69. *Chydaekata scopula* n. sp., allotype female 'b' 6.5 mm., gnathopods and pereopods 2-6.

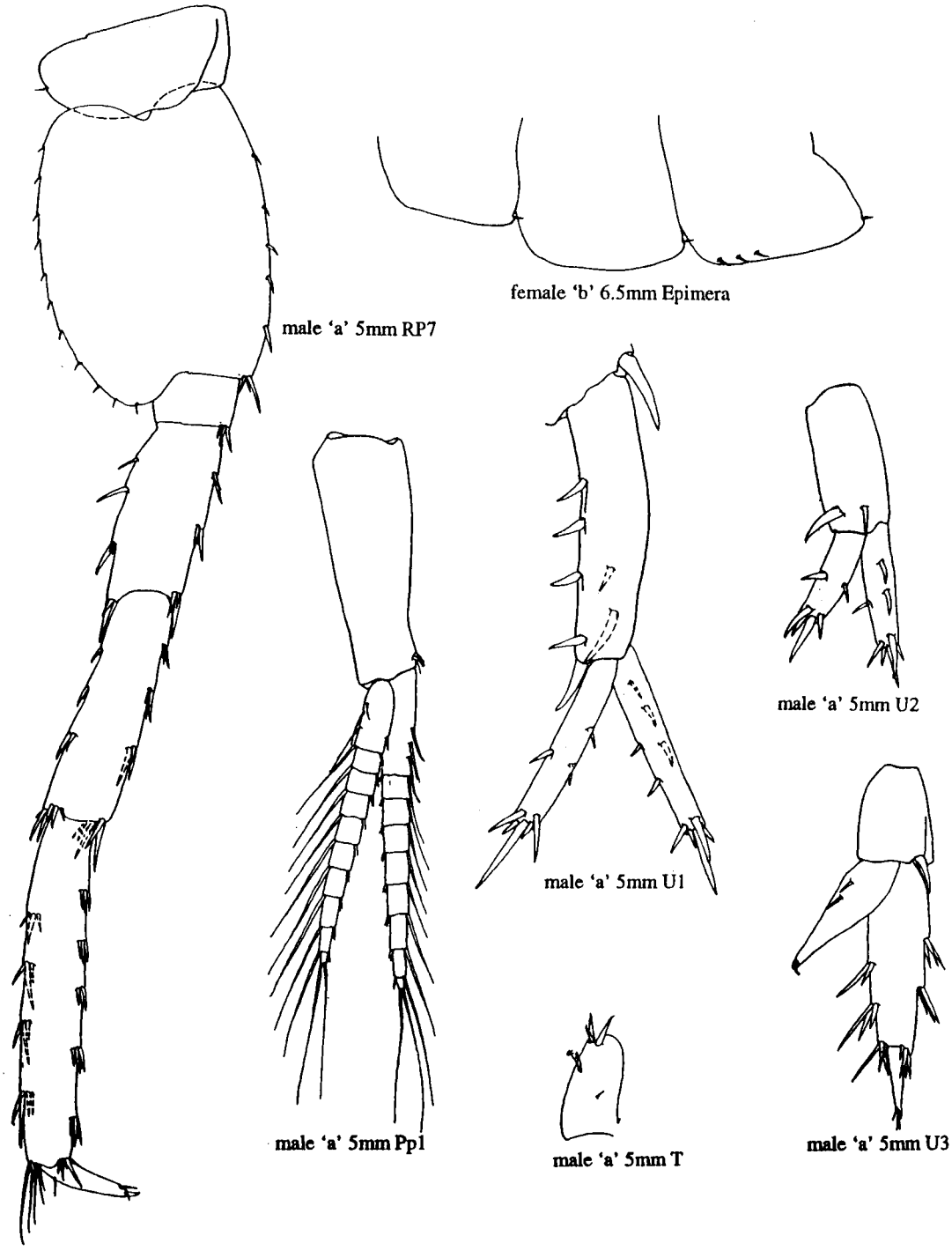

Fig. 3.70. *Chydaekata scopula* n. sp., holotype male 'a' 5.5 mm., pleopod 1, uropods 1-3, telson. Allotype female 'b' 6.5 mm., pereopod 7, epimera.

none naked, 2 pappose; palp, second article moderately setose medially; third article sparsely setose laterally, moderately setose medially, with 3 facial, and 2 ventrofacial long strong setae basal to the dactyl, the apex moderately produced, setulate, with 2 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 3 anteroventral setae, and no ventral setae; merus without posterior hump; carpus of moderate length, 1.5 x width, subtriangular, posterior margin, with setae ranked in 4 transverse bands; propodus subrectangular, moderate size, length 1.7 x width, posteroventral corner rounded, with 2 lateral and 1 medial robust setae, and 3 additional lateral elongate setae, palmar angle slightly oblique, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 2 anteroventral setae, and no ventral setae; carpus length 2.2 x width, subtriangular, with posterior setae ranked in 6 transverse bands; propodus subrectangular, moderate size, length 1.7 x width, with 2 lateral and 1 medial robust setae, and 2 additional lateral elongate setae, palmar angle weakly oblique, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Pereopods*: pereopod 3 longer than the second gnathopod, coxa with 1 anterior seta, 1 short ventral seta, and 1 seta at the posteroventral corner; carpus weakly setose posteriorly; pereopod 4 subequal in length with pereopod 3, coxa anteroventral margin with 4 setae, posteroventral margin with 4 setae, ventral margin with no setae, posterior margin moderately emarginate, carpus weakly setose posteriorly; coxa 5 bearing 1 seta on anterior lobe, and 1 seta on the posterior lobe; basis with short slender posterior setae, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing no setae on anterior lobe; basis moderately expanded, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 1 seta on the posterior lobe; basis bearing short and long robust anterior setae, moderately lobate posteroventrally; bases of periopods equally expanded. *Epimera*:first epimeron with 1 slender seta on the posterior margin, posterior margin straight, posteroventral corner rounded; second epimeron with 1 robust seta on the anteroventral margin, posterior margin straight, posteroventral corner rounded; third epimeron with 3 robust setae on the anteroventral margin, without slender setae on ventral margin; posterior margin convex, posteroventral corner rounded, with small spine. *Pleon*: dorsolateral margin of pleonite 1 with no feeble setae, of pleonite 2 with 2 feeble

setae, of pleonite 3 with 1 feeble seta, and no distolateral robust setae. *Pleopods*: first and second pleopods with 1 accessory retinacula, and third pleopod with no accessory retinacula. *Urosomites*: first urosomite bearing 1 distolateral slender seta and 1 distolateral robust seta; urosomite 2 with no distolateral slender setae, and 3 distolateral robust setae. *First uropod*: peduncle length 1.4 x the length of the inner ramus, with a strong row of 3 dorsolateral robust setae, and 3 dorsomedial robust setae; outer ramus with 1 dorsolateral robust seta, and 2 dorsomedial robust setae; inner ramus with 2 dorsolateral robust setae, 2 dorsomedial robust setae, and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about 1.2 x length of inner ramus, with 1 apicolateral, no dorsomedial, and 1 apicomedial robust setae; inner ramus with 1 dorsolateral, 1 dorsomedial, and 5 apical robust setae; outer ramus with 1 dorsolateral, no dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.7 x length of uropod 1; peduncle length 0.4 x outer ramus, shorter than, 0.8 x, urosomite three, with 1 apicolateral robust seta, and no apicolateral slender setae, with no dorsomedial robust setae, and no dorsomedial slender setae, with no apicomedial robust setae, and no apicomedial slender setae, and with no mediodistal robust setae; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands, with 2 lateral transverse bands of robust setae, with 2 medial transverse bands of mixed robust and small setae, 4 apicolateral robust setae, no apicolateral small setae, 4 apicomedial robust setae, no apicomedial small setae, and no apicomedial long slender setae; distal article short, with no apical robust setae, and 3 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender seta. *Telson*: shorter than, 0.7 x, urosomite 3; cleft 71 %, shorter than broad, length 0.9 x breadth; apices rounded and laterally notched, with 3 subapical robust setae and no subapical slender setae; apical penicillate setae absent, with paired lateral penicillate setae at M0.6 from the telson base.

Description of the allotype (female 'b' 6.5mm)

With the characteristics of the Holotype except. *Body*: length 6.5mm. *First antenna*: without aesthetascs or calceoli. *Second antenna*: without calceoli. *First gnathopod*: coxa bearing 7 (versus 4) marginal setae; carpus longer than male, bearing 6 (versus 4) posterior translateral setal bands; propodus smaller and less robust than the male, tapering apically, bearing 3 (versus 2) mediofacial ranks of

setae, palm and dactyl similar to male. *Second gnathopod*: coxa bearing 6 (versus 3) marginal setae and a large, ovate, margianally smooth and naked oostegite, length about 0.7x coxal plate; carpus longer and narrower than the male, subrectangular rather than subtriangular, bearing 7 (versus 6) posterior translateral bands of setae as well as additional medial setae; propodus less robust than the male, longer and narrower, bearing 5 (versus 4) posterior translateral setal bands and additional medial setae, palm and dactyl similar. *Pereopods*. Pereopod three: coxa bearing 6 (versus 3) marginal setae, longer than the male, with a large, ovate, marginally smooth and naked oostegite, length about 0.7x coxal plate. Pereopod four: coxa bearing small, paddle shaped, naked, round oostegite, length about 0.5x coxal plate. Pereopod five: coxa bearing 1 (versus none) ventro-marginal seta on the anterior lobe, and a small round naked oostegite, length about 0.4x coxal plate. Pereopods six and seven: similar to the Holotype. *Epimera*: second epimeron lacking marginal anteroventral seta.

Relationships

C. scopula differs from others of the genus in: left first maxilla palp article 2 with no subapical facial strong slender setae; epimera 2 posterior margin straight; second uropod outer ramus bearing no dorsomedial robust setae; third uropod outer ramus proximal article with no medial transverse bands of robust setae but 2 medial transverse bands of mixed robust and small setae.

3.1.4.14 *Chydaekata scuticara* sp. nov. Figs. 3.71 - 3.74.

Etymology

From the Latin 'scutica' (whip, lash), referring to the presence of a pappose seta on the molar of the left mandible.

Type locality

Newman bore W135, 23°17'S, 119°52'E.

Material examined

Holotype (Western Australian Museum, C24687) male 'a' 6.5mm, Allotype (Western Australian Museum, C24688) female 'b' 6mm, male 6mm, 33 others in the type series, same data as the holotype (Western Australian Museum, C24689). Collection number BES 6379, S.Eberhard, 20/11/98.

Diagnosis

Second antenna: peduncle article 5 bearing 3 calceoli, flagellum 16 articulate, with calceoli on articles 1-10. Mandible: palp article 2 with a medio-distal row of 5 robust rastellate setae; article 3 with 14 D and 4 E setae apically. Left first maxilla: palp article 2 with 6 apical setae. Right first maxilla: palp apex with no articulated, and 4 fused broad based tooth setae. Maxilliped outer plate with a row of 9 slender naked, medial submarginal to disto-facial setae; a medial row of 8 submarginal to subapical robust, naked, tooth setae; 2 apicolateral setae. First gnathopod propodus: dactyl reaching to palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 6 transverse bands. Telson: cleft 80%, bearing 3 subapical robust setae.

Description of the holotype (male 'a' 6.5mm)

Body: urosomites 1 and 2 bearing 2 dorsolateral robust setae. *First antenna*: length 0.7 x body, 1.8 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 36 articles; accessory flagellum of 6 articles, reaching to article 7 of primary flagellum. *Second antenna*: length 0.4 x body; peduncle length greater than flagellum, article 5 bearing 3 calceoli, article 4 shorter than article 5, articles 3-5 with sparse setation; flagellum 16 articulate, with sparse setation, bearing calceoli on articles 1 - 10. *Left mandible*: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 14 D and 4 E setae, facially setulose (pubescent); incisor with 5 teeth, lacinia mobilis with 5 teeth, and 4 plumose interraker setae; molar bearing pappose seta, with 3 penicillate hooked brushy basal setae, and no penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 5 robust rastellate setae, article 3 with 14 D and 4 E setae; incisor with 4 teeth, and 2 plumose interraker setae; molar without penicillate hooked brushy basal setae, and no penicillate setules. *Left first maxilla*: palp article 2 with 2 apical and 1 subapical facial strong slender setae, and 3 apicomedial setae; outer plate with 10 robust setae - 10 denticulate, none naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with no articulated and 4 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 3.4 x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 2.6 x width, extending to M0.7 of the outer plate, bearing small setules on the lateral margin and

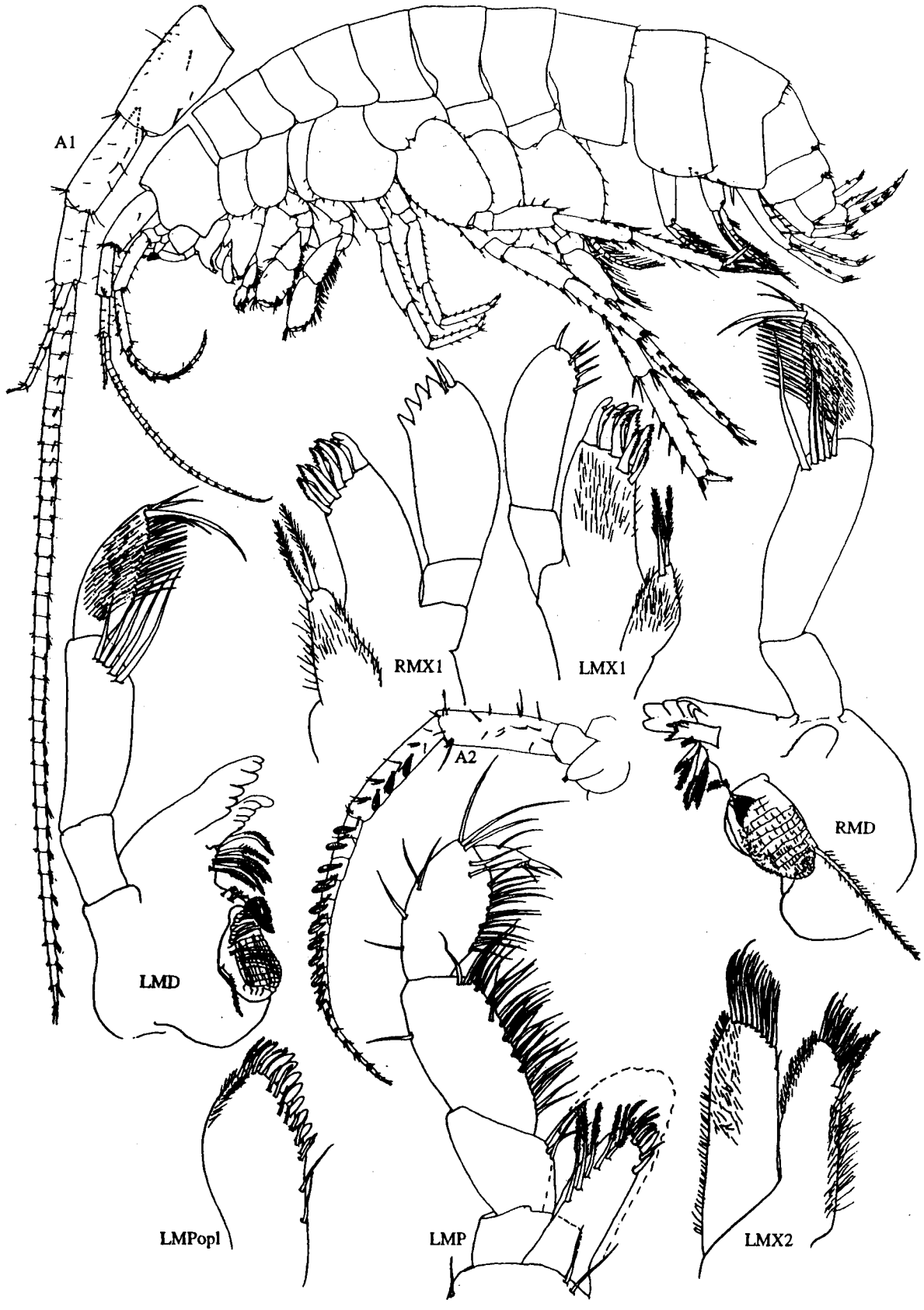

Fig. 3.71. *Chydaekata scuticara* n. sp., holotype male 'a' 6.5 mm., whole animal, antennae and mouthparts.

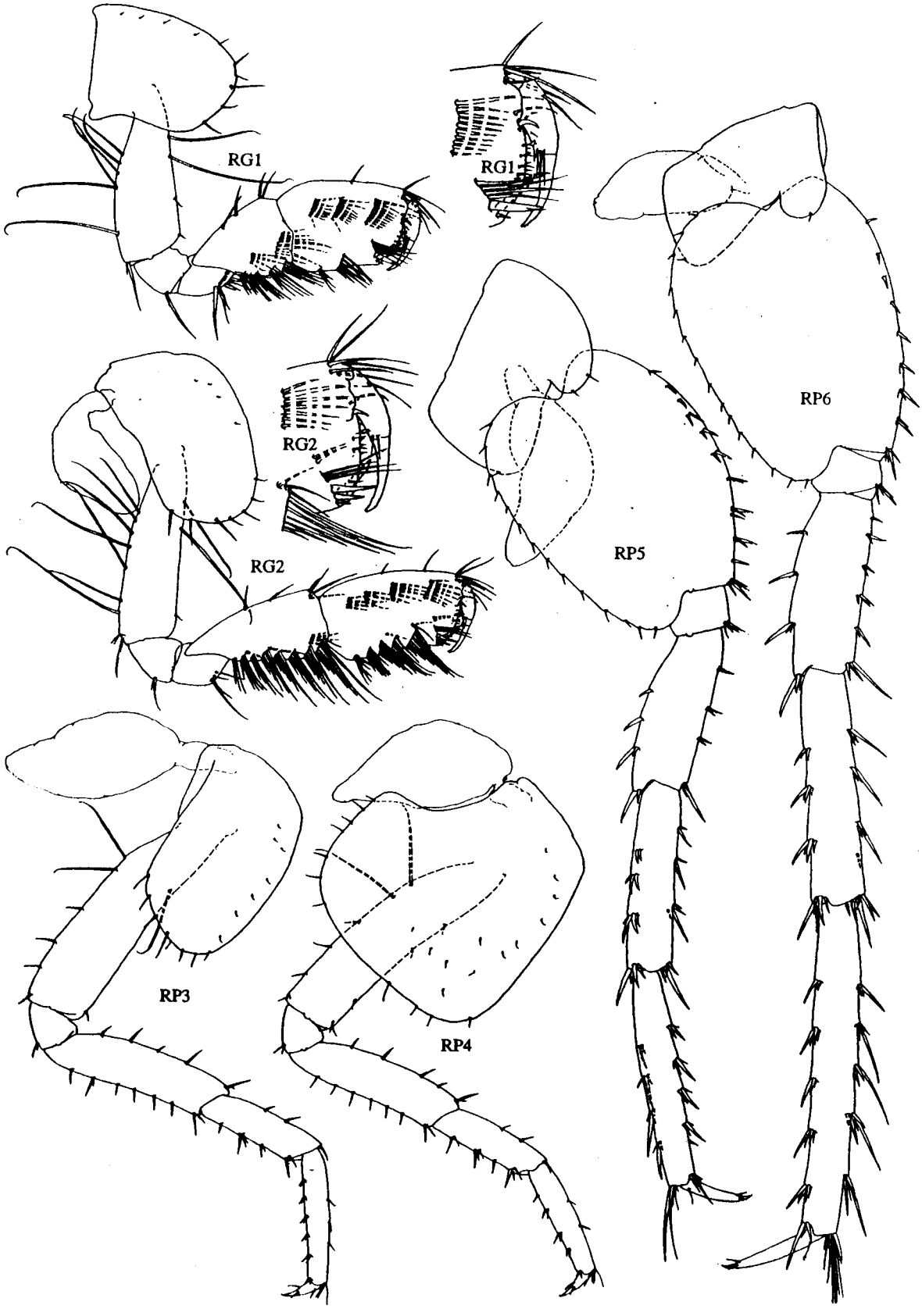

Fig. 3.72. *Chydaekata scuticara* n. sp., holotype male 'a' 6.5 mm., gnathopods and pereopods 3-6.

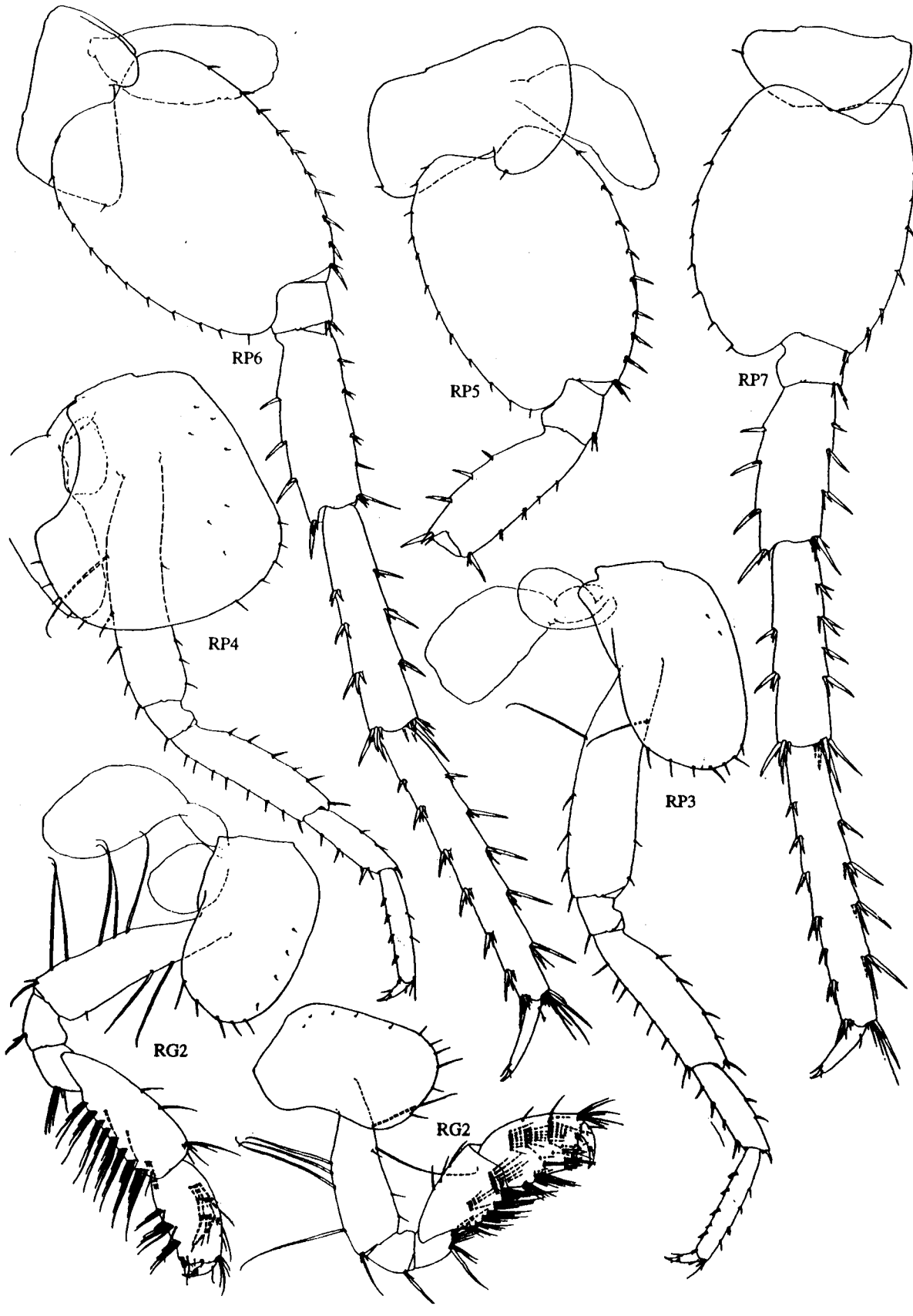

Fig. 3.73. *Chydaekata scuticara* n. sp., allotype female 'b' 6 mm., gnathopods and pereopods.

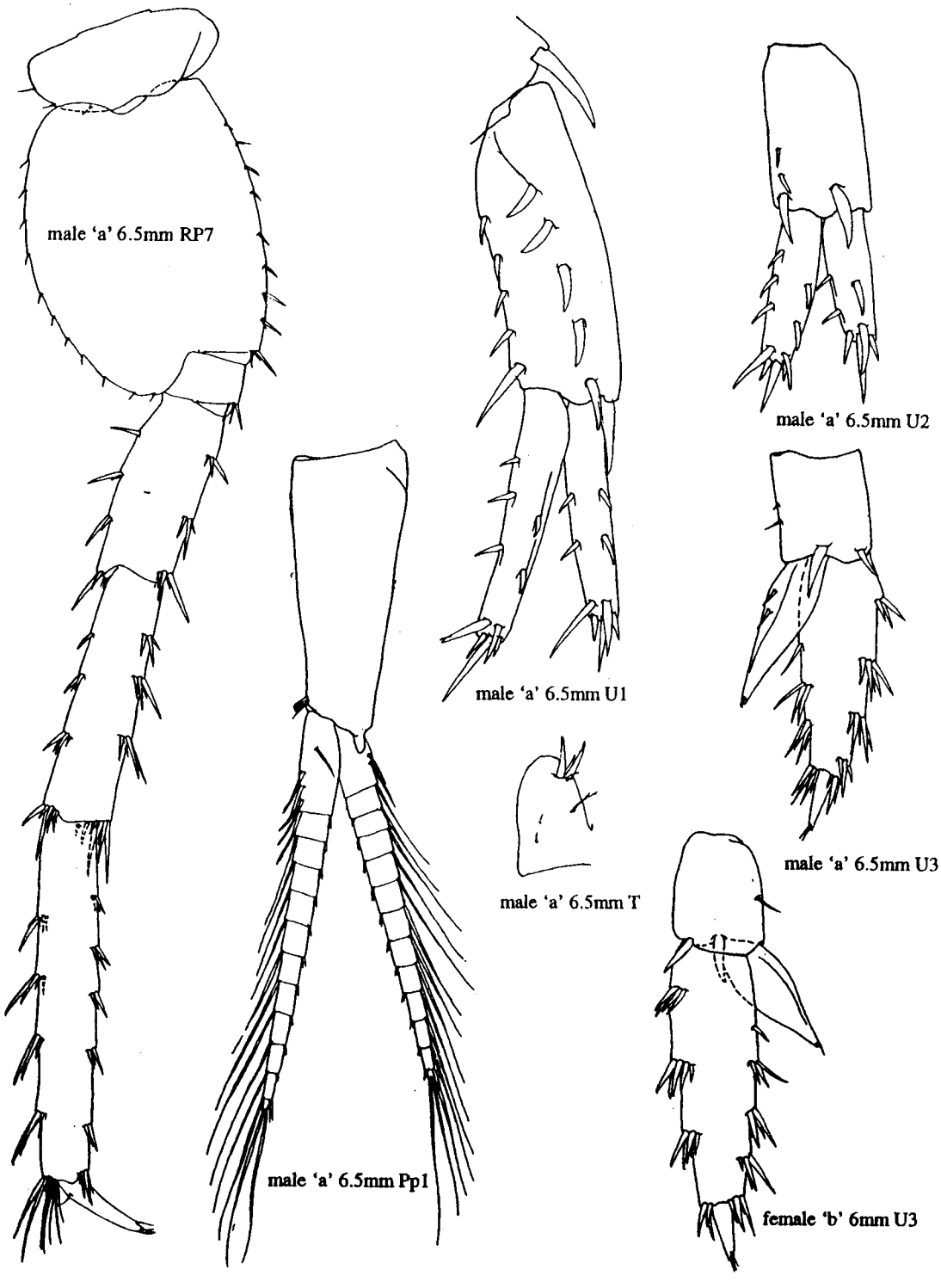

Fig. 3.74. *Chydaekata scuticara* n. sp., holotype male 'a' 6.5 mm., pereopod 7, pleopod 1, uropods 1-3, telson. Allotype female 'b' 6 mm., uropod 3.

medioproximal face, no facial pappose setae, no medial pappose setae, with a row of 4 submarginal to subapical pappose setae, extending to a row of 5 similar subapical, and 2 apical setae, with 1 apicomedial and 3 apical naked tooth setae; outer plate broad, length 1.7 x width, distally setulose (pubescent), with a row of 12, slender naked, medial submarginal to distal facial setae, a medial row of 9 submarginal to subapical robust, naked, tooth setae, and 3 apicolateral setae - none naked, 3 pappose; palp, second article moderately setose medially; third article sparsely setose laterally, moderately setose medially, with 2 facial, and 3 ventrofacial long strong setae basal to the dactyl, the apex weakly produced, setulate, with 3 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 2 anteroventral setae, and 3 ventral setae; merus without posterior hump; carpus of moderate length, 1.3 x width, subtriangular, posterior margin , with setae ranked in 6 transverse bands; propodus ovate, small, length 1.7 x width, posteroventral corner rounded, with 1 long and one small lateral robust setae, and 4 additional lateral elongate setae, palmar angle weakly oblique, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 3 anteroventral setae, and 3 ventral setae; carpus length 2.1 x width, subtriangular, with posterior setae ranked in 8 transverse bands; propodus subrectangular, small, length 1.9 x width, with 3 lateral robust setae, 1 medial robust seta, and 2 additional lateral elongate setae, palmar angle transverse, smooth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine. *Pereopods*: pereopod 1 longer than the second gnathopod coxa with 1 anterior seta, no long ventral setae, 6 short ventral setae, 1 seta at the posteroventral corner carpus weakly setose posteriorly; pereopod 4 subequal in length with pereopod 3 coxa anteroventral margin with 4 setae, posteroventral margin with 7 setae, ventral margin with no setae, posterior margin moderately emarginate carpus weakly setose posteriorly; coxa 5 bearing 1 seta on anterior lobe, and 1 seta on the posterior lobe; basis of periopod 5 with short slender posterior setae, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing 1 seta on anterior lobe, basis moderately expanded, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 2 setae on the posterior lobe basis bearing short and long robust anterior setae, moderately lobate posteroventrally; bases of periopods equally expanded. *Epimera*: first epimeron with 1 slender seta on the

posterior margin, posterior margin convex, posteroventral corner rounded; epimeron 2 with 3 robust setae on the anteroventral margin, posterior margin straight, posteroventral corner rounded; epimeron 3 with 6 robust setae on the anteroventral margin, with 1 slender setae on the ventral margin, posterior margin concave, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 4 feeble setae, of pleonite 2 with 7 feeble setae, of pleonite 3 with 6 feeble setae, and no distolateral robust setae. *Pleopods*: first, second and third pleopods with 1 accessory retinacula. *Urosomites*: urosomite 1 bearing 1 distolateral slender seta, and 2 distolateral robust setae; urosomite 2 with 1 distolateral slender setae, and 3 distolateral robust setae. *First uropod*: peduncle length 1.2 x the length of the inner ramus; with a strong row of 4 dorsolateral robust setae, and 4 dorsomedial robust setae; outer ramus with 2 dorsolateral robust setae, and 2 dorsomedial robust setae; inner ramus with 2 dorsolateral robust setae, 3 dorsomedial robust setae, and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about 1.1 x length of inner ramus; with 1 apicolateral, 1 dorsomedial, and 1 apicomedial robust setae; inner ramus with 1 dorsolateral, 2 dorsomedial, and 5 apical robust setae; outer ramus with 2 dorsolateral, 3 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.7 x length of uropod 1; peduncle length 0.4 x outer ramus, shorter than, 0.9 x urosomite three, with 1 apicolateral robust seta, and no apicolateral slender setae, with no dorsomedial robust setae, and 2 dorsomedial slender setae, with no apicomedial robust setae, and no apicomedial slender setae, and with no mediodistal robust setae; inner ramus length 0.6 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands or arranged medially singly with, with 4 lateral transverse bands of robust setae, with 2 medial transverse bands of robust setae, with no medial transverse bands of mixed robust and small setae, 1 medial robust seta, 3 apicolateral robust setae, no apicolateral small setae, 2 apicomedial robust setae, no apicomedial small setae, 3 apicomedial long slender setae; distal article short, with no apical robust setae, and 2 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender setae. *Telson*: shorter than, 0.9 x, urosomite 3; cleft 80 %, shorter than broad, length 0.8 x breadth; apices rounded and laterally notched with 3 subapical robust setae, and no subapical slender setae, with 1 apical penicillate seta and paired lateral penicillate setae at M0.5 from the telson base.

Description of the allotype (female 'b' 6mm)

With the characteristics of the Holotype except. *Body*: length 6mm. *First antenna*: without aesthetascs or calceoli. *Second antenna*: without calceoli. *First gnathopod*: coxa longer than male but similarly armed; carpus longer, more slender than male but similarly subtriangular, bearing 7 (versus 5) posterior translateral setal bands; propodus less robust, narrower and apically tapering, bearing 3 (versus 2) lateral robust setae at the palmar corner. *Second gnathopod*: coxa bearing 5 (versus 7) marginal setae, with a small/moderate round naked oostegite, length about 0.5x coxal plate; carpus longer and more slender than the male, but similarly armed; propodus less robust than the male, shorter and narrower, tapering apically, bearing 3 (versus 5) posterior translateral bands of setae and 3 (versus 4) medio-facial bands, palmar corner with 1 (versus 3) lateral robust seta, otherwise palm and dactyl similarly armed. *Pereopods*. Pereopod three: coxa with 7 (versus 8) marginal setae, bearing moderately small ovate, naked oostegite, length about 0.5x coxal plate. Pereopod four: coxa with 6 (versus 7) posterior marginal setae and 5 Versus. 4) anterior marginal setae, bearing a small, ovate, naked oostegite, length about 0.4x coxal plate. Pereopod five: coxa without oostegite, with 1 (versus 2) ventro-marginal seta. Pereopod six: coxa anterior lobe without a ventro-marginal seta (versus 1). Pereopod seven: coxa bearing 1 (versus 3) seta on the posterior lobe. *Uropods*: Third uropod: peduncle bearing 1 (versus 2) small medial seta; inner ramus small medial setae (versus 2); outer ramus proximal article with 3 (versus 4) translateral setal ranks and 4 (versus 3) transmedial setal ranks.

Relationships

C. scuticara differs from others of the genus in: second antenna peduncle article 4 shorter than article 5, flagellum 16 articulate, bearing calceoli on 10 articles; left mandible palp article 3 with 14 D setae; left first maxilla palp article 2 with 2 apical strong slender setae; maxilliped outer plate with a row of 12 slender naked medial submarginal to disto facial setae; first gnathopod]: propodus post ventral corner with 1 lateral robust seta; second gnathopod carpus with strong post. rastellate setae ranked in 8 transverse bands; pereopod 3 coxa with 6 short ventral setae; epimera 3 with 1 slender seta present on ventral margin; dorsolateral margin of pleonite 3 with 6 feeble setae; third uropod outer ramus proximal article with 4 lateral transverse bands of robust setae, proximal article with 2 apicomedial robust setae.

3.1.4.15 *Chydaekata brachybasis* sp. nov. Figs. 3.75 - 3.77.

Etymology

From the Greek 'braches' (short), and 'basis' (base), referring to the length of the peduncle of the second antenna, which is shorter than the flagellum.

Type locality

Newman bore W126, 23°15'S, 119°53'E.

Material examined

Holotype (Western Australian Museum, C24690) male 'a' 4mm, Allotype (Western Australian Museum, C24691) female 'b' 4mm, male 5mm, 5 others in the type series, same data as the holotype (Western Australian Museum, C24692). Collection number BES 3575, S.Eberhard, 12/11/98.

Diagnosis

Second antenna: peduncle article 5 bearing 1 calceolus, flagellum 11 articulate, with calceoli on articles 1-5. Mandible: palp article 2 with a medio-distal row of 4 robust rastellate setae; article 3 with 8 D and 4 E setae apically. Left first maxilla: palp article 2 with 6 apical setae. Right first maxilla: palp apex with no articulated, and 3 fused broad based tooth setae. Maxilliped outer plate with a row of 5 slender naked, medial submarginal to disto-facial setae; a medial row of 9 submarginal to subapical robust, naked, tooth setae; 3 apicolateral setae. First gnathopod propodus: dactyl reaching beyond palmar corner, with a single recumbent inner tooth spine. Second gnathopod carpus: with posterior setae ranked in 5 transverse bands. Telson: cleft 74%, bearing 2 subapical robust setae.

Description of the holotype (male 'a' 4mm)

Body: urosomites 1 and 2 bearing 2 dorsolateral robust setae. *First antenna*: length 0.6 x body, 1.5 x second antenna; peduncle article 1 longest, with sparse setae; primary flagellum of 28 articles; accessory flagellum of 4 articles, reaching to article 6 of primary flagellum. *Second antenna*: length 0.4 x body; peduncle length less than flagellum, article 5 bearing 1 calceoli, article 4 subequal with article 5, articles 3-5 with sparse setation; flagellum 11 articulate, with sparse setation, bearing calceoli on articles 1 - 5. *Left mandible*: palp article 2 with a medio-distal row of 4 robust rastellate setae, article 3 with 8 D and 4 E setae, facially strongly setulose (pubescent); incisor with 6 teeth, lacinia mobilis with 5 teeth, and 4 plumose interraker setae; molar bearing pappose seta, without penicillate hooked

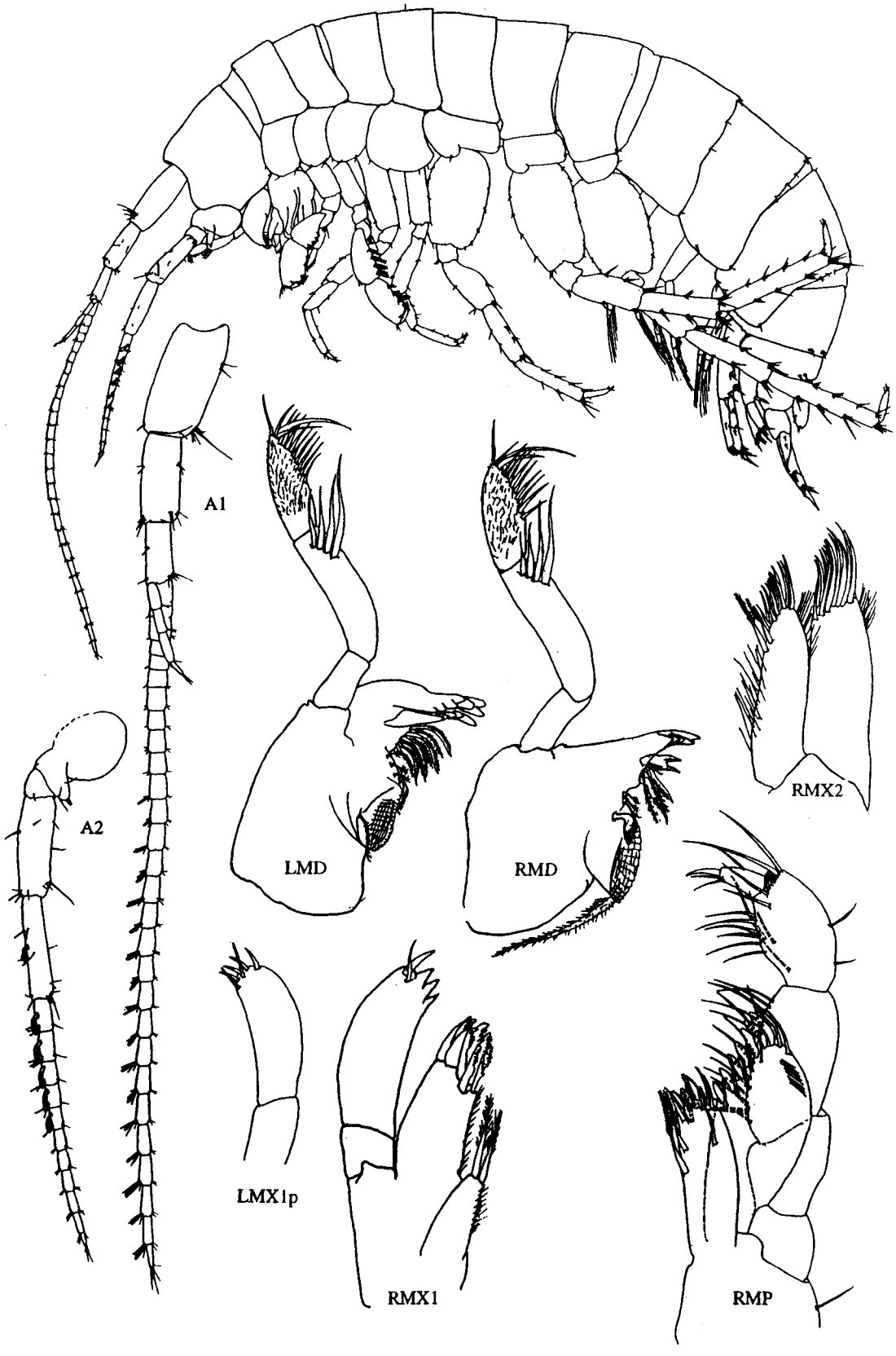

Fig. 3.75. *Chydaekata brachybasis* n. sp., holotype male 'a' 4 mm., whole animal, antennae and mouthparts.

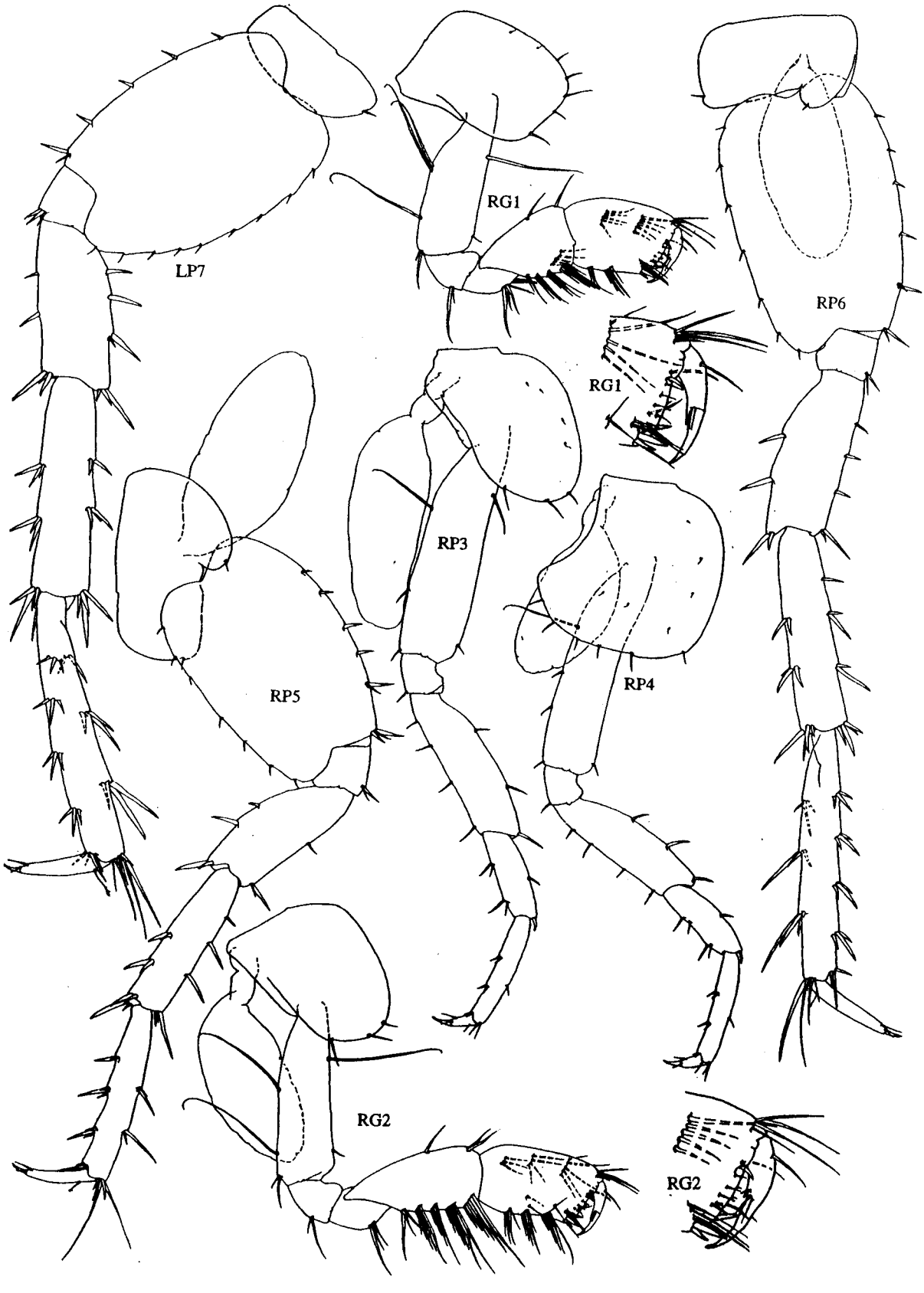

Fig. 3.76. *Chydaekata brachybasis* n. sp., holotype male 'a' 4 mm., gnathopods and pereopods.

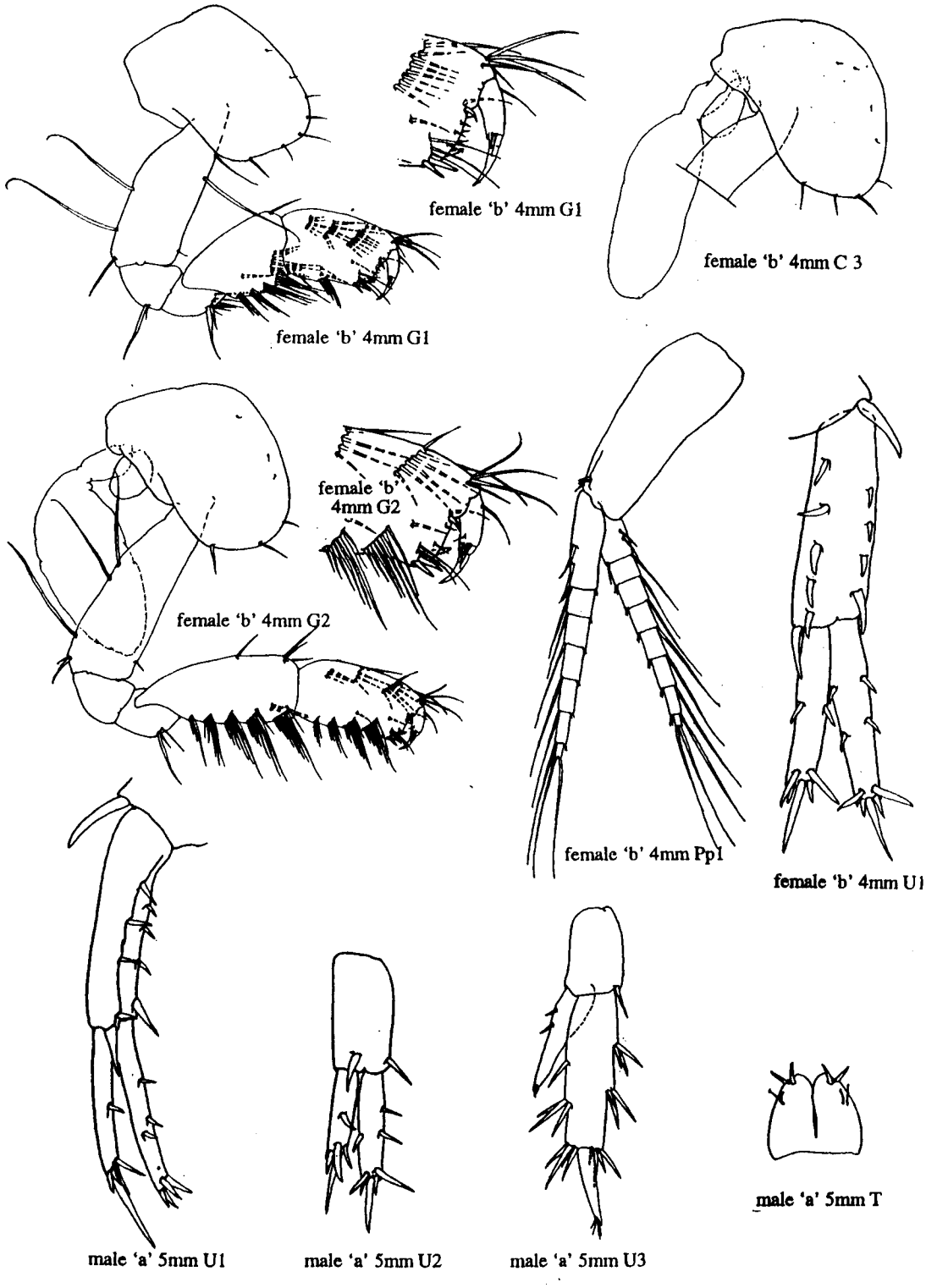

Fig. 3.77. *Chydaekata brachybasis* n. sp., holotype male 'a' 4 mm., uropods 1-3, telson. Allotype female 'b' 4 mm., gnathopods 1-2, coxa 3, pleopod 1, uropod 1.

brushy basal setae, and, few penicillate setules. *Right mandible*: palp article 2 with a medio-distal row of 4 robust rastellate setae, article 3 with 9 D and 4 E setae; incisor with 6 teeth, and 2 plumose interraker setae; molar without penicillate hooked brushy basal setae, and, few penicillate setules. *Left first maxilla*: palp article 2 with 4 apical and 1 subapical facial strong slender setae, with 1 apicomedial seta; outer plate with 10 robust setae - 10 denticulate, none naked; inner plate subtriangular, facially and medially setulose (pubescent). *Right first maxilla*: palp apex with no articulated and 3 fused broad based tooth setae, and 1 subterminal apicolateral facial seta. *Second maxilla*: outer plate length 3.6 x width, bearing distal long, curved naked setae; apicomedial corner of inner plate with 2 weakly submarginal thick plumose/pappose setae. *Maxilliped*: inner plate length 1.9 x width, extending to M0. 8 of the outer plate, bearing small setules on the lateral margin and medioproximal face, no facial pappose setae, no medial pappose setae, with a row of 3 submarginal to subapical pappose setae, extending to a row of 4 similar subapical, and 1 apical seta, with 1 apicomedial, 1 mediodistal, and 3 apical naked tooth setae; outer plate broad, length 2.7 x width, distally setulose (pubescent), with a row of 9, slender naked, medial submarginal to distal facial setae, a medial row of 5 submarginal to subapical robust, naked, tooth setae, and 3 apicolateral setae - none naked, 3 pappose; palp, second article moderately setose medially; third article sparsely setose laterally, weakly setose medially, with 2 facial and 2 ventrofacial long strong setae basal to the dactyl, the apex moderately produced, setulate, with 2 long slender naked setae, and 1 dorsal accessory seta. *First gnathopod*: coxal plate with 3 anteroventral setae and no ventral setae; merus bearing posterior hump; carpus of moderate length, 1.5 x width, subtriangular, posterior margin with setae ranked in 4 transverse bands; propodus ovate, small, length 1.6 x width, posteroventral corner rounded, with 2 lateral and 1 medial robust setae, and 3 additional lateral elongate setae, palmar angle weakly oblique, smooth, dactyl reaching beyond palmar corner, with a single recumbent inner tooth spine. *Second gnathopod*: slightly larger than first; coxal plate with 2 anteroventral setae, and no ventral setae; carpus length 2.3 x width, subrectangular, with posterior setae ranked in 5 transverse bands; propodus subrectangular, moderate size, length 2 x width, with 2 medial robust setae, 1 lateral robust seta, and 2 additional lateral elongate robust setae, palmar angle transverse, smooth, dactyl reaching beyond palmar corner, with a single recumbent inner tooth spine. *Pereopods*: pereopod 3

longer than the second gnathopod; coxa with 1 anterior seta, no long ventral setae, 1 short ventral seta, 1 seta at the posteroventral corner; carpus weakly setose posteriorly; pereopod 4 subequal in length with pereopod 3; coxa anteroventral margin with 1 seta, posteroventral margin with 2 setae, ventral margin with 2 setae, posterior margin moderately emarginate; carpus moderately setose posteriorly; coxa 5 bearing 1 seta on anterior lobe, and 1 seta on the posterior lobe; basis of periopod 5 with short slender posterior setae, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 6 coxa bearing 1 seta on anterior lobe; basis moderately expanded, bearing short and long robust anterior setae, moderately lobate posteroventrally; pereopod 7 coxa with 1 seta on the posterior lobe; basis bearing short and long robust anterior setae, moderately lobate posteroventrally; bases of periopods equally expanded. *Epimera*: first epimeron with 1 slender seta on the posterior margin, posterior margin straight, posteroventral corner rounded; epimeron 2 with 1 robust seta on the anteroventral margin, posterior margin straight, posteroventral corner rounded; epimeron 3 with 2 robust setae on the anteroventral margin, without slender setae on ventral margin, posterior margin straight, posteroventral corner rounded, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 3 feeble setae, of pleonite 2 with 3 feeble setae, of pleonite 3 with 1 feeble seta, and 1 distolateral robust seta. *Pleopods*: first and second pleopods with 1 accessory retinacula, and third pleopod with no accessory retinacula. *Urosomites*: first urosomite bearing 1 distolateral slender seta, and 2 distolateral robust setae; urosomite 2: with no distolateral slender setae, and 2 distolateral robust setae. *First uropod*: peduncle length 1.2 x the length of the inner ramus; with a strong row of 3 dorsolateral robust setae, and 3 dorsomedial robust setae; outer ramus with 1 dorsolateral robust seta, and 1 dorsomedial robust seta; inner ramus with 1 dorsolateral robust seta, 2 dorsomedial robust setae, and 5 apical robust setae. *Second uropod*: 0.6 x length of uropod 1, peduncle about 1.1 x length of inner ramus, with no apicolateral, no dorsomedial, and 1 apicomedial robust setae; inner ramus with no dorsolateral, 1 dorsomedial, and 5 apical robust setae; outer ramus with 1 dorsolateral, 2 dorsomedial, and 5 apical robust setae. *Third uropod*: extending beyond uropods 1 and 2 in intact specimen, 0.8 x length of uropod 1; peduncle length 0.4 x outer ramus, subequal in length to urosomite 3, with 1 apicolateral robust seta, and no apicolateral slender setae, with no dorsomedial robust setae, and 1 dorsomedial slender seta, with no apicomedial

robust setae, and no apicomedial slender setae, and with no mediodistal robust setae; inner ramus length 0.5 x outer ramus; outer ramus proximal article setae arranged laterally and medially in transverse bands or arranged medially singly with, with 2 lateral transverse bands of robust setae, with 1 medial transverse band of robust setae, with no medial transverse bands of mixed robust and small setae, 1 medial robust seta, 4 apicolateral robust setae, no apicolateral small setae, 4 apicomedial robust setae, no apicomedial small setae, no apicomedial long slender setae; distal article long, with no apical robust setae, and 4 apical slender setae; inner ramus with 2 medial robust setae, no apical robust setae, and 1 apical slender seta. *Telson*: shorter than, 0.5 x, urosomite 3; cleft 74 %, as long as broad; apices rounded and laterally notched, with 2 subapical robust setae, and no subapical slender setae; apical penicillate setae absent, with paired lateral penicillate setae at M0.7 from the telson base.

Description of the allotype (female 'b' 4mm)

With the characteristics of the Holotype except. *Body*: length 4mm. *First antenna*: without aesthetascs or calceoli. *Second antenna*: without calceoli. *First gnathopod*: coxa as in the male; carpus broader and more ovate than male, bearing additional medio-facial setae; propodus with 1 (versus 2) posterior translateral setal bands and 3 (versus 2) medio-facial bands, more slender than the male, tapering apically, palm and dactyl similarly armed. *Second gnathopod*: coxa bearing a small, round, naked oostegite, length about 0.3x coxal plate; carpus elongate, longer than male, but similarly armed; propodus less robust, narrower, longer than male, bearing 4 (versus 3) posterior translateral setal bands, and 3 medio-facial bands, palm and dactyl similarly armed. *Pereopods*. Pereopod three: coxa bearing 4 (versus 3) marginal setae, and a small, paddle shaped, naked oostegite, length about 0.4x coxal plate. Pereopods four and five: coxa (bearing small naked ovate oostegite). Pereopods six and seven: similar to the Holotype. *Uropods*. Third uropod: peduncle bearing 4 (versus 3) dorsolateral robust setae; outer ramus with 1 (versus none) medial robust seta; inner ramus with 2 (versus 1) lateral robust setae.

Relationships

C. brachybasis differs from others of the genus in: left mandible palp article 3 with 8 D setae; maxilliped outer plate length 2.6-3.0 x width, bearing a medial row of 5 submarginal to subapical robust, naked, tooth setae; dorsolateral margin of pleonite

3 with 1 distolateral robust seta; third uropod outer ramus distal article with 4 apical slender setae.

3.1.5. The genus *Molina* gen. nov.

Introduction.

The genus *Molina* was erected to accommodate a second species from the Millstream area of the Pilbara region of Western Australia. Three specimens of this blind, unpigmented species were collected from a piezometer by the Western Australian Museum.

Type Species

Molina pleobranchos by monotypy.

Etymology

The name of this genus is derived from the Latin 'molina' (mill). Therefore the word relates to the type locality - Millstream.

Diagnosis

Body: cuticle smooth; pereon and pleon sparsely setose dorsally; urosomite 3 without dorsolateral robust setae. Head: rostrum vestigial; eyes absent. First antenna: article 3 shortest; flagellum much longer than peduncle; bearing aesthetascs; articles uniform, and sparsely setulate. Second antenna: setate. Upper lip: apical margin evenly rounded; connection to epistome symmetrical. Left mandible: palp article 2 with no small outer or medial margin setae, bearing an oblique distofacial row of robust rastellate setae, article 3 much shorter than article 2, bearing DE setae, mandible with 4 setose accessory blades; molar fully triturating. Right mandible: palp article 2 with no small outer or medial marginal setae, bearing an oblique distofacial row of robust rastellate setae, article 3 much shorter than article 2; lacinia mobilis bifid and denticulate; with 2 denticulate arms strongly extended; mandible bearing 2 setose accessory blades; molar bearing pappose seta, fully triturating. Left first maxilla: inner plate elongate, subtriangular to subrectangular, with 2 apicomedial plumose setae, outer plate with 10 robust denticulate apical setae, palp bearing 6 apical and 2 ventrofacial robust articulated

setae. Right first maxilla: palp asymmetrical with left; article 2 with 1 apicolateral robust seta, 1 ventrofacial articulate robust seta and 4 apical setae fused to the article forming a row of broad teeth. Second maxilla: outer plate subtriangular, marginally setulose. Maxilliped: inner plate subrectangular; outer plate subovate; dactyl of palp third article bearing 2 accessory setae basal to the nail. First gnathopod: coxal plate subrectangular, with 1 posteroventral corner seta; merus with elongate scythe setae; carpus without posteroventral lobe or expansion; propodus posteroventral corner not lobate; bearing 4 lateral robust setae; palm convex; dactyl ; with accessory setules at the junction of the nail. Second gnathopod: coxal plate ovate, with 3 posteroventral corner setae, and large ovate gill; merus without posterior hump, with elongate scythe setae; carpus long, without posteroventral lobe or expansion, posterior margin strongly setose; propodus posteroventral corner subquadrate, not lobate, bearing 4 robust setae, palm convex, dactyl with accessory setules at the junction of the nail. Pereopods: dactyls of pereopods 5-7 multispinous; merus of pereopod 3 weakly setose posteriorly; pereopods 5-7 similar; basis of pereopod 5 moderately expanded; coxa 6 bearing 1 seta on the posterior lobe, basis of pereopod 6 bearing short slender posterior setae; pereopod 7 coxa bearing no setae on anterior lobe, article 2 moderately expanded, bearing short slender posterior setae. Gills: coxal gills present on coxae 2-7, gill of pereopod 6 not reduced; sternal gills present on sternites 2-7, of simple sausage form, attached to anterior of lateral edge of segments. Epimera: epimera 1: without anteroventral setae, without robust setae on anteroventral or posteroventral margin, without slender setae on ventral margin, posteroventral corner without spine or seta; epimera 2: without anteroventral setae, or robust setae on posteroventral margin, without slender setae on ventral margin, with 1 slender seta on the posterior margin, posteroventral corner without spine or seta; epimera 3: without anteroventral setae, or robust setae on posteroventral margin, or slender setae on posterior margin, posteroventral corner without spine or seta. Pleon: pleonite 2 with no distolateral robust setae; pleonite 3 without setae. Pleopods: peduncle of first pleopod with 2 retinacula and 2 additional setae disjunct from retinacula; peduncle of second pleopod with 2 retinacula and 1 additional seta disjunct from retinacula; peduncle of third pleopod with 2 retinacula and 1 additional setae disjunct from retinacula. Urosomites: first urosomite bearing long distoventral robust seta at the base of uropod 1; urosomite 3: bearing no distolateral slender or robust setae. Uropods:

first uropod peduncle with no apicodistal robust setae; second uropod bearing 2 apicolateral and 1 apicomedial robust setae, the outer ramus shorter than inner, with 4 apical robust setae; second uropod peduncle with 4 dorsolateral robust setae, outer ramus shorter than inner; third uropod moderately long; peduncle with 1 dorsolateral robust seta,1 dorsolateral and 1 mediodistal slender setae; inner ramus shorter than outer; outer ramus two articulate, proximal article without small setae, with lateral transverse bands of robust setae only, and with only robust apical setae; distal article of outer ramus narrow; sub triangular; without lateral or medial setae; and only small slender distal setae; inner ramus with 1 lateral robust seta, 2 medial robust setae and a single short slender apical seta. Telson: deeply cleft, lateral margins tapering, straight; single small slender dorsal setae present; without lateral setae; with single robust and short penicillate apical setae; bearing paired lateral penicillate setae.

Relationships.

Molina has many similarities to *Chydaekata*, and thus differences from others of the family Paramelitidae. Nevertheless, *Molina* differs in significant ways from *Chydaekata*: calceoli are absent from the male antennae, gnathopodal propodi bear 4 or 5 robust posterior corner setae rather than 3, dactyls of the pereopods are multispinous rather than simple, coxa 7 bears a gill and sternal gills are present on segments 2-7 compared with 6-7, a robust lateral seta is present on the inner ramus of the third uropod whereas *Chydaekata* has none, posterior marginal setae are present on the epimera, and dorsal setae are present on the telson. The presence in *Molina* of a coxal gill on pereopod seven, and of sternal gills on sternites two to seven are characters borne in common with *Austrogammarus*, the most primitive of Australian paramelitids (Williams and Barnard, 1988). Notwithstanding, many differences clearly separate the two genera. Likewise, similarities are found with other genera: in common with *Austrocrangonyx* ventrodistal setae at the base of the first uropod are long and robust, coxae 1-3 do not bear posterior robust setae, and gills are present on coxae 2-7, the seventh being reduced; *Hurleya* also has only DE setae present on the mandibular palp, absence of medial setation on the maxillae, presence of two apicomedial plumose setae on the inner plate of the first maxilla, no oblique facial row of setae on the inner plate of the second maxilla, and slight apical extension of the third article of the maxillary palp; like *Protocrangonyx* the third

article of the mandibular palp bears only DE setae, and, in common with *Toulrabia*, the inner plate of the second maxilla lacks an oblique facial row of setae; *Toulrabia* also bears only 2 apicomedial setae on the inner plate of the first maxilla; *Chillagoe* is similar to *Molina* in the presence of only DE setae on the mandibular palp, the inner plate of the first maxilla bearing only 2 apicomedial plumose setae, absence of an oblique facial setal row on the second maxilla, and simplicity of palmar setae; in common with *Pilbarus* the second article of the mandibular palp bears a distal oblique row of robust rastellate setae, maxillae are without medial setae, the inner ramus of the first maxilla bears two plumose apical setae and the inner plate of the second maxilla lacks an oblique facial row of setae and bears only two plumose apicodistal setae, the inner ramus of the third uropod is similarly elongate and the first article of the outer ramus bears transverse rows of robust setae without small slender setae and the second article is small; in common with *Toulrabia* coxae 2-7 bear gills and sternites 2-7 bear simple lateral gills.

However, these similarities are few compared with the differences between *Molina* and other genera of Paramelitidae. Most similarities are found with *Chydaecata*, but the presence of a seventh coxal gill, and of sternal gills on segments 2-7, the absence of calceoli in *Molina*, the greater number of corner setae on the gnathopodal propodi, the presence of lateral setae on the inner ramus of the third uropod and the presence of additional (multispinous) setae on the dactyls of pereopods 5-7 all indicate *Molina* a distinct genus.

Distribution

Millstream in the Pilbara region of north western Western Australia.

3.1.5.1 *Molina pleobranchos* sp. nov. Figs. 3.78 - 3.81

Etymology

From the Greek 'branchos' (gill), and 'pleos' (full), referring to the presence of a full complement of both coxal and sternal gills.

Type locality

Millstream aquifer, Western Australia, 21°35'S, 116°58'E.

Material examined

Holotype (Western Australian Museum, C24693) female 'a' 6.5mm, Allotype (Western Australian Museum, C24694) male 'b' 6mm; male 'c' 5.5mm, 1 other in the type series, same data as the holotype (Western Australian Museum, C24695). Collection number BES3994. Coll. W. F. Humphreys, taken with haul net in piezometer, 19/10/96.

Diagnosis

With the characteristics of the genus.

Description of the holotype (female 'a' 6.5mm)

Body: cuticle smooth; pereon and pleon sparsely setose dorsally; first urosomite bearing 1 dorsolateral robust seta; second urosomite bearing 3 dorsolateral robust setae; third urosomite without dorsolateral robust setae. *Head*: rostrum vestigial; eyes absent. *First antenna*: length 0. 6 x body, 1.8 x second antenna, peduncle article 1 longest, article 3 shortest, with sparse setae; flagellum much longer then peduncle, of 33 articles, bearing aesthetascs; accessory flagellum of 6 articles, reaching to article 5 of primary flagellum, articles uniform, and sparsely setulate. *Second antenna*: length 0. 3 x body; peduncle length less than flagellum, peduncle article 5 without calceoli, article 4 longer than article 5, articles 3-5 with sparse setation; flagellum 12 articulate or 16 articulate, with moderate setation, without calceoli. *Upper lip*: apical margin evenly rounded, connection to epistome symmetrical. *Left mandible*: palp article 2 with no small outer or medial marginal setae, with a medio-distal oblique facial row of 5 robust rastellate setae, article 3 much shorter than article 2, with 12 D setae, and 4 E setae, facially strongly setulose (pubescent); incisor with 7 teeth, lacinia mobilis with 5 teeth, mandible with 4 setose accessory blades, and 4 plumose interraker setae; molar bearing pappose seta, with 5 penicillate hooked brushy basal setae, and, few penicillate setules, fully triturating. *Right mandible*: palp article 2 with no small outer or medial marginal setae, with a medio-distal row of 5 robust rastellate setae, article 3 much shorter than article 2, with 11 D setae, and 4 E setae; incisor with 6 teeth, lacinia mobilis bifid and denticulate, with 2 denticles strongly extended, mandible with 2 setose accessory blades, and 2 plumose interraker setae; molar bearing pappose seta, with 3 penicillate hooked brushy basal setae, and , few penicillate setules, fully triturating. *Left first maxilla*: palp article 2 with 6 apical, and no subapical facial strong slender setae, with no apicomedial, with no submarginal apicomedial, with 2 ventrofacial apicomedial strong slender setae; outer plate with 10 robust setae, (10

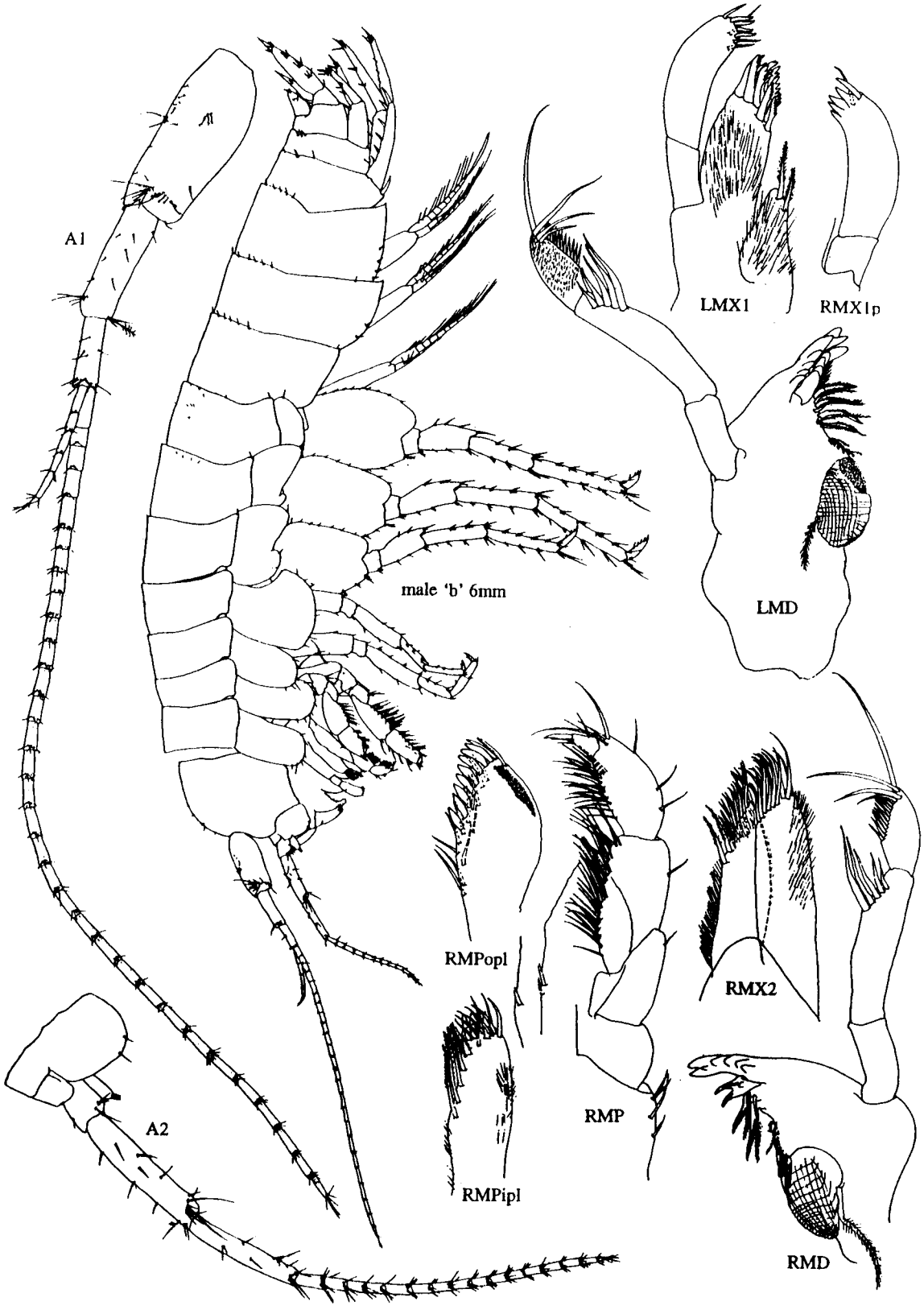

Fig. 3.78. *Molina pleobranchos* n. sp., holotype female 'a' 6.5 mm., antennae and mouthparts. Allotype male 'b' 6 mm., whole animal.

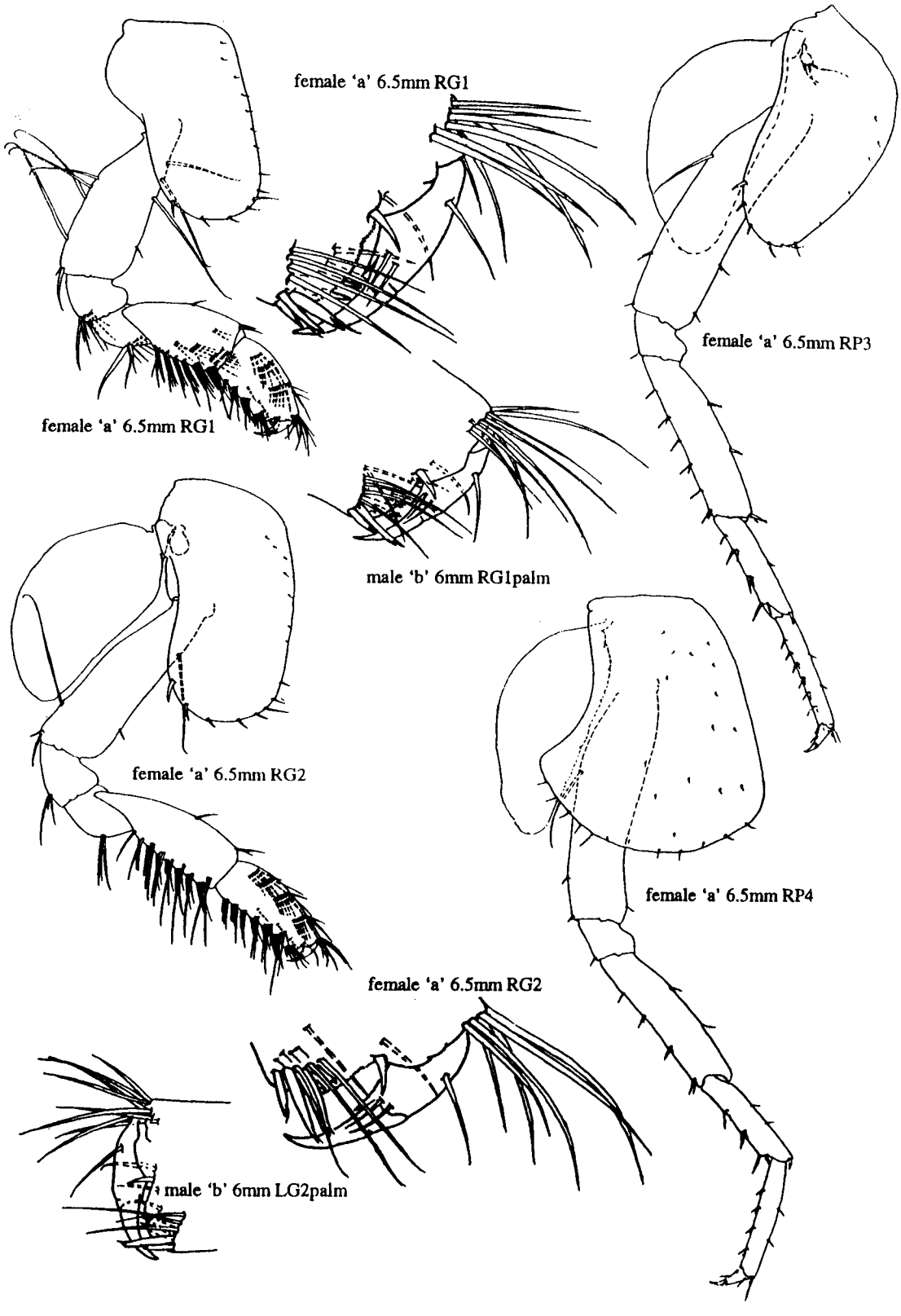

Fig. 3.79. *Molina pleobranchos* n. sp., holotype female 'a' 6.5 mm., gnathopods 1-2 and pereopods 3-4. Allotype male 'b' 6 mm., gnathopodal palms 1-2.

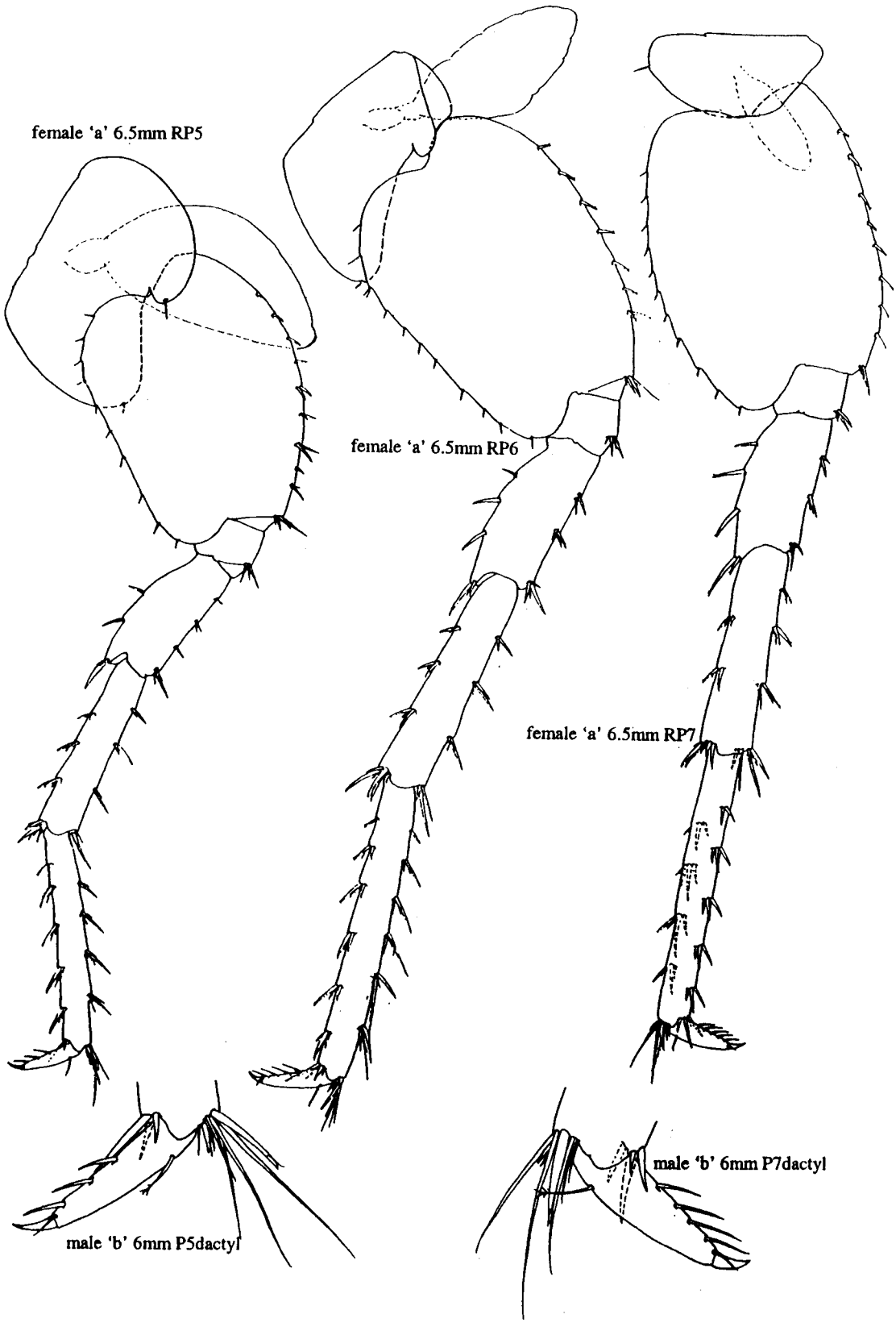

Fig. 3.80. *Molina pleobranchos* n. sp., holotype female 'a' 6.5 mm., pereopods 5-7. Allotype male 'b' 6 mm.; dactylus, pereopods 5 and 7.

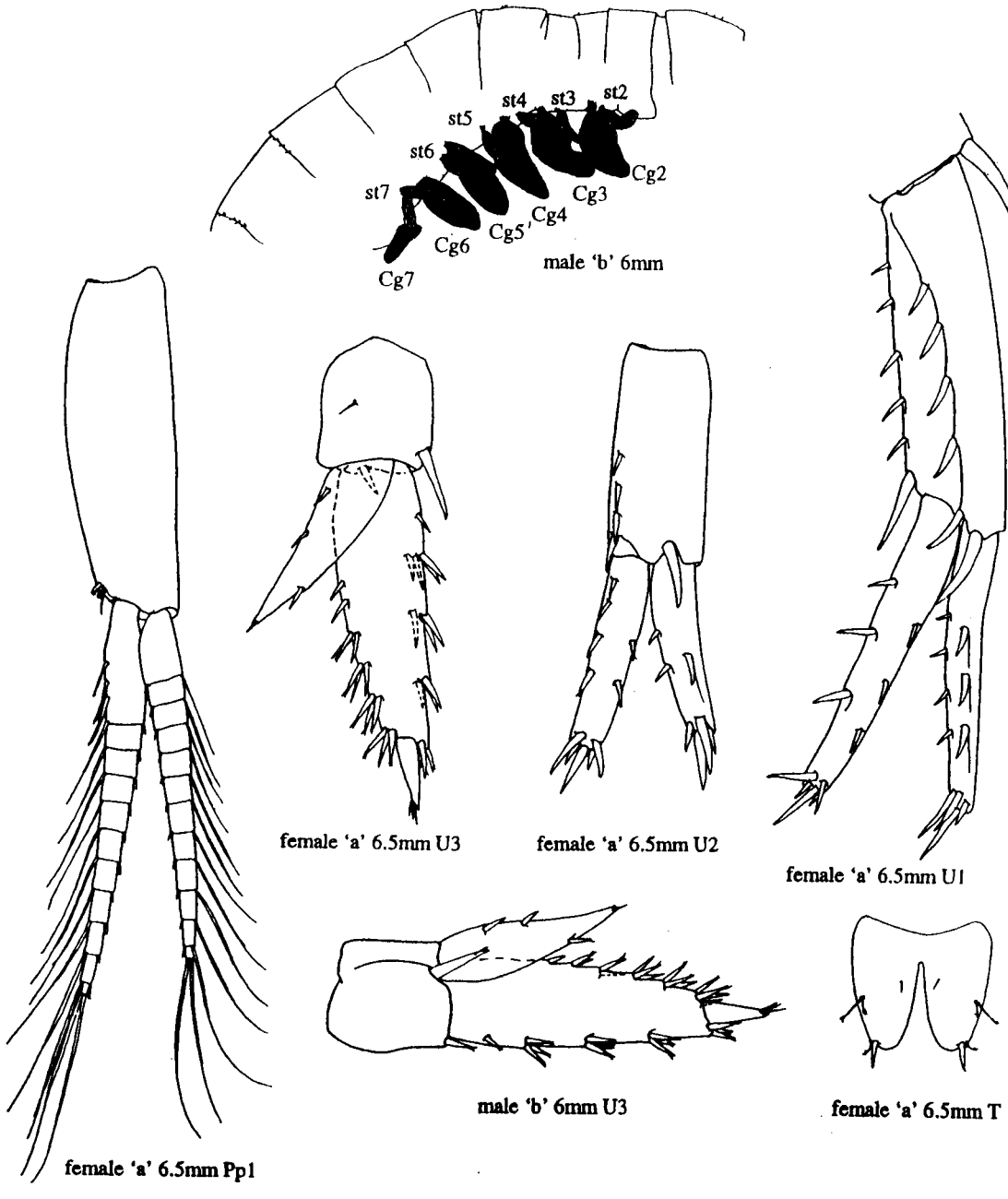

Fig. 3.81. *Molina pleobranchos* n. sp., holotype female 'a' 6.5 mm., pleopod 1, uropods 1-3, telson. Allotype male 'b' 6 mm., gills, uropod 3.

denticulate, no naked); inner plate subtriangular, with 2 apicomedial plumose setae, facially and medially setose (pubescent). *Right first maxilla*: right palp asymmetrical with left, apex with no articulated, and 4 fused broad based tooth setae, 1 apicolateral robust setae, and 1 subterminal apicolateral facial setae. *Second maxilla*: outer plate subrectangular, elongate, length 4 x width, bearing distal long, curved rastellate setae, marginally setulose; apicomedial corner of inner plate with 2 weakly submarginal thick plumose setae. *Maxilliped*: inner plate subrectangular, elongate, length 3.3 x width, extending to M0.9 of the outer plate, bearing small setules on the lateral margin and medioproximal face, 1 facial pappose setae, at M0.8 of its length, 6 medial pappose setae, with a row of 5, subapical pappose setae, with 1 apicomedial naked tooth setae, with 3 apical naked tooth setae; outer late subovate, broad, length 1.8 x width, distally naked, with a row of 12, slender naked, medial submarginal to disto facial setae, a medial row of 8 submarginal to subapical robust, naked, tooth setae, and 2 apicolateral setae, (1 naked, and 1 pappose); palp, second article strongly setose medially; palp third article sparsely setose laterally, moderately setose medially, with no facial, and 3 ventrofacial long strong setae basal to the dactyl, the apex weakly produced, setulate, with 4 long slender naked setae, the dactyl bearing 2 accessory setae basal to the nail, and 1 dorsal accessory seta. *First gnathopod*: coxal plate subrectangular, with 5 anteroventral setae, with 1 posteroventral corner setae, and 1 ventral setae; merus bearing posterior hump, with elongate scythe setae; carpus moderate length, 2 x width, subtriangular, without posteroventral lobe or expansion, posterior margin, with setae ranked in 6 transverse bands; propodus subrectangular, small, length 1.8 x width, posteroventral corner rounded, not lobate, with 2 medial robust setae, 3 lateral robust setae, and 4 additional lateral elongate robust setae, palmar angle weakly oblique, palm convex, bearing fine marginal teeth, dactyl reaching beyond palmar corner, with a single recumbent inner tooth spine, with accessory setules at the junction of the nail. *Second gnathopod*: slightly larger than first; coxal plate ovate, with 5 anteroventral setae, 2 posteroventral corner setae, and 1 ventral setae, and large ovate gill; merus bearing posterior hump, with elongate scythe setae; carpus long, 3 x width, subrectangular, without posteroventral lobe or expansion, posterior margin , with setae ranked in 8 transverse bands; propodus trapezoidal, small, length 2.5 x width, posteroventral corner rounded, not lobate, with 2 medial robust setae, 3 lateral robust setae, and 3 additional lateral elongate

robust setae, palmar angle weakly oblique, palm convex, bearing fine marginal teeth, dactyl reaching to palmar corner, with a single recumbent inner tooth spine, with accessory setules at the junction of the nail. *Pereopods*: dactyls of pereopods 5-7 multispinous, with 3, 4, and 5 setae; pereopod 3 longer than gnathopod 2, coxa 3 with no anterior setae, 3 long ventral setae, no short ventral setae, 3 setae at the posteroventral corner; merus weakly setose posteriorly; carpus weakly setose posteriorly; pereopod 4 subequal in length with P3, coxa 4 anteroventral margin with 2 setae, posteroventral margin with 5 setae, ventral margin with 2 setae, posterior margin moderately emarginate, carpus weakly setose posteriorly; pereopods 5-7 similar; coxa 5 bearing 1 setae on anterior lobe, and 1 setae on the posterior lobe; basis of pereopod 5 moderately expanded, bearing short slender posterior setae, bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally; coxa 6 bearing no setae on anterior lobe, and 1 setae on the posterior lobe; basis of pereopod 6 moderately expanded, bearing short slender posterior setae, basis of pereopod 6 bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally; coxa 7 bearing no setae on anterior lobe, and 1 setae on the posterior lobe; basis of pereopod 7 moderately expanded, bearing short slender posterior setae, bearing short robust anterior setae or bearing long robust anterior setae, moderately lobate posteroventrally. Bases of pereopods 5-7 equally expanded. *Oostegites*: oostegites present on coxae 2-5, rudimentary. *Gills*: coxal gills present on coxae 2-7, gill of pereopod 6 not reduced, the seventh reduced; sternal gills present on sternites 2-7, of simple, sausage form, attached to anterior of lateral edge of segments. *Epimera*: First epimeron without anteroventral setae, without robust setae on anteroventral margin, without robust setae on posteroventral margin, without slender setae on ventral margin, with 1 slender setae on the posterior margin, posterior margin straight, posteroventral corner subquadrate, without spine or seta, Second epimeron with anteroventral setae, with 2 robust setae on the anteroventral margin, without robust setae on posteroventral margin, without slender setae on ventral margin, with 1 slender setae on the posterior margin, posterior margin straight, posteroventral corner acuminate, without spine or seta, Third epimeron without anteroventral setae, with 4 robust setae on the anteroventral margin, without robust setae on posteroventral margin, without slender setae on ventral margin, without slender setae on posterior margin, posterior margin straight, posteroventral corner

acuminate, without spine or seta. *Pleon*: dorsolateral margin of pleonite 1 with 6 feeble setae, and no distolateral robust setae; of pleonite 2 with 6 feeble setae, and no distolateral robust setae; of pleonite 3 with 5 feeble setae, and no distolateral robust setae. *Pleopods*: peduncle of first pleopod with 2 retinacula, and 2 accessory retinacula, and no additional setae disjunct from retinacula; second pleopod with 2 retinacula, and 1 accessory retinacula, and no additional setae disjunct from retinacula; third pleopod with 2 retinacula, and 1 accessory retinacula, and no additional setae disjunct from retinacula. *Urosome.* First urosomite: bearing 2 distolateral slender setae, 1 distolateral robust setae, and a distoventral robust seta at the base of uropod 1. Second urosomite: bearing no distolateral slender setae, and 3 distolateral robust setae. Third urosomite: bearing no distolateral slender setae, and no distolateral robust setae. *Uropods.* First uropod: peduncle length 1.1 x the length of the inner ramus, with a strong row of 4 dorsolateral robust setae, 2 apicolateral robust setae, 5 dorsomedial robust setae, and 1 apicomedial robust setae; outer ramus shorter than inner, with 3 dorsolateral robust setae, with 4 dorsomedial robust setae, and 4 apical robust setae; inner ramus with 3 dorsolateral robust setae, with 3 dorsomedial robust setae, and 5 apical robust setae. Second uropod: 0.6 x length of uropod 1; peduncle about 1.2 x length of inner ramus, with no dorsolateral robust setae, 1 apicolateral robust seta, 3 dorsomedial robust setae, 1 apicomedial robust setae; outer ramus shorter than inner; inner ramus with 2 dorsolateral robust setae, with 4 dorsomedial robust setae, and 5 apical robust setae; outer ramus with 1 dorsolateral robust setae, with 2 dorsomedial robust setae, and 4 apical robust setae. Third uropod: longer than U1-2 in intact specimen, long, 0.7 x length of uropod 1; peduncle length 0. 3 x outer ramus, subequal in length to urosomite three, with no dorsolateral robust setae, no dorsolateral slender setae, with 1 apicolateral robust setae, no apicolateral slender setae, with no dorsomedial robust setae, no dorsomedial slender setae, with no apicomedial robust setae, no apicomedial slender setae, with 1 mediodistal robust setae, with no mediodistal slender setae; inner ramus shorter than outer ramus; length 0.6 x outer ramus; outer ramus two articulate, proximal article setae arranged laterally and medially in transverse bands, with 4 lateral transverse bands of robust setae, with no lateral transverse bands of small setae, with no lateral transverse bands of mixed robust and small setae, with 5 medial transverse bands of robust setae, with no medial transverse bands of small setae, with no medial transverse bands of mixed robust

and small setae, 3 apicolateral robust setae, no apicolateral small setae, no apicolateral long slender setae, 3 apicomedial robust setae, no apicomedial small setae, no apicomedial long slender setae; distal article short, narrow, sub triangular, with no lateral robust setae, with no lateral slender setae, with no medial robust setae, with no medial slender setae, with no medial slender plumose setae, with no apical robust setae, with 3 apical slender setae, with no apical plumose setae; inner ramus with 1 lateral robust setae, with no lateral slender setae, with 2 medial robust setae, with no medial slender setae, with no medial plumose setae, with no apical robust setae, with 1 apical slender setae, with no apical plumose setae. *Telson*: subequal in length to urosomite three; deeply cleft, (80 %), shorter than broad, length 0.9 x breadth; lateral margins tapering, convex; apices rounded and laterally notched; with no dorsal robust setae, with 1 dorsal slender setae, with no lateral slender setae; with 1 apical robust setae, with no apical slender setae; with 1 apical penicillate setae, and paired lateral penicillate setae, at M0.7 from the telson base.

Description of the allotype (male 'b')

Similar to the holotype except: *Body*: 6mm. *First antenna*: length 0.6x body, flagellum of 34 articles, bearing aesthetascs on articles 9-33; accessory flagellum of 6 articles. *Second antenna*: without calceoli on peduncle or flagellum, flagellum of 17 articles. *Mandibles*: third article of mandibular palps bearing 13D and 4E setae only. *First gnathopod*: propodus bearing 2 lateral and 2 medial robust setae at the palmar corner, with 4 long accessory setae laterally. *Second gnathopod*: propodus bearing 2 lateral and 2 medial robust setae at palmar corner and 3 accessory setae laterally. *Pereopods*: dactyls of pereopods 5-7 multispinous, with 3, 4 and 4 setae. *Uropods*. Third uropod peduncle bearing 1 small facial seta, 1 lateral and 1 mid dorsal robust setae; inner ramus bearing 1 medial and 2 lateral setae and 1 small, single apical seta; lateral margin of the first article of the outer ramus bearing a single basolateral, 3 translateral bands, and 3 apicolateral robust setae, the medial margin bearing a single basomedial, 4 trans medial bands and 4 apicomedial robust setae; the second article of the outer ramus naked medially and laterally, bearing 3 slender apical and subapical setae.

Description of male 'c'

Juvenile. Similar to the allotype except: *Body*: 5.5mm. *First antenna*: 0.6x body, 1.8x antenna 2, without aesthetascs, primary flagellum of 24 articles, accessory flagellum of 5 articles. *Second antenna*: flagellum of 12 articles; peduncle and

flagellum without calceoli. *Pereopods* (Fig. 61): dactyls of pereopods 5-7 multispinous with 3,4,3 setae. *Uropods* (Fig. 62): third uropod similar to female except peduncle without small facial seta; medial and lateral translateral bands of setae similar but bearing variable numbers of setae.

3.1.6. The genus *Antipodeus* Williams and Barnard

Type species.

Gammarus antipodeus Smith 1909.

Introduction.

The genus *Antipodeus* was established by Williams and Barnard (1988) to accommodate species originally assigned by G. M. Thomson (1893) to *Niphargus* [*A. mortoni*, which G. W. Smith (1900) later removed to *Neoniphargus* and by Barnard and Barnard (1983) to *Austrocrangonyx*] and by G. W. Smith (1909) to *Gammarus* (*A. antipodeus*, *A. wellingtoni*, *A. ripensis*) and to *Neoniphargus* (*A. niger*). Williams and Barnard (1988) also described a sixth species *A. franklini*.

Antipodeus differs from most other Paramelitidae (excepting *Pilbarus*) in that it lacks sternal gills. It is considered closer to *Austrocrangonyx* than *Austrogammarus*, and various characters such as the apically placed major armaments of the telson, parviramous uropod 3, vestigial distal article on the outer ramus of uropod 3, and reduced maxillary setation 'anticipate more specialised genera related to *Neoniphargus*' (Williams and Barnard 1988); explaining, perhaps, earlier placement of five of the species within the Niphargidae or the Neoniphargidae.

Antipodeus is an endemic Tasmanian taxon commonly occurring in two quite distinct habitats: cave streams and their efflux streams, and in mid altitude streams of mountainous areas. In the Central Highlands, Mount Arthur and Ben Lomond in the north east, in the central north on the slopes of the Northern Tiers, and further south on Mount Wellington and in the Hartz, *Antipodeus* is found in streams of the peri-glacial region; ie. those streams about 500 to 1000m altitude which were on the fringes of areas of glaciation during past ice ages. Other than underground and in cave efflux streams *Antipodeus* is not found in either low-lying or higher altitude

waters. No studies have been carried out on the genus since it was erected by Williams and Barnard (1988).

All described species of the genus *Antipodeus* are robust, relatively large, and have well developed, strongly pigmented eyes and, including those dwelling in the efflux streams of caves but not the inhabitants of caves themselves, display no troglobitic characteristics such as reduction of pigmentation, modification or absence of eyes and attenuation of the limbs (Holsinger 1993).

Problems associated with morphological distinction among the six described species of this genus were recognised by Williams and Barnard (1988), who noted they could be arranged in two separate genera in several ways, there being a 'great cross mixture of characters', and that the 'diversity of form in the species suggests *Antipodeus* is a polyphyletic genus'. *Antipodeus* examined in the course of this study, which included four of the six type sites as well as many other epigean sites, proved difficult to distinguish morphologically. Indeed, the description of *A. wellingtoni* based on Smith's material lodged in the Hope Museum, Oxford, and redescribed by Williams and Barnard, appeared more similar to specimens collected at the type location of *A. niger* (Lake Perry in the Hartz Mountains), the types of which are also lodged at the Hope Museum, than to those collected on Mount Wellington.

Examination of available specimens and of material collected in the course of this study indicate the described number of *Antipodeus* species (six) probably significantly underestimates species diversity. Subtle morphological heterogeneities among the majority of specimens preclude taxonomic discrimination on morphological grounds alone. These minor characters include: placement of setae on the gnathopods and pereopods; setation of the body, antennular peduncles and uropods; gape of the outer lobes and extension of the mandibular lobes of the lower lip; relative lengths of the pereopods; setation of the epimera; and numbers of articles of the rami of pleopods. Such morphologically-ambiguous, "cryptic" species are ideal candidates for molecular analysis (Hansen *et al* 2001; Richardson *et al* 1986). The biological species concept, accorded to Mayr (1963), is that a species is composed of a group of individuals capable of

Table 3.1. *Antipodeus* Collection sites, location, OTU number, habitat type and sample size

Site	Locality	Date	Habitat	Longitude °E	Latitude °S	Sample size
0201	Mt. Rufus canal	02-03-97	mountainside trickle	146° 07.1'	42° 09.8'	11
0206	stream exiting Clarence Lagoon	02-03-97	upland lake outflow	146° 19.3'	42° 05.3'	7
0413	Waddamana	04-03-97	mountain trickle	146° 45.2'	42° 08.0'	11
0415	Ouse R. tributary	04-03-97	mountain trickle	146° 46.4	42° 18.8	11
0505	Mt. Wellington 1100m	05-03-97	mountain trickle	147° 14.1'	42° 53.5'	11
0506 a&b	Mt. Wellington 1000m	05-03-97	mountain trickle	147° 14.4'	42° 55.0'	11
0602	Hartz Mts. stream	06-03-97	mountain trickle	146° 46.7'	43° 12.2'	11
0603	L. Perry, Hartz Mts.	06-03-97	lake outflow	146° 45.6'	43° 13.1'	11
0702	Exit Cave a	07-03-97	main cave stream	146° 50.0'	43° 29.0'	8
0704	Exit Cave b	07-03-97	tributary cave stream	146° 50.0	43°29.0	3
0801	near Franklin. 500m	08-03-97	small stream	146° 59.0'	43° 05.0'	6
0901	Russell Falls Mt. Field NP	09-03-97	mountain stream	146° 42.6'	42° 40.6	11
1102 a&b	Strickland Falls Mt. Wellington	11-03-97	stream below falls	147° 15.7'	42° 54.6'	11
1103	Silver Falls Mt. Wellington	11-03-97	stream above falls	147° 16.0'	42° 56.0'	11
1209	Huon R. tributary 1 on Scotts Peak Rd. upstream of "L. Pedder"	12-03-97	mountain trickle	146° 22.2'	42° 51.0'	11
1210 a&b	Huon R. tributary 2 on Scotts Peak Rd. upstream of "L. Pedder"	12-03-97	mountain trickle	146° 21.9'	42° 51.2'	11
1306	Mt. Barrow	13-03-97	mountain trickle	147° 25.0'	41° 21.7'	11
1307	Mt. Barrow	13-03-97	mountain trickle	147° 25.4'	41° 22.6'	11
1308	Mt. Barrow	13-03-97	upland stream	147° 25.8'	41° 22.2'	11
1411	Mt. Arthur	14-03-97	upland stream	147° 16.9'	41° 28.1'	3
1602	stream near Liffey Falls	16-03-97	mountain stream	146°45.0'	41°01.3'	11
1604	Meander R. near "Huntsmans"	16-03-97	tributary to mountain stream	146° 32.6'	41° 43.4'	11
1701	Marakoopa Creek	17-03-97	stream 1km below cave	146° 17.5'	41° 34.4'	11
1702 a&b	Mole Creek. Wet Cave.	17-03-97	cave stream	146° 30.0	41° 53.0	11
1801	Marakoopa Cave.	18-03-97	stream in cave	146° 17.5'	41° 34.2'	2
1802	Marakoopa Ck.	18-03-97	cave efflux stream	146° 17.5'	41° 34.3'	11
1803	Marakoopa Ck. tributary	18-03-97	stream entering cave efflux	146° 17.5	41° 34.2	11

exchanging genetic material with each other, but reproductively isolated from other groups; consequently, individuals of a single species are likely to share a high degree of genetic similarity, and individuals of different species are likely to show genetic differences. Genetic markers can be used to readily identify instances of hybridisation and introgression amongst taxa (Avise 1994; Hillis *et al* 1996). Applications of allozyme electrophoresis to the genetic discrimination of species are reviewed in detail by Richardson *et al* 1986, and have been used successfully on amphipoda, both marine and freshwater, as well as other aquatic crustacea (France 1994; Horwitz *et al* 1990; Humphreys and Adams 1991; Stewart 1992 a, b; Stewart *et al* 1994; Stewart and Griffiths 1992a, b; Vainio *et al* 1995; Hebert and Wilson 2000).

Allozyme studies of *Antipodeus* were undertaken to investigate the genetic affinities of the populations.

3.1.6.1 Allozyme electrophoresis.

Methods.

Antipodeus examined in this study were gathered from 26 sites, including caves and the type sites of described species (all epigean), excepting *A. ripensis* and *A. mortoni* which could not be relocated (Table 3.1).

[*The type location for* A. ripensis, *Great Lake (Smith, 1909), is out of character; the other five described epigean species and all the populations sampled reside in fast flowing mountain streams; the lake itself is large, of surface area more than 150 square kilometres, the level has been artificially raised for water storage since 1922, and subject to frequent artificial fluctuation relating to generation of hydro-electricity. Possibly the original outflow of the lake may have been the type location;* Antipodeus *specimens from natural lakes, Lake Perry in the Hartz and Clarence Lagoon in the central Highlands, are found only in the outflow streams of those waters. Type material of the poorly described* A. mortoni *could not be located by Williams and Barnard (1988), nor could new material be collected in the Franklin area (visited three times), the type locality indicated by Thomson (1893),*

and it seems this species should be regarded as a nomen dubium, *although Williams and Barnard (1988) hesitated to do so*].

Details of allozyme electrophoresis techniques and statistical analyses are set out in 'Materials and Methods' (Chapter 2).

Results

Eleven loci were scored, all of which showed fixed allelic differences. Allele frequencies at the 11 loci for 31 populations are shown in Table 3.2. The number of alleles demonstrable at polymorphic loci varied between four and ten, although most individual sample sets displayed a single allele at the majority of loci.

Sympatric OTUs were found at four sites, namely 0506(a&b), 1102(a&b), 1210(a&b), and 1702(a&b), exhibiting fixed differences at eight, eight, five and two loci, respectively. Nei D values and percent fixed differences (%FDs) between pairs of OTUs are presented in matrix form in Table 3.3. Values of percentage fixed differences varied between 0 and 100 with all but 29 of the 450 comparisons generating a value above 36 %FD, and a majority (376/450) greater than 50 %FD. The UPGMA dendrogram (Fig. 3.82) indicates two genetically diverse basal groupings present, although at higher levels of divergence branch lengths are short. Fixed differences at 36% are indicated on the figure as a dotted line (lower 90% confidence limits of 17%FD - 4 loci).

From the analysis, at least 20 species are represented in the sampled 24 sites when compared under the "15% rule" (Baverstock *et al* 1977). Application of the less-stringent criteria of Horwitz *et al.* (1990), Ayala (1982) or Thorpe (1982) only serve to increase the number of species recognised to 27 and 28 respectively.

Discussion

With the exceptions noted, allopatric populations of *Antipodeus* are readily diagnosable from one another at multiple loci. Nei D values ranged between 0 and 4 with only 10 comparisons less than 0.41 and the majority (409/450) 0.75 or

Locus	Allele	0201	0206	0413	0415	0505	506A	506B	0602	0603	0702	0704	0801	0901	1102c	1102d	1103	1209	1210e	1210f	1306	1307	1308	1411	1602	1604	1701	1702a	1702b	1801	1802	1803
Pgi	g																															
	f							100	95																	4		25				
	e			4						100	100	100				100									5	23		75				
	d			91	100		100		5				75	100	100			55		56	27	27	5	100	50	41			100			
	c		100	5		18							25				100	36		44	41	64	35		45	32						
	b	100				82												9	100		27	9	55									
	a																				5		5				100		100	100	100	100
	N	11	7	11	11	11	9	2	11	11	8	3	6	11	2	9	11	11	3	8	11	11	11	3	11	11	11	2	9	2	11	11
Pgm	j																			6												
	i										75	50																				
	h			32							25	50						5				27	18									
	g		15	68			6											8					4	66		18	18				9
	f	32	14		91				95	55			33	95				82		88	9		73		100	68	82			9		
	e												67	5					50			68		17				75	56	100	41	91
	d	59	50		9	100	94		5	45					100	6	55			6			5					25	44		50	
	c		21															5			81	5				14						
	b	9						100								94	45		50		5	5		17								
	a																															
	N	11	7	11	11	11	9	2	11	11	8	3	6	11	2	9	11	11	3	8	11	11	11	3	11	11	11	2	9	2	11	11
Apk	f																															
	e		100								100	100											100									
	d			100	100		100	100	100				100	100	100	100		100	100	100		100		100	100		100				100	100
	c	100				100				100											100					100					
	b																100													100		
	a																											100	100			
	N	11	7	11	11	11	9	2	11	11	8	3	6	11	2	9	11	11	3	8	11	11	11	3	11	11	11	2	9	2	11	11
Ao-1	e							100	91	100						100																
	d										100	100									100	100	100	100	100	100	100			100	100	100
	c			100	100	100			9								100															
	b	100					100						100	100	100			100		100								100	100			
	a		100																100													
	N	11	7	11	11	11	9	2	11	11	8	3	6	11	2	9	11	11	3	8	11	11	11	3	11	11	11	2	9	2	11	11
Ao-2	f																															
	e			5			27								100												100			100	100	100
	d			8		100	67						58	50				27		68											
	c	100	100		5		6		100	100			42	50				18	50	13	100											
	b			82	95			100			100	100				100	100	55	50	19		100	100	100	100	100		100	11			
	a			5																									78			
	N	11	7	11	11	11	9	2	11	11	8	3	6	11	2	9	11	11	3	8	11	11	11	3	11	11	11	2	9	2	11	11
Fum	d																															
	c	100	100			100							100												100	100						
	b			100	100		100		100		100	100		100	100			18					100				100			100	100	100
	a							100		100						100	100	82	33	100	100	100		100				100	100			
	N	11	7	11	11	11	9	2	11	11	8	3	6	11	2	9	11	11	3	8	11	11	11	3	11	11	11	2	9	2	11	11
Locus	Allele	0201	0206	0413	0415	0505	506A	506B	0602	0603	0702	0704	0801	0901	1102c	1102d	1103	1209	1210e	1210f	1306	1307	1308	1411	1602	1604	1701	1702a	1702b	1801	1802	1803

Table 3.2: Allele frequencies at 11 loci for 31 *Antipodeus* populations.

*** = No activity at this locus N= sample size

Mdh-1	d																																				
	c	95	100																																		
	b	5		100	100	100	100	100	100		100	100		100	100																						
	a									100			100			100			100																		
	N	11	7	11	11	11	9	2	11	11	8	3	6	11	2	9	11	11	3	8	11	11	11	3	11	11	11	2	9	2	11	11					
Mdh-2	f										56	33																									
	e										44	67				6																					
	d	68	100				83							100	100			100																			
	c	32		100	91	100	17		100	100			100			94	100	100		100		100					100				100					
	b				9			100											100										100	100	100	100		100	100		
	a																					100	100		100												
	N	11	7	11	11	11	9	2	11	11	8	3	6	11	2	9	11	11	3	8	11	11	11	3	11	11	11	2	9	2	11	11					
Got-1	i																						14														
	h																							14													
	g																																				
	f																																				
	e								100										100		80	77	76					100									
	d												8									9	5							100							
	c					100	100						92	100	100			95		100																	
	b							100		***	100	100				100	***	5			20		5	100	100	100		100		***			100	100			
	a	100	***	100	100																																
	N	11		4	11	11	9	2	11		8	3	6	11	2	9		11	3	8	5	11	11	3	11	11	11	2		2	11	11					
Got-2	i																																				
	h																																				
	g	95					94								100			59	100	69 31													9			
	f	5	100			100							100	100				36										100				100	91	100		
	e								91	100							77	5								9									
	d			100	100		6				81	100					23				100	100				55	100									
	c							100	9							100								100		36										
	b										13																	100	100								
	a										6																										
	N	11	7	11	11	11	9	2	11	11	8	3	6	11	2	9	11	11	3	8	11	11	11	3	11	11	11	2	9	2	11	11					
Me	e																																				
	d	95						100	100	45							100		33	100																	
	c		100	100	100	100				55	100	100	92	100	100	100		100						100		100	100					100	100			
	b	5											8						67				5		100				100							
	a																				100	100						100		100						
	N	11	7	11	11	11	9	2	11	11	8	3	6	11	2	9	11	11	3	8	11	11	11	3	11	11	11	2	9	2	11	11					

Table 3.2: (Continued)

	0201	0206	0413	0415	0505	0506A	0506B	0602	0603	0702	0704	0801	0901	1102c	1102d	1103	1209	1210e	1210f	1306	1307	1308	1411	1602	1604	1701	1702a	1702b	1801	1802	1803
0201	-	0.8	1.97	1.76	0.98	0.87	1.6	1.53	1.19	2.22	2.23	1.23	1.04	0.68	1.46	2.14	0.98	1.78	1.68	1.83	4.2	3.42	0.78	2	1.04	1.06	2.85	2.49	1.24	0.77	0.81
0206	50	-	2.07	2.04	0.95	1.9	4	1.21	1.41	2.2	2.21	1.15	0.94	1.01	2.22	1.4	0.96	0.98	1.63	1.74	1.72	2.51	0.82	1.4	2.08	1.5	4.29	1.93	1.5	1.38	1.5
0413	82	80	-	0.07	0.93	0.86	1.01	1	1.51	0.54	0.5	1.67	1.24	1.68	1.31	1.46	1.57	1.89	1.26	1.04	2.11	1.44	0.89	1.12	0.86	1.62	0.73	0.47	2.35	1.59	1.64
0415	73	80	9	-	0.98	0.87	0.98	0.82	1.34	0.57	0.54	1.57	0.99	1.64	1.33	1.43	1.26	1.8	1.05	1	2.11	1.2	0.98	0.86	0.75	1.39	0.74	0.49	1.73	1.5	1.36
0505	55	50	55	55	-	1	2.38	1.34	1.02	1.63	1.64	1.3	1.44	1.29	2.37	1.69	2.31	1.87	1.7	3.54	3.98	3.54	2.36	2.24	2.33	0.98	1.16	0.75	2.38	0.68	0.8
0506A	45	70	27	36	55	-	1.25	1.28	2.65	1.57	1.57	1.08	0.5	0.41	2.14	1.89	0.74	3.25	1.08	1.41	3.59	1.9	1.24	3.09	1.38	0.92	1.42	1.25	1.33	0.81	0.93
0506B	73	100	64	55	91	73	-	1.12	1.58	1.24	1.25	2.39	1.68	1.7	0.45	1.36	1.8	1.3	3.97	1.15	1.21	1.63	0.94	1.12	0.68	1.29	1.03	1.23	1.7	1.26	1.29
0602	64	60	55	45	64	55	55	-	0.63	1.35	1.36	1.09	0.73	1.41	1.11	2.4	1.02	1.07	0.88	0.94	1	0.81	1.44	0.9	0.87	0.7	0.71	0.85	1.73	0.75	0.69
0603	60	70	80	70	60	70	80	40	-	1.51	1.52	1.2	2.22	3.07	0.66	1.53	1.62	1.1	1.21	1.1	0.84	0.96	2.24	0.93	0.88	1.36	2.12	1.03	1.34	1.34	1.35
0702	91	90	36	45	82	73	73	73	80	-	0	4.78	1.61	2.34	1.22	2.02	1.85	1.82	2.08	1.57	2.2	1.11	1.27	1.03	1.38	2.28	1.19	0.62	4	2.3	2.31
0704	91	90	36	45	82	73	73	73	80	0	-	4.78	1.62	2.34	1.22	1.99	1.85	1.82	2.08	1.49	2.15	1.11	1.22	1.04	1.37	2.24	1.2	0.63	4	2.31	2.29
0801	55	40	64	64	55	55	91	55	50	91	91	-	0.42	0.79	0.95	3.56	0.37	1.24	0.4	1.68	1.2	1.73	1.26	1.21	1.03	1.14	1.86	1.76	1.97	1.16	1.13
0901	55	50	64	64	73	36	82	45	80	82	82	27	-	0.42	1.66	2.22	0.2	1.78	0.53	1.68	2.03	1.58	0.95	1.4	1.63	1.03	1.61	1.49	1.7	1.11	1.01
1102c	45	60	82	73	73	27	82	73	90	91	91	55	36	-	1.66	1.82	0.53	2.28	1.03	3.64	2.09	3.24	0.76	1.97	2.06	0.77	2.13	1.89	1.3	0.67	0.78
1102d	64	80	73	64	82	73	36	55	40	64	64	64	82	73	-	1.35	0.98	0.98	1.16	1.51	0.7	1.19	0.72	0.75	0.65	1	1.26	0.92	1.69	0.97	1.01
1103	80	70	70	60	70	70	70	80	70	80	80	90	90	80	70	-	1.45	1.58	1.65	2.61	0.97	1.34	1.39	1.31	1.62	4	1.44	1.5	2.26	3.51	4
1209	36	30	64	64	64	36	82	55	70	82	82	18	9	36	64	70	-	0.96	0.32	1.31	1.1	0.96	0.76	1.21	1.34	1.2	1.91	1.88	1.17	1.27	1.16
1210e	73	60	73	64	82	82	64	55	60	73	73	55	73	91	55	60	45	-	1.06	0.85	0.73	1.22	1.74	1.45	2.92	2.27	1.44	1.58	2.28	1.55	1.58
1210f	64	60	64	55	64	45	91	55	60	82	82	27	36	55	55	60	18	45	-	1.31	1.28	1.05	1.72	1.41	1.58	1.3	1.47	1.38	1.68	1.38	1.27
1306	64	70	55	36	91	55	64	55	60	73	73	64	64	91	73	80	55	45	55	-	0.88	0.87	1.39	1.93	1.37	2.2	1.25	2.09	0.91	2.03	2.02
1307	91	80	73	82	91	91	73	64	80	82	82	55	82	82	55	60	64	36	64	55	-	0.45	1.08	0.73	1.13	1.6	1.09	2.05	1.2	1.56	1.57
1308	91	80	64	64	91	82	82	55	80	64	64	73	73	91	73	70	55	64	55	45	27	-	1.43	0.76	0.96	1.79	1.25	1.55	1.3	1.93	1.74
1411	45	50	55	64	91	55	55	73	90	73	73	64	64	55	45	50	36	73	73	64	55	73	-	0.82	0.64	0.97	2.2	2.36	1.27	0.93	0.98
1602	82	60	64	55	82	91	64	55	50	64	64	45	64	82	45	70	55	73	64	64	45	45	55	-	0.56	1.29	1.96	1.22	1.65	1.43	1.27
1604	55	80	45	45	91	64	45	45	50	64	64	55	73	82	45	80	64	91	64	55	55	55	45	36	-	1.05	1.51	1.41	1.35	1.12	1.04
1701	55	70	73	73	64	55	73	45	70	82	82	64	64	55	64	100	64	91	73	82	73	82	64	73	64	-	1.64	1.55	0.62	0.12	0.1
1702a	82	90	55	45	64	64	64	36	80	73	73	82	82	82	64	70	82	64	64	73	64	73	82	82	73	82	-	0.21	2.35	1.56	1.65
1702b	70	70	40	30	50	50	70	30	50	50	50	60	70	80	50	70	80	60	60	80	80	80	80	60	70	80	20	-	4	1.42	1.55
1801	64	70	91	82	91	73	82	82	70	100	100	73	82	73	82	90	64	91	82	55	64	73	73	82	73	45	91	100	-	0.9	0.8
1802	45	70	73	73	45	45	73	45	70	91	91	64	64	45	55	90	55	82	64	73	73	82	55	73	64	9	73	70	55	-	0.02
1803	45	70	73	73	55	55	73	45	70	82	82	64	64	55	64	100	55	82	73	73	64	82	64	73	64	9	82	80	55	0	-

Table 3.3 . Genetic diifferences matrix for Antipodeus OTUs showing % fixed differences below the diagonal and Nei's genetic distance 'D' (Nei 1978) above the diagonal .

above. Levels of genetic divergence between these allopatric populations are well above those encountered within a single biological species (Richardson *et al* 1986). Two genetically diverse basal groupings are present. However, at higher levels of divergence branch lengths are short, suggesting the UPGMA dendrogram (Fig. 3.82) is unlikely to contain any specific phylogenetic information regarding individual taxa, even if rates of evolution are relatively constant throughout.

There is little doubt the sympatric OTUs at sites 0506 (a&b), 1210 (a&b), 1102 (a&b), and 1702 (a&b) represent distinct sympatric species as all sympatric pairs display fixed differences at 2-8 loci and the probability of observing no heterozygous phenotypes through sampling error at only two loci is $4x10^{-4}$ (for OTU # 1702; one locus $[1-2x2/11x9/11]^{11}=0.0206 = 2x10^{-2}$. For 2 loci; $0.0206^2=4.424x10^{-4}$), considerably less than 5%.

Morphological analysis of the 26 *Antipodeus* collections proved inadequate to determine species boundaries amongst those twenty or more species identified by the allozyme data, and confirmed the morphologically cryptic nature of this genus. Lack of gene flow may be attributed to the fact these amphipods are restricted to cool streams, the lower limit to their epigean distribution being truncated at about 500m altitude, before the majority of stream confluences and before conjunction with the major portion of watersheds. The upper limit of distribution is at about 1000m; below the plateau altitude of the Central Highlands and other mountain systems of the island.

Amphipods, like other peracarids, brood their young, and have no migratory larval stage, nor any resistant phase such as desiccation resistant eggs, factors which Barnard and Barnard (1983) and Stewart (1992a) suggest can lead to a high degree of endemism and speciation.

The high species radiation in this genus may be related to one or more of several causes. *Antipodeus* are apomorphic paramelitids (Williams & Barnard 1988), closer to *Austrocrangonyx* than *Austrogammarus*. They occupy altitudes between the

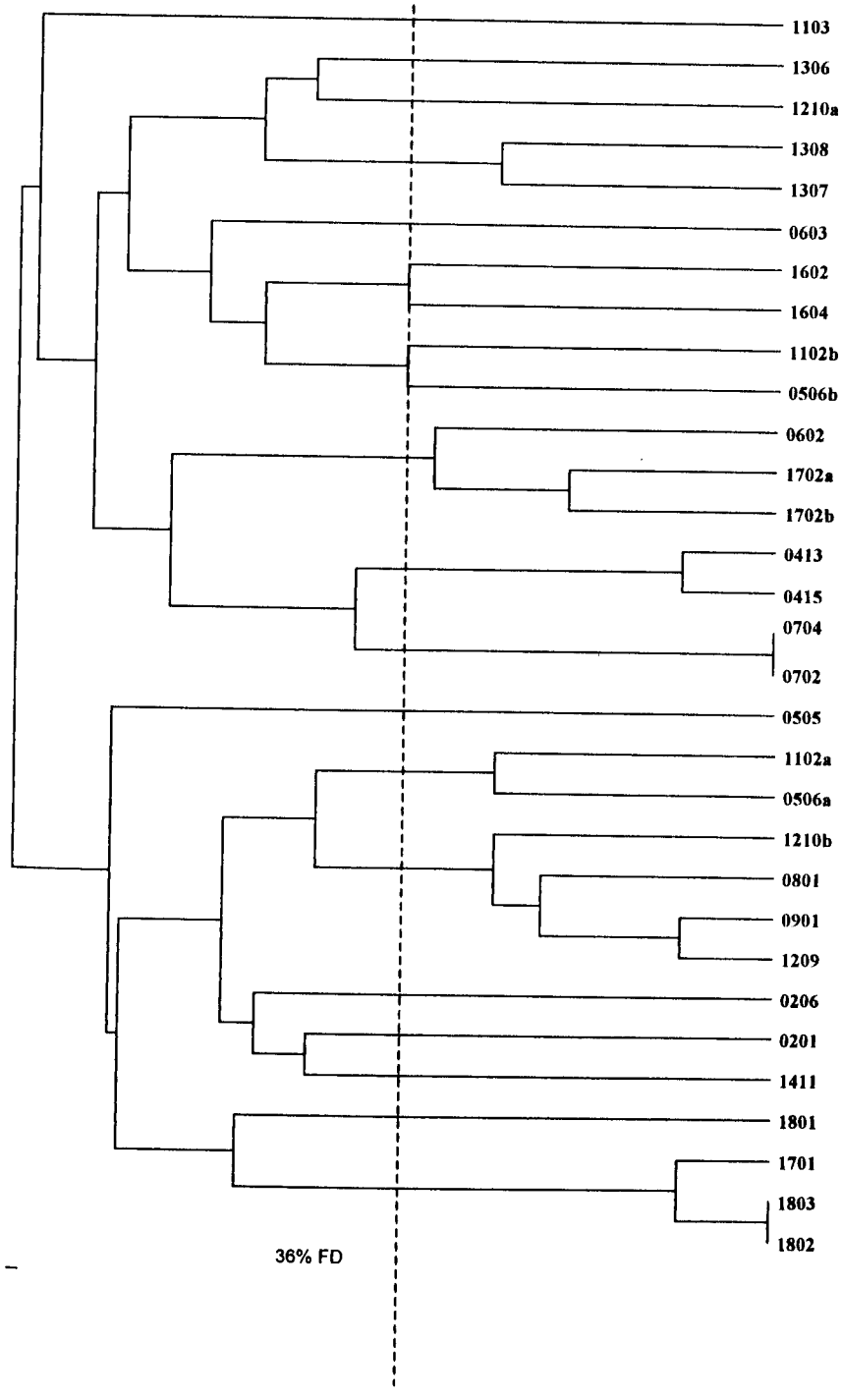

Fig. 3.82: UPGMA dendrogram of %fixed differences between the 31 populations of *Antipodeus*.

maximum lower limit of most recent periglacial activity (around 450m), and the ice cap (around 1200m) of the Pleistocene ice age, about 20 000-15 000 years ago (Davies 1974). Furthermore, they are restricted to the periphery of mountainous regions. Thus their present distribution might be related to the influences of glaciation. Are they then the product of vicariant events resulting from glacial and post glacial isolation of surviving relicts stranded by altitude and climate, or are they the descendants of a species that occupied a niche vacated with glacial recession? The former seems the more plausible explanation, as no *Antipodeus* sp. has dispersed to high altitude habitats beyond the level of periglacial activity; habitats which are now dominated by the Neoniphargidae. Some comparison may be made with speciation among freshwater snails. Ponder *et al* (1993) found that in the speciose genus *Beddomeia* evolution within the group was primarily the result of range restriction, isolation and differentiation of peripheral populations, rather than large scale dispersal, with the result that closely related taxa were also related geographically. Such a relationship does not, however, seem to be reflected among *Antipodeus*. Allozyme analyses indicate a lack of geographic continuity, suggesting these may be surviving relicts stranded by climatic change, rather than the products of local endemism.

The mechanism(s) whereby *Antipodeus* is so restricted in distribution is unknown. Temperature constraints could be related; occurrence of the genus within caves and their immediate efflux streams where temperatures are cool and remarkably constant (Exit Cave temperature remains 11°C throughout the year - A. Clarke pers.com.), as well as in cool mountain streams suggest this possibility. The upper limits of distribution of *Antipodeus*, however, could not be attributed to a requirement for a cool environment; on the Central Plateau, and similar regions throughout the island, water temperatures remain low year round. But, this may in itself be the reason for the absence of *Antipodeus* from those regions as winter temperatures fall well below freezing. As a consequence free water is not available for substantial periods during winter. Without some means of over wintering *Antipodeus* could probably not survive under the conditions prevailing at higher altitudes.

Considering the numbers of species present in the samples tested, many species of *Antipodeus* might be expected to be found among populations of this common taxon of mountain streams and of caves in Tasmania. This remains a challenge for future research.

3.1.7 Distribtion of Australian species of the family Paramelitidae. Fig.3.83

No new species of the Western Australian genera *Protocrangonyx, Uroctena, Hurleya*, or *Toulrabia*, are described here. Similarly, *Chillagoe*, represented by a single, moderately abundant species *C. thea* Barnard and Williams 1995, from the Chillagoe caves in northern Queensland, has not been described from elsewhere. *Giniphargus* is known from a single representative specimen collected by Sayce (1899), and *Austrocrangonyx* by two species from the Barrington Tops region of New South Wales. Known distributions of these taxa remain as stated by Williams and Barnard (1988) and Barnard and Williams (1995).

The new stygobiont genus *Chydaekata*, represented by fifteen species, is endemic to the Pilbara region of Western Australia, in ground waters of the Fortescue River within a radius of approximately 50km of Newman (119°44'E, 23°22'S). *Molina* and *Pilbarus* are monospecific genera also of the Pilbara region of Western Australia, being collected from the Millstream area (~117°E,21°35'S). The monospecific genus *Totgammarus*, also a Western Australian endemic, is represented by a single male specimen taken on the Scott River road, in the south west of the state (34°17'E, 115°20'S).

The eleven species of *Austrogammarus*, including the four new species described here, are taxa of lowland to low altitude streams of Victoria and Tasmania, including the Bass Strait islands, with a single species *A. telsosetosus* as far west as creeks flowing into Lake Bonney in South Australia. The most widely distributed species is *A. smithi* which occurrs at a single site in western Victoria as well as north western Tasmania. The least common of the genus is *A. australis*, thought to be extinct within its type location - Dandenong Creelk, Bayswater (now suburban Melbourne, Williams and Barnard 1988), although since located at sites in the

nearby Dandenong Ranges (T. Doeg pers. com.), and which I have positively identified. The distributions of new species described here are set out above, and of the remaining five species are as set out in Williams and Barnard (1988) and Barnard and Williams (1995).

No new species of the endemic Tasmanian genus *Antipodeus* are described. However, as seen in the genetic analysis of specimens of the genus, new species abound, mainly restricted to streams of the epiglacial, but also occurring within cave streams, and thus widespread in Tasmania.

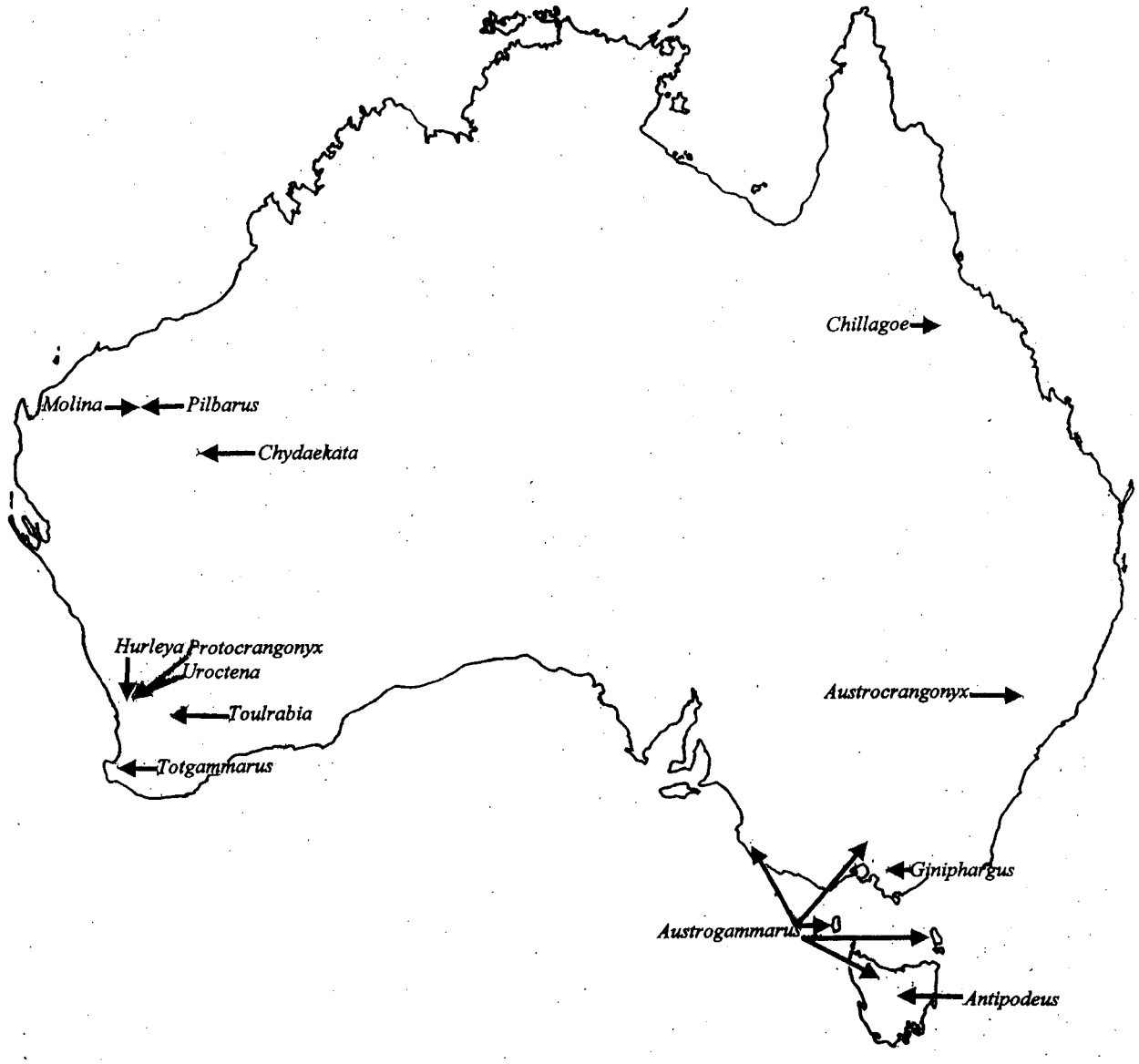

Fig. 3.83. Distribution of Australian genera of the family Paramelitidae.

3.1.8 Composition of the family Paramelitidae (Australian taxa).

Checklist of Australian Paramelitidae.

Austrogammarus australis (Sayce, 1901) - Dandenong Range, Victoria.

Austrogammarus smithi Williams and Barnard, 1988 - Magnet Ck. N.W. Tas.

Austrogammarus haasei (Sayce, 1901) - Dandenong Range, Victoria.

Austrogammarus saycei Williams and Barnard, 1988 - Dandenong Range, Victoria.

Austrogammarus spinatus Williams and Barnard, 1988 - Dandenong Range, Vic.

Austrogammarus multispinatus Williams and Barnard, 1988 - Dandenong Rng. Vic.

Austrogammarus telsosetosus Barnard and Williams, 1995. L. Bonney, S. A.

Austrogammarus badgerhill n. sp. Flinders Island, Tasmania

Austrogammarus robbins n. sp. King Island, Tasmania

Austrogammarus pegarah n. sp. King Island, Tasmania

Austrogammarus dovel n. sp. Willis Track near Dove Lake, Tasmania

Austrocrangonyx barringtonensis (Chilton, 1916). Barrington Tops, N.S.W.

Austrocrangonyx hynesi Williams and Barnard, 1988. Barrington Tops, N.S.W.

Antipodeus antipodeus (G.W.Smith, 1909). Mole Ck.,Tasmania.

Antipodeus wellingtoni (G.W.Smith, 1909). Mt. Wellington, Tasmania.

Antipodeus niger (G.W.Smith, 1909. Hartz Mts. Tasmania.

Antipodeus ripensis (G.W.Smith, 1909). Great Lake, Tasmania.

Antipodeus mortoni (Thomson, 1893). Huon R. Valley, Tasmania.

Antipodeus franklini Williams and Barnard, 1988. Huon R. Valley, Tasmania.

Chillagoe thea Barnard and Williams, 1995. Chillagoe Caves, Queensland.

Chydaekata acuminata sp. nov. Newman region, Pilbara, Western Australia

Chydaekata anophelma sp. nov. Newman region, Pilbara, Western Australia

Chydaekata brachybasis sp. nov. Newman region, Pilbara, Western Australia

Chydaekata breviclava sp. nov. Newman region, Pilbara, Western Australia

Chydaekata carscutica sp. nov. Newman region, Pilbara, Western Australia

Chydaekata diagonalis sp. nov. Newman region, Pilbara, Western Australia

Chydaekata dolichodactyla sp. nov. Newman region, Pilbara, Western Australia

Chydaekata gyraspis sp. nov. Newman region, Pilbara, Western Australia

Chydaekata nudula sp. nov. Newman region, Pilbara, Western Australia

Chydaekata ovatosetosa sp. nov. Newman region, Pilbara, Western Australia

Chydaekata scopula sp. nov. Newman region, Pilbara, Western Australia

Chydaekata scuticara sp. nov. Newman region, Pilbara, Western Australia

Chydaekata simulata sp. nov. Newman region, Pilbara, Western Australia

Chydaekata tetraspis sp. nov. Newman region, Pilbara, Western Australia

Chydaekata transversa sp. nov. Newman region, Pilbara, Western Australia

Giniphargus pulchellus (Sayce, 1899). Thorpdale, Gippsland, Victoria.

Hurleya kalamundae Straskraba, 1966. Kalamunda, W.A.

Molina pleobranchos sp. nov. Millstream, Pilbara, Western Australia

Pilbarus millsi Bradbury and Williams, 1997b. Millstream, Pilbara, W. A.

Protocrangonyx fontinalis Nicholls, 1926a. Darling Range, Western Australia.

Totgammarus eximius Bradbury and Williams, 1995. South West, W. A.

Toulrabia willsi Barnard and Williams 1995. Stirling Range, Western Australia.

Uroctena affinis Nicholls, 1926c. Near Perth, Western Australia.

Uroctena setosa Nicholls, 1926c. Katanning and near Perth, Western Australia.

Uroctena westralis (Chilton, 1925). Near Perth, Western Australia.

Uroctena whadjukia Barnard and Williams 1995. Wungong System, W. A.

Uroctena yellandi Nicholls, 1926d. South of Armadale, near Perth, W. A.

3.2 FAMILY PERTHIIDAE Williams and Barnard

Introduction

The family Perthiidae was erected by Williams and Barnard (1988) to accommodate the species *Perthia acutitelson* Straškraba 1964, and a species originally assigned to the Neoniphargidae (*Neoniphargus*), *Perthia branchialis* (Nicholls 1924). These Williams and Barnard (1988) regarded as clearly Crangonyctoidea, although 'not readily accommodated' in either of the other Australian crangonyctoid families - Paramelitidae and Neoniphargidae. Crangonyctoid characters include the possession of linear calceoli, 2 articulate accessory flagellum of the first antenna, 2 articulate third uropod outer ramus, coxa 4 larger than coxae 5-7, absence of a basofacial robust seta on the first uropod, 2 articulate maxilla-1 palp, presence of D as well as E setae on the mandibular palp, and the first gnathopod not dominant (Williams and Barnard 1988).

Unlike genera of the Paramelitidae and Neoniphargidae *Perthia* lacks a triturative molar, the first antenna is short, the outer plate of the maxilliped is small, the attachment of propodi to carpi on the gnathopods is cantilevered and the gnathopods are large, the antennal sinus is well developed. The sternal gills are dendritic, unlike Paramelitidae, and the maxilliped and gnathopods lack rugosities such as are found in the Neoniphargidae. Williams and Barnard (1988) also point out there are a number of unusual features among the characters of *Perthia* which separate it from Paramelitidae and Neoniphargidae, including the short first antenna, cantilevered gnathopods, non-triturative molar, absence of significant pubescence (short setae) on the maxillae although presence of short facial setae on the outer plate of the second maxilla, the symmetrical palps of the first maxilla (excepting in *Wesniphargus*, although this has been revised in redefining *Wesniphargus* and redescribing *W. nichollsi* - see 3.3.7), the small second maxilla, the poorly setate inner plate of the maxilliped and absence of apical setae, the reduced maxillipedal outer plate and strongly spinose dactyl, greater density of setae on the pereopods, and the short inner rami of the pleopods.

SAMPLING SITE	sub site	DATE	COLL.**	LONG. °E	LAT. °S	FAMILY	GENUS	SPECIES
Victoria								
Broken Creek, Katamatite,Vic.	-	09 Nov94	Souter	145°42'	36°05'	Perthiidae	*Perthia*	*unknown*
New South Wales								
Smiths Creek, Yielima, N.S.W.	-	26Oct93	Souter	145°14'	34°54'	Perthiidae	*Perthia*	*unknown*
South Australia								
Aldgate Creek, S.A.	edge	16Nov95	Taylor	138°44'	35°01'	Pethiidae	*Perthia*	*unknown*
Aldgate Creek, Aldgate Vy. Rd.	edge	02Dec98	Taylor	-	-	Perthiidae	*Perthia*	*unknown*
Echunga Creek, S.A.	-	28May98	Taylor	138°46'	35°06'	Pethiidae	*Perthia*	*unknown*
Hadrian Creek, above Scott Creek	-	03Nov98	Taylor	-	-	Perthiidae	*Perthia*	*unknown*
Kangarilla Creek, S.A.	edge	18Jul00	Taylor	-	-	Perthiidae	*Perthia*	*unknown*
Leslie Creek, Mylor, S.A.	edge	27Oct97	Taylor	138°46'	35°03'	Perthiidae	*Perthia*	*unknown*
Murray River, Woods Point, S.A.	-	11Oct84	-	146°16'	37°32'	Perthiidae	*Perthia*	*unknown*
Onkaparinga River, Shillabeer Rd.	-	16Jul01	Taylor	-	-	Perthiidae	*Perthia*	*unknown*
Scott Creek, Scott Bottom, S.A.	-	21Oct99	Taylor	-	-	Perthiidae	*Perthia*	*unknown*
Spoehr Creek, S.A.	-	16Jul01	Taylor	-	-	Perthiidae	*Perthia*	*unknown*
Western Australia								
Arumvale Pipe, W.A.	stream	02Jan00	SE*	~115°	~34°	Perthiidae	*Perthia*	*acutitelson*
Bob's Hollow Spring, W.A.	spring	31Dec00	SE	~115°	~34°	Perthiidae	*Perthia*	*acutitelson*
Cape Leeuwin Spring, W.A.	spring	29Aug99	SE	115°23'	34°09'	Perthiidae	*Perthia*	*acutitelson*
Connelleys Cave, W.A.	main stream	28 Jan00	SE	~115°	~34°	Perthiidae	*Perthia*	*acutitelson*
Easter Cave, Margaret River, W.A.	B2	27Oct99	SE	115°02'	34°03'	Perthiidae	*Perthia*	*acutitelson*
Easter Cave-Tiffany's Lake, W.A.	B1	05Feb02	SE	115°02'	34°03'	Perthiidae	*Perthia*	*acutitelson*
Jewel Cave, nr Augusta, W.A.	FR2	20Feb01	SE	115°08'	34°20'	Perthiidae	*Perthia*	*acutitelson*
Mammoth Cave, Witchcliffe, W.A.	main	15Jun99	SE	115°02'	34°06'	Perthiidae	*Perthia*	*acutitelson*
Ruddocks Cave	pool	02Jan00	SE	~115°	~34°	Perthiidae	*Perthia*	*acutitelson*
Strongs Cave	stream	06Jan91	SE	~115°	~34°	Perthiidae	*Perthia*	*acutitelson*
Turners Spring, W.A.	benthos	27Feb02	SE	~115°	~34°	Perthiidae	*Perthia*	*acutitelson*

Table 3.4. Perthiidae. Sampling locations mentioned in the Text. (* SE = Stefan Eberhard).

3.2.1 Discussion

No new species of the family Perthiidae or genus *Perthia* are described. However, I have examined specimens of Perthiidae from Western Australia, Victoria, New South Wales and South Australia (Taylor 2002), which include new records of the taxa from regions outside Western Australia (Table 3.4).

Animals collected in Western Australia all belong to one or other of the two described species. However, variation of eye pigmentation initially suggested specific differences among specimens, nominally *P. acutitelson*, from sites adjacent to and within caves of the Leeuwin-Naturaliste Park region of south west Western Australia, approximately 34°S 115°E (S. Eberhard, pers. com). I examined 120 specimens from Arumvale Pipe (stream), Bobs Hollow Spring, Cape Leeuwin Spring, Connelleys Cave, Easter Cave, Jewel Cave, Mammoth Cave, Ruddocks Cave, Strongs Cave and Turners Spring (all collected by S. Eberhard) (Table 3.4). Close examination of morphological characters of these 120 specimens, including eye form and pigmentation, revealed very little variation of characters excepting density of eye pigmentation, and without loss of the underlying eye form. It was concluded these were specimens of *P. acutitelson*.

Specimens of the family Perthiidae were collected from Broken Creek near Katamatite (36°05'S 145°42'E) south of the Murray River in northern Victoria; 4 specimens 10-12mm, including an ovigerous female (12mm). A further 2 specimens (12mm ovigerous female and 5mm immature specimen) were collected from Smiths Creek, Yielima (35°54'S 145°14'E) north of the Murray River in southern New South Wales (P. Suter, pers. com.) (Table 3.4). These specimens bore the characteristics of the genus *Perthia*, although whether new species are represented has not been determined.

Amphipoda collected by D. J. Taylor (2002) (Table 3.4) from streams of the southern Mount Lofty Ranges in South Australia included specimens of Perthiidae (Taylor 2002). I examined these specimens, from the Onkaparinga River, Aldgate Creek, Echunga Creek, Hadrian Creek, Kangarilla Creek, Leslie Creek, Scott Creek,

Spoehr Creek and the Murray River at Woods Point. All were of the genus *Perthia*, although with characters other than those of *P. acutitelson* or *P. branchialis*.

Perthiidae therefore is represented outside Western Australia, in the south central and east of the continent, although no detailed studies have been completed at this time. The family remains monogeneric, and the number of described species remains two: *Perthia acutitelson*, *Perthia branchialis*, but new, undescribed, taxa are known from South Australia, Victoria and New South Wales (Fig. 3.84).

Fig. 3.84. Distribution of genera of the family Perthiidae.

3.3 FAMILY NEONIPHARGIDAE Bousfield

Introduction, Diagnosis and Composition of the Family

E. L. Bousfield established the family Neoniphargidae in 1977 and 1978, although Straskraba (1964) recognised dissimilarities between *Neoniphargus*, and 'related' genera; *Perthia*, *Uroctena*, *Eoniphargus*. Bousfield created the family from an amalgamation of the several apparently apomorphic, heterogeneous, antiboreal, mainly epigean crangonyctoids including *Neoniphargus*, *Indoniphargus*, *Eoniphargus*, *Protocrangonyx* and *Perthia*, although he anticipated family sub-splitting at some later time. Notwithstanding, Bousfield (1982) subsequently extended the family to include *Giniphargus*, *Sandro*, and *Austroniphargus*. The Neoniphargidae then included four Australian genera (*Neoniphargus*, *Protocrangonyx*, *Perthia* and *Giniphargus*) among the eight family members.

Williams and Barnard (1988) disagreed with the composition of Bousfield's (1977, 1982a) family, finding *Sandro*, *Austroniphargus* and the Australian genus *Perthia* worthy of separate family status (and thus establishing the new Australian family Perthiidae). Concurrently, they (Williams and Barnard 1988) removed *Giniphargus* and *Protocrangonyx* to the Australian and South African family Paramelitidae, and rejected *Indoniphargus* and *Eoniphargus* as not being Crangonyctoidea. Thus, only *Neoniphargus* remained of the original Neoniphargidae. However, Williams and Barnard (1988) added three new genera *Tasniphargus*, *Wesniphargus* and *Yulia*, upholding the family status, although emending the diagnosis. *Yulia* and *Tasniphargus* were raised from new species found among incorrectly identified types from the 1907-8 collections of G. W. Smith (1909a) and *Wesniphargus* from a single new species collected by Straskraba and ascribed to *Neoniphargus* (Straskraba 1964). The Neoniphargidae became a wholly Australian family of four genera and ten species, although Williams and Barnard (1988) mooted a future need for a 'more formal rediagnosis' when more specimens became available for examination.

Neoniphargus occurs in Tasmania and Victoria and includes seven described species. Remaining genera are monospecific; *Tasniphargus* and *Yulia* are restricted

to Tasmania, and *Wesniphargus* is from a site near Perth, Western Australia (Williams and Barnard 1988). Excepting *Wesniphargus* (from a creek at Cannington), all are known only from high altitude tarns, pools, springs and streams of alpine or subalpine regions.

In redefining the family Williams and Barnard (1988) particularly noted two new characters which were considered significant among the Neoniphargidae: the presence of 'rugosities' on the third article of the maxillipedal palp and the gnathopods, and the presence of dendritic or lumpy sternal gills. Their diagnosis of the family Neoniphargidae is: *Antennal sinus of head weak or absent. Molar of mandible well developed, triturative. Outer plate of maxilla two with one kind of seta apicolaterally. Outer plate of maxilliped of ordinary size. Rugosities present on maxillipedal palp article three and gnathopods. Gnathopods small or of medium size, almost mittenform, first not dominant, carpi short and lobate, propodi attached to carpi normally, spines on palms not of bifid crangonyctoid form. Posterior lobes of coxae five to seven but especially of coxa six, dominant. Oostegites broad to medium width. Sternal gills dendritic or bearing small lumps. Urosomites separate. Inner ramus of uropod three present.*

Williams and Barnard (1988), as well as Bousfield (1977, 1982a), anticipated revision of family characters at such time as more representatives of the family had been collected: they were certain there would be more specimens collected and new taxa defined. Barnard and Williams (1995) remark their 1988 report represented a 'foundation' for future work.

3.3.1 Review of Family Characters

In this study specimens apparently of Neoniphargidae were found to display characteristics other than those defined by Williams and Barnard (1988). However, differences were confined to two characters only: *oostegites* of several cave dwelling specimens from New South Wales and of specimens of the pholeteros (Lake 1977; Horwitz 1988; Richardson, pers. com.) from high alpine areas of Tasmania, were narrow rather than broad; *sternal gills* were seen to be simple rather

than dendritic or lumped among several cave dwelling specimens from New South Wales. In other respects, including the other new character introduced by Williams and Barnard (1988) - rugosities of the maxillipedal palp and gnathopods - these specimens conformed to the neoniphargid family diagnosis.

Dendritic, lumpy, or simple sternal gills are well described and illustrated (Williams and Barnard 1988; Bousfield 1977), although their true function, whether respiratory or osmotic, is debated (Barnard and Barnard 1983; Bousfield 1977). They can be clearly observed under the light microscope. As a diagnostic character they are potentially valuable. Introduced by Williams and Barnard (1988), and omitted in earlier diagnoses (Bousfield 1977, 1982a), the character of either dendritic or lumpy sternal gills was certainly applicable to all Neoniphargidae described by, or included in, their (Williams and Barnard 1988) studies. However, as already noted, when specimens from a variety of habitats were examined sternal gills were found to vary from dendritic to lumpy to simple (although never absent, as in some of the Paramelitidae) The absence of simple sternal gills is not a unique, diagnostic family character as simple gills are also characteristic of Paramelitidae; nor is the presence of dendritic sternal gills as they are also characteristic of Perthiidae.

Oostegites in neoniphargids were defined by Williams and Barnard (1988) as being of broad to medium width. Cave dwelling specimens from New South Wales bear narrow oostegites. A common characteristic of hypogean Amphipoda, however, is the attenuation and often elongation of the appendages, as well as reduction of the number of eggs brooded, which themselves tend to be considerably larger than those borne by epigean species (Holsinger 1994b). Williams and Barnard described no stygobiont Neoniphargidae. Narrowing and elongation of the oostegites among stygal amphipods might therefore be anticipated, even though not observed previously. Oostegite width varies from broad, to medium, to narrow within the family and is thus an unreliable diagnostic character for Neoniphargidae.

Rugosities of the maxillipedal palp and gnathopods, in contrast, were found universally among Neoniphargidae examined, and although Williams and Barnard (1988) found no evidence of rugosities on *Wesniphargus*, examination of new samples of the species *W. nichollsi*, including previously undescribed male

specimens, indicated rugosities present on both the maxillipedal palp and gnathopods. Rugosities, regions of cuticle of rough appearance under moderate magnification, are said to occur also on the maxillipedal palps of *Protocrangonyx fontinalis* F. Paramelitidae and *Perthia acutitelson*, F. Perthiidae (Williams and Barnard 1988). If rugosities are present on the maxillipedal palps and gnathopods of some Paramelitidae and Perthiidae, their usefulness as diagnostic characters of Neoniphargidae is limited.

No detailed description, nor closer examination of these structures, was associated with their introduction as a definitive character of Neoniphargidae (Williams and Barnard 1988). To determine whether rugosities are unique characters of the family scanning electron microscope examination of maxillipedal palps and gnathopods of representative taxa of Australian freshwater amphipoda was undertaken.

Examination of Rugosities

A Scanning Electron Microscope (SEM) study of rugosities was undertaken as indicated in Chapter 2.4. Cuticular structures of the gnathopods and maxillipedal palps of eighteen species of twelve genera of three Australian Crangonyctoidea families, as well as a species of the Talitroidea family Ceinidae, were examined at 400 to 2000 magnifications (Table 3.5).

Results

Examination under the light microscope confirmed the consistent presence of rugosities among neoniphargids on the posterior lobes or keels on some or all of articles two to six of the gnathopods, and on apical extensions of the third article of the maxillipedal palps. Rugosities were not visible under the light microscope among any species other than of the family Neoniphargidae, including *Protocrangonyx fontinalis*. Scanning Electron Microscope (SEM) examination revealed details of cuticular structures only at magnifications greater than 400×.

Neoniphargidae
Neocrypta primaris Bradbury and Williams, 1997. Lime Kiln Cave, New South Wales.
Neoniphargus sp. nov.'a' Dinner Plain, Mt.Hotham, Victoria.
Neoniphargus thomsoni Stebbing, 1899. Mt.Wellington, Tasmania.
Neoniphargus sp.nov.'b' Quamby Brook, Tasmania.
Tasniphargus tyleri, Williams and Barnard, 1988. Woods Lake, Tasmania.
Wesniphargus nichollsi, (Straškraba, 1964). Boyanup, Western Australia.
Wesniphargus sp.nov.'a' York River at Nalg, Tasmania.
Wesniphargus sp. nov.'b' Tooms Lake, Tasmania.
Wesniphargus sp.nov.'c' Green Pond Rivulet, Tasmania.
Wesniphargus sp.nov.'d' Cock Creek Plain, Tasmania.
Yulia yuli, (G.W.Smith, 1909). Youls Tarn, Ben Lomond, Tasmania
Ceinidae
Austrochiltonia australis, (Sayce, 1901). Meadows, South Australia.
Paramelitidae
Antipodeus niger, (G.W.Smith, 1909) Mt. Wellington, Tasmania.
Austrocrangonyx sp.nov. Barrington Tops, New South Wales.
Austrogammarus spinatus, Williams and Barnard, 1988. Bayswater, Victoria.
Protocrangonyx fontinalis, Nicholls, 1926. Darlington, Western Australia.
Uroctena westralis, (Chilton, 1925). Darlington, Western Australia.
Perthiidae
Perthia acutitelson, Straškraba, 1964. Yeagarup Lake, Western Australia.

Table 3.5. Amphipoda examined with the Scanning Electron Microscope.

Cuticular polygonal surface patterning is seen in several species on the gnathopods and, more exceptionally, maxillipedal palps (Fig. 3.85b, c). Polygonal patterning is mostly five- or six-sided, and discernible through overlying microsetae, whether simple or complex, small (Fig. 3.85d, e) or elongate (Figs. 3.85f, 3.86a). Not all articles were so patterned, and apolygonal cuticle also occurred both on gnathopods (Fig. 3.86b, c) and maxillipedal palps (Fig. 3.86d).

Several types of setal structures were found on most species. Lanceolate structures arranged singly (Fig. 3.86e), or in groups (Fig. 3.86f), often arising from a broad common base (Fig. 3.87a), occur facially on gnathopodal articles (Fig. 3.87b, c) and maxillipedal palps (Fig. 3.87d) of neoniphargids and others, as well as post-ventrally on articles of the gnathopods of non-neoniphargids (Fig. 3.87e).

Setae of the rugose areas of Neoniphargidae visible under the light microscope, when seen under the scanning electron microscope, are basally stalked, hand-like

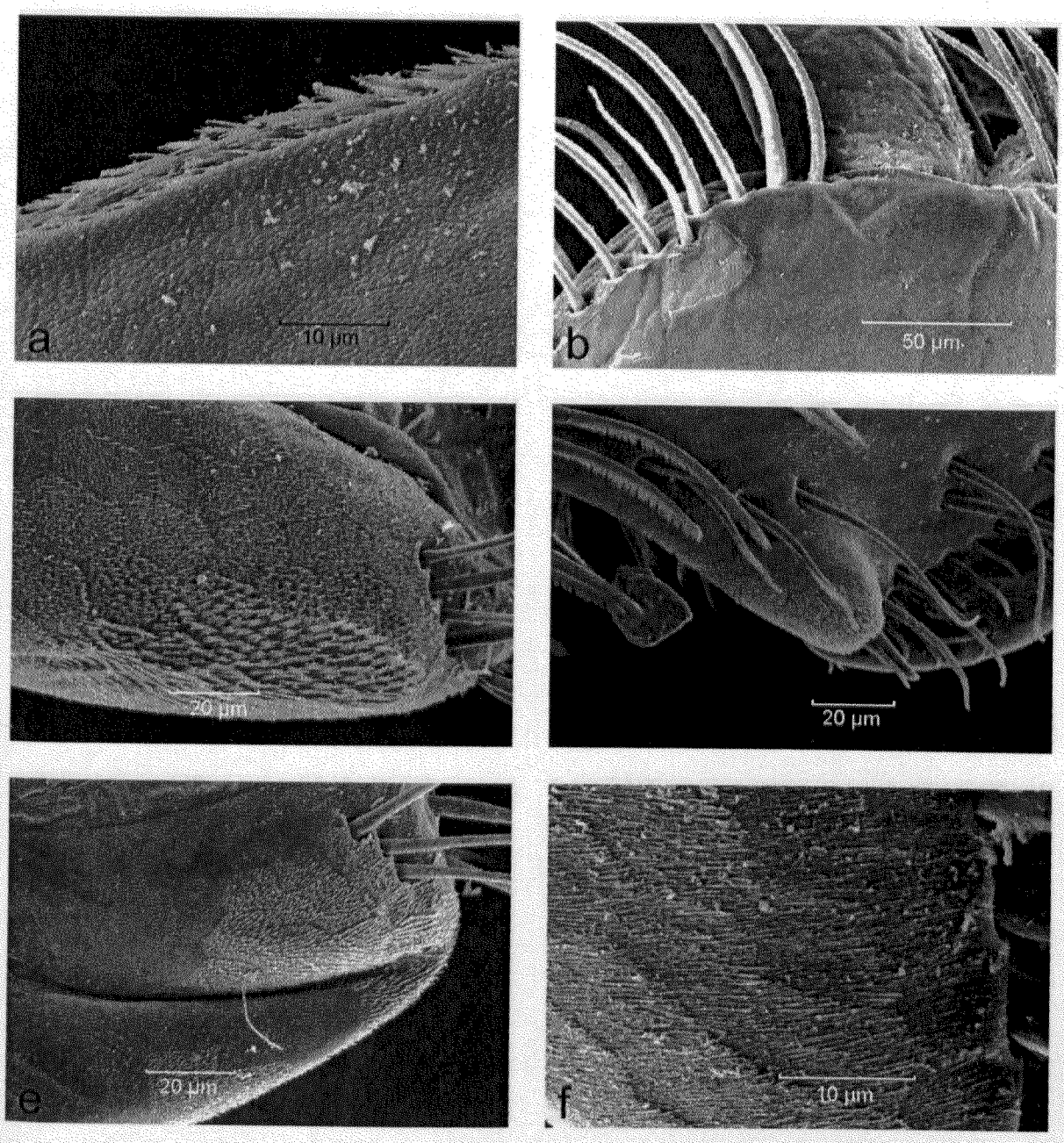

Fig. 3.85. SE-micrographs of rugosities. **a**. *Neocrypta primaris*: ventral margin, gnathopod one. **b**. *Perthia acutitelson*: maxillipedal palp article three apex and base of dactyl. **c**. *Wesniphargus* sp. nov. 'a': disto-lateral face and ventral margin of merus, gnathopod two. **d**. *Austrochiltonia australis*: palmar corner and disto-ventral margin, gnathopod one propodus. **e**. *Wesniphargus* sp. nov.'b': lateral face and disto-ventral margin, gnathopod two merus. **f**. *Austrogammarus spinatus*: posterior face and margin, gnathopod one ischium.

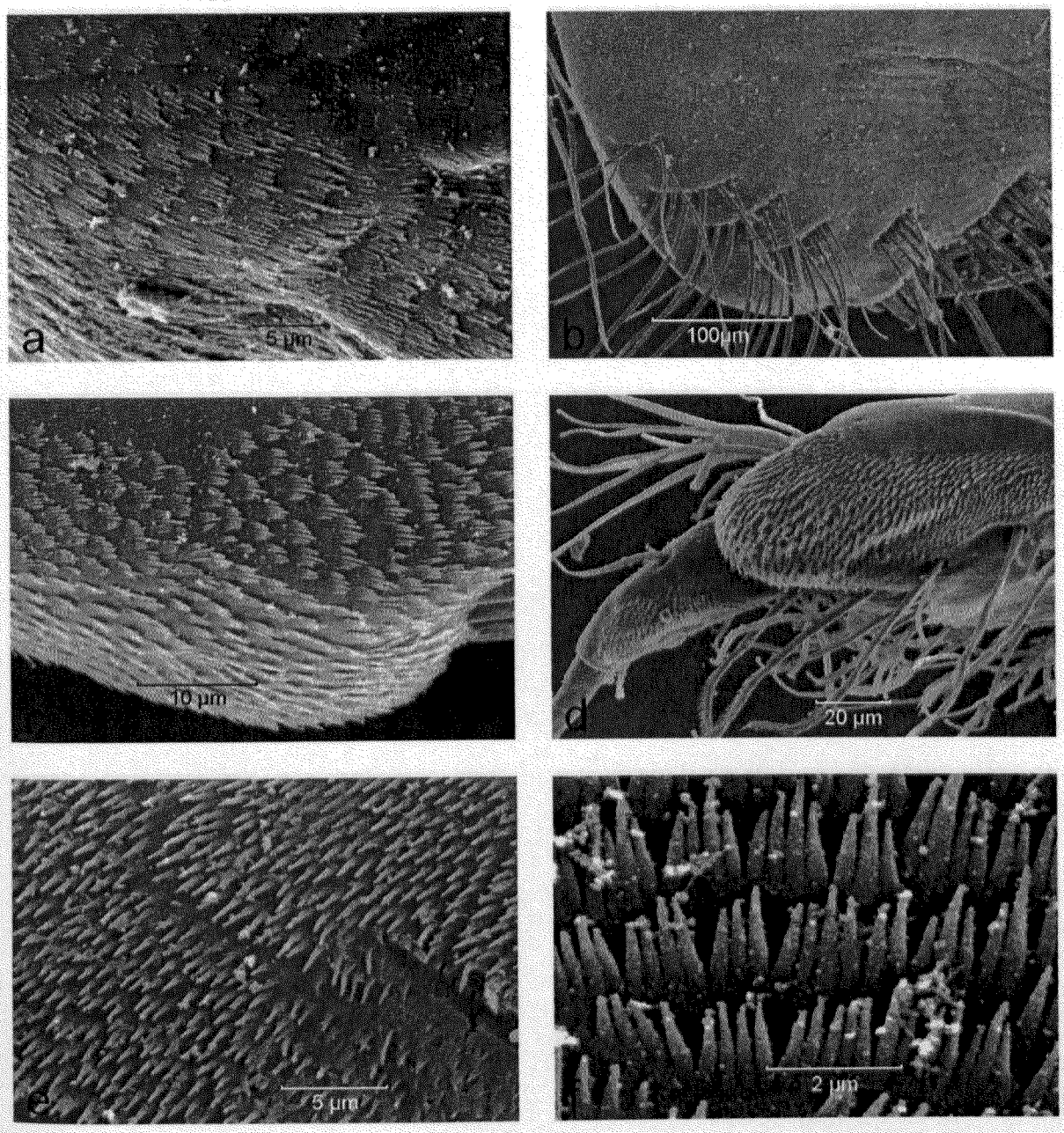

Fig. 3.86. SE-micrographs of rugosities. **a**. *Perthia acutitelson*: disto-ventral corner, gnathopod one basis. **b**. *Neoniphargus* sp. nov.'a': disto-ventral apex (palmar corner), gnathopod one propodus. **c**. *Wesniphargus* sp. nov.'b': disto-ventral corner, gnathopod one basis. **d**. *Wesniphargus* sp. nov.'b': maxillipedal palp article three apex and dactyl. **e**. *Wesniphargus* sp. nov.'b': disto-lateral face, gnathopod two basis. **f**. *Antipodeus niger*: ventro-lateral face, gnathopod one propodus.

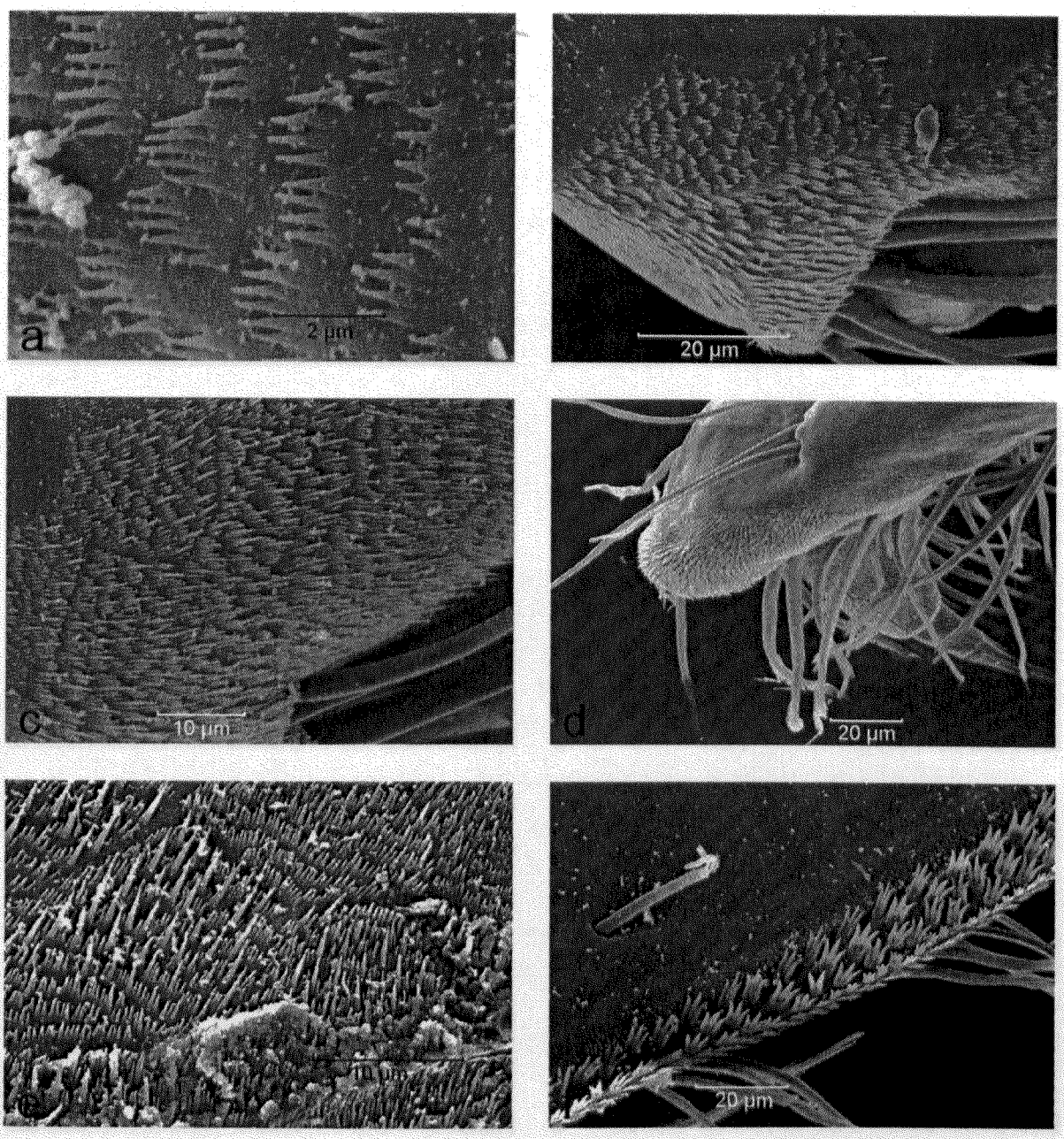

Fig. 3.87. SE-micrographs of rugosities. **a**. *Neoniphargus thomsoni*: lateral face, posterior lobe, gnathopod one carpus. **b**. *Wesniphargus* sp. nov.'b': lateral view, disto-ventral margin, gnathopod two basis. **c**. *Wesniphargus* sp. nov.'c': lateral view, disto-ventral margin, gnathopod one ischium. **d**. *Yulia yuli* : maxillipedal palp article three apex and dactyl. **e**. *Antipodeus niger*: ventro-lateral face, gnathopod one basis. **f**. *Yulia yuli* : ventro-distal margin, gnathopod one propodus.

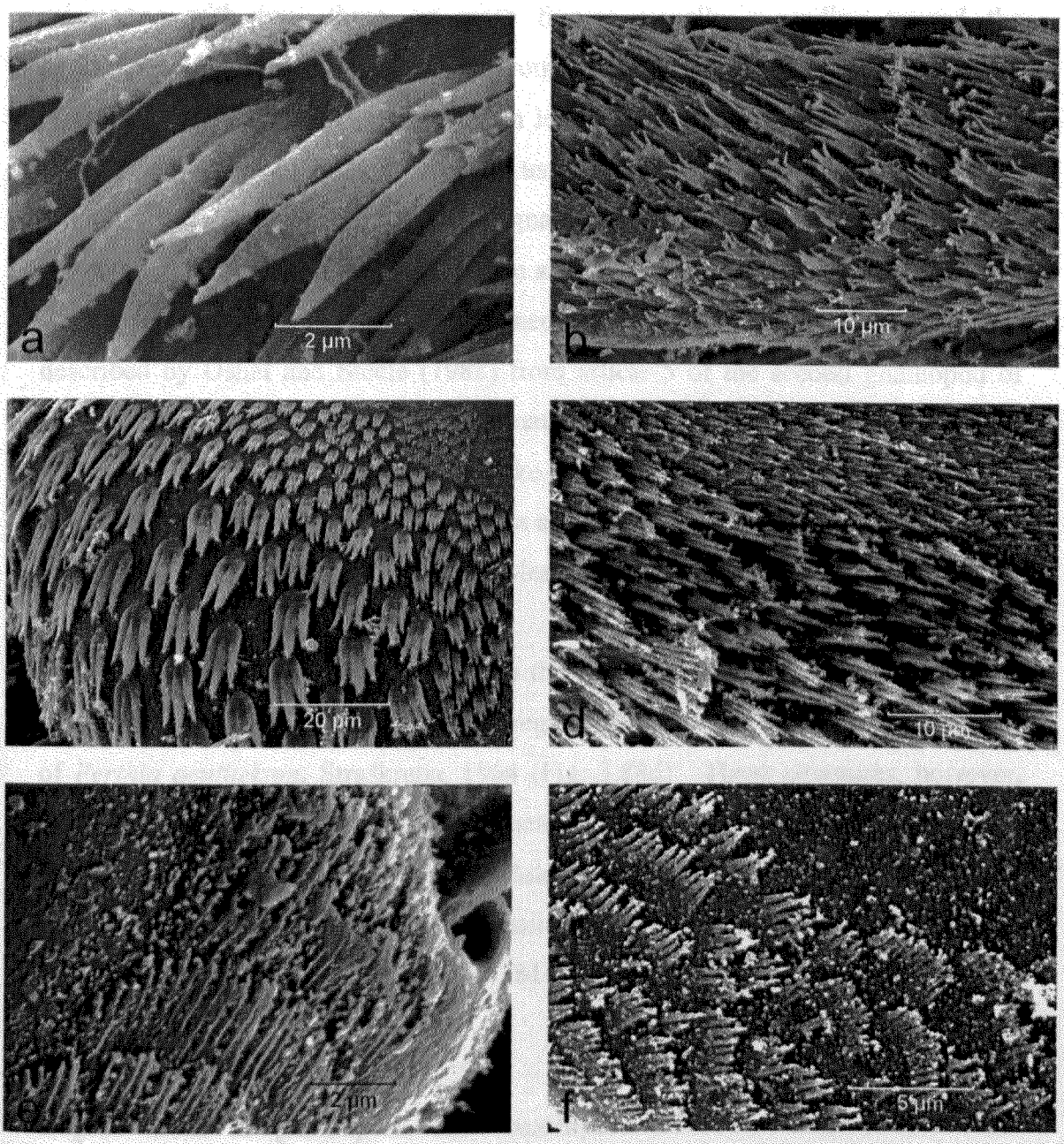

Fig. 3.88. SE-micrographs of rugosities. **a**. *Neoniphargus thomsoni*: post-ventral margin setae, gnathopod one carpal lobe. **b**. *Tasniphargus tyleri*: medial face, ventral margin, maxillipedal palp third article. **c**. *Neoniphargus* sp. nov.'a': lateral face, posterior lobe, gnathopod one merus. **d**. *Perthia acutitelson*: lateral face, disto-ventral margin, gnathopod one basis. **e**. *Protocrangonyx fontinalis*: ventro-distal corner, gnathopod one ischium. **f**. *Protocrangonyx fontinalis*: ventro-lateral margin, gnathopod one basis.

microsetae with two, three, or more fingers, usually expanding toward the peripheries, the lateral digits curving outward apically (Figs. 3.87f, 3.88a, b). Microsetae of the rugose areas varied in length from 2.5μm (Fig. 3.85c) to 20μm (Fig. 3.88b), those at the outer periphery usually much longer than those facial (Fig. 3.88c). Such setae occurred on the gnathopods and maxillipedal palps of all neoniphargids examined, varying only in size and proportion, but not in form, and were absent from all other taxa examined. They are, however, similar to setae described by Oshel and Steele (1988) from article 5 of the second gnathopod of *Lysianassa alba*, Holmes 1903, designated type 4e; 'palmate, with a broadly flattened end and three or more finger-like projections; may or may not be stalked', and by Kaufmann (1994) from the carpus and propodus of the second gnathopod of the Lysianassidae *Orchomene limodes*, Meador and Present, 1985.

Microsetae with superficial similarity to the palmate structures of Neoniphargidae occur on a small area of the post-distal region of the second article of gnathopod 2 of *Perthia acutitelson*, Straškraba, 1964 (Fig. 3.88d). These structures, however, appear to be broad-based, compound linear microsetae with short lateral and long central elements, and without the disto-lateral bent apex or stalked bases as in the rugosities of Neoniphargidae, and are similar to linear microtrichs of the coxal plate of *Podocerus* sp. (*Podocerus*, Leach, 1814) described by Halcrow and Bousfield (1987).

Rugose areas of gnathopods and maxillipeds of *Protocrangonyx fontinalis* described by Williams and Barnard (1988) were found to be crowded regions of compound lanceolate microsetae (*sensu* Halcrow and Bousfield 1987) (Fig. 3.88e, f), and not equivalent to the rugosities of Neoniphargidae.

Discussion

Cuticular polygonal patterning was noted in representatives of all families, at times through long or dense overlying setae. Halcrow and Bousfield (1987) found them abundant among gammarid amphipods, but were unable to suggest any functional significance, although they noted trends in similarity of pore and polygon patterns

in agreement with earlier work (Bousfield 1978, 1982a, 1983). In this study, it was not possible, to discern higher order characteristics in cuticular patterning.

Studies of cuticular micro-structures of amphipods are reported by several authors, notably Halcrow and Bousfield (1987), Oshel and Steele (1988) Oshel *et al.* (1988), Platvoet (1985), Watling (1989), and Read and Williams (1991). Watling (1989) established fundamental definitions of cuticular outgrowths, and classified setae into four principle groups, these being adapted and modified by Wagner (1994). Oshel and Steele (1988) grouped small (length less than 25mm) amphipod setae - "microtrichs" - into 4 classes and 13 types on the basis of morphology whilst acknowledging their groups were not exhaustive since many amphipod taxa had not been studied. Fish (1972), in a study of isopod setae distinguished two microtrich types on the basis of form and size: triangular structures of approximately 2mm length arranged in crescent rows, and 10mm long single microtrichs set into sockets in the cuticle. Platvoet (1985) in study of the side line organs (which were termed Type II microtrichs *sensu* Oshel and Steele 1988) of *Gammarus Fabricius*, 1775 and *Echinogammarus* Stebbing, 1899 considered those organs of phylogenetic significance, observing differences of structure, composition, and location between the genera. Wagner (1994) in reviewing the Thermosbaenacea Monod, 1927 employed microsetal types in taxonomic discriminations within that group.

Lanceolate microsetae occurring facially and post-ventrally on the gnathopodal articles and maxillipedal palp of Australian non-Neoniphargidae, and facially on the gnathopods and maxillipedal palps of neoniphargids are similar to the lanceolate microtrichs reported by Halcrow and Bousfield (1987: Figs. 20, 24-6, 30), in a spectrum of amphipod species. The elongate paired (or more) microsetae of *Perthia acutitelson*, Straškraba, 1964 appear to be derived forms of compound linear microsetae like those described as compound microtrichs by Halcrow and Bousfield (1987, Fig. 30) from a coxal plate of *Podocerus* sp., or dense lanceolate microsetae similar to those on the head of *Metoediceros fuegiensis*, Schellenberg, 1931 (cf. Halcrow and Bousfield 1987, Fig. 25). They are unlike the rugosities of Neoniphargidae.

Rugosities recorded from the gnathopods and maxillipedal palp of *Protocrangonyx fontinalis* (Williams and Barnard 1988) were not visible under the light microscope in specimens examined here, but may be visible in larger specimens. In any case, those areas which appeared rough to Williams and Barnard (1988) do bear microsetae visible under the scanning electron microscope of our specimens. However, the setae present were not Neoniphargidae-type rugosities, but rather ranks of compound linear microsetae, similar to, although longer than, hammate setae (rows) recorded as associated with 'Type A pegs' (Read and Williams 1991) widely distributed on the cuticle of *Gammarus pseudolimnaeus*, Bousfield 1977.

Palmate microsetae were present on the gnathopods and mandibular palps of Neoniphargidae examined; all taxa bore microsetae of a similar morphology in rugose areas, structures not found in any of the other species examined. However, similar structures have been described by Oshel and Steele (1988, Fig. 16) from the second gnathopod of *Lysianassa alba*, and by Kaufmann (1994, Fig. 9B) from the second gnathopod of the Lysianassidae *Orchomene limodes*. An phylogenetic association between Neoniphargidae and Lysianassidae (marine species with a single freshwater genus, *Onisimus*, Boeck, 1871 in shallow water of the Caspian Sea), seems unlikely.

Microscopic examination of Neoniphargidae rugosities, albeit at very great magnification, gives no indication of the function of these organs, although their location suggests a simple tactile purpose. Kaufmann (1994) considered that the similar structures found in *Orchomene limodes* were non-innervated spines; i.e. non-articulated cuticular processes, with perhaps a cleaning function during grooming, or gustatory function during feeding. This may be true of *O. limodes*, but that species bore the structures on the second gnathopod alone, which was seen to have a distinctly different function from the first gnathopod during both grooming and feeding. The Neoniphargidae, however, bear them not only on the carpus and propodus of the second gnathopod, but also, according to species, on other articles of both gnathopods, as well as on the maxillipedal palps. It seems likely that the organs have at least a gustatory function. Oshel and Steele (1988) considered similar structures of the second gnathopod of *Lysianassa alba* to be 'setae' (type 4e); i.e., structures produced not as an epidermal outgrowth, but by 'the

actions of specialised cells', and thus of phylogenetic significance. Because of their length and overlapping, the exact nature of attachment of these microsetae in Neoniphargidae cannot be clearly seen from the scanning electron microscope pictures, although their distinctly stalked base is clear.

As a family characteristic, however, Neoniphargidae rugosities are consistent and visible under the light microscope at moderate magnification, and therefore important taxonomic criteria for Australian Crangonyctoidea. Where some family characters have been shown as absent, as in the case of simple rather than budded or fully dendritic sternal gills, the presence of rugosities indicates affinity with the Neoniphargidae.

The consistency of this character across the family, and its general absence in other families, supports the placement of the new genera, *Wombeyanus* and *Neocrypta*, of New South Wales cave habitats within the Neoniphargidae (Bradbury *et al* 1998).

3.3.2 Redefinition of the Family Neoniphargidae;

Gnathopodal and maxillipedal rugosities, having been confirmed as unique family characteristics among the Australian freshwater Amphipoda, and the presence of dendritic or lumpy sternal gills and broad oostegites as not constant characters, emendation of the definition of the family Neoniphargidae was appropriate. Accordingly, the family Neoniphargidae is redefined, taking into account the earlier works of Bousfield (1977, 1982a) and Williams and Barnard (1988), the characters of known species, and those displayed by new genera and species described below: *Antennal sinus of head weak or absent; molar of mandible well developed, triturative; outer plate of maxilla two with one kind of seta apicolaterally; outer plate of maxilliped of ordinary size; rugosities present on maxillipedal palp and gnathopods; gnathopods small or of medium size, almost mittenform, first not dominant, carpi short and post-ventrally lobate or bearing keel, propodi attached to carpi normally, robust setae on palms rarely of bifid crangonyctoid form; posterior lobes of coxae five to seven dominant; oostegites narrow to broad; sternal gills 2-6 present, dendritic or lumpy or simple; urosomites separate; inner ramus of uropod*

three present as well as short article two of the outer ramus; telson cleft, with few robust apical setae, lobes truncate, apically notched.

Description Of New Genera And Species

Among described species, *Wesniphargus nichollsi* (Straŝkraba) was known only from the female (Williams and Barnard 1988). New specimens from several sites in Western Australia included male *W. nichollsi*, enabling description of the male for the first time and redefinition of the genus, as well as description of a new species, *W. yanchepensis*.

Three new Neoniphargidae genera and twelve new species from caves in New South Wales are described: three new species of *Neoniphargus* - *N. coolemanensis*, *N. secus*, and *N. richardi*; six species of the new genus *Neocrypta* - *N. primaris*, *N. robinae*, *N. moniae*, *N. georginae*, *N. annae*, and *N. simoni*; and one each of *Wesniphargus* (*W. yanchepensis*), and the new genera *Wombeyanus* (*W. botulosus*), and *Jasptorus* (*J. solepti*).

3.3.3 *Neocrypta* n.gen.

Etymology

Named for the family, and for the cryptic habit of the genus.

Type species

Neocrypta primaris n.sp.

Diagnosis

Pleonites with weak dorsal arms; rostrum small; lateral cephalic lobes weakly to moderately projecting; antennal sinus weak to moderate; eyes absent. First antenna: elongate, longer than second antenna, ratio of lengths of peduncular articles 10:9:5 to 10:13:8, accessory flagellum two-articulate, calceoli absent. Second antenna: peduncle and flagellum without calceoli. Mandibular palp; ratio of articles 8:11:12 to 8:18:17, article two naked, article three weakly falcate to linear, setae DE, rarely CDE. Labium without inner lobes. Maxillae inner plates not setose medially; first

maxilla inner plate ovato-triangular with two, rarely three apical plumose setae, the outer plate with seven robust setae, the palps asymmetric - left side with thin apical robust setae, the right side broad, with thick apical robust setae, not fused to the article; second maxilla inner plate with no oblique row of facial setae, but upper member of 1-2 main medial setae slightly submarginal, or not. Maxillipedal palp article three with a rugose apical lobe. Coxae one to four elongate, sparsely to moderately setose ventrally; coxae one to three lacking a row of post robust setae; coxa one weakly tapering below or not; coxa four with shallow emargination; coxa five much shorter than coxa four. Gnathopods small, sexual dimorphism minor, carpi short and lobate, articles two to four both with or without a posterior rugose lobe, palms slightly oblique and convex, bearing rugosities, three robust setae at the palmar corner, occasionally four, robust setae along palm sparse to moderate, without triggers, dactyls with stiff spinules at inner nail articulation, with additional spinules along inner dactyl margin. Pereopods five to seven moderately elongate, subequal, article two broadly expanded, ovate, and weakly to moderately post-ventrally lobate. Pereopods three to seven with one marginal and one facial dactylar setules. Coxae two to six with sac like gills; sternites two to six bearing simple gills without dendricities or lumps. Pleopods reduced; rarely the outer ramus of moderate length and article number, most with one, rarely two articles on the inner ramus, with no or one marginal setae, and two terminal setae, and reduced numbers of articles on the outer ramus; peduncles each with two retinaculae, no accessory retinaculae. Epimera post ventral tooth short or absent, some with facial robust setae near the vent margin, posterior margins weakly setulate. Peduncles of uropods one and two with one sub-apical robust seta on the apico-medial corner, of moderate length, not long with a complex tip. Basofacial arms absent from the first uropod, rami of both uropods extending unequally, their margins variably spinose, the inner rami usually with one robust seta row, the outer rami one or two rows, never with dense spination. Third uropod strongly extended, parviramous, the peduncle short, outer ramus 2 articulate, the second article very short, the first article without setae, the inner ramus reaching to M0.13 or less of article one of the outer ramus. Telson moderately long, cleft 11 to 20%, the lobes baso-laterally weakly tumid with apical and in some mid lateral spination, no major setation or baso-facial armaments, paired lateral penicillate setules at M0.6 on either lobe.

Additional description

Upper lip uniform, rounded but weakly asymmetrical below. Mandibular accessory blades (rakers) usually with interraker plumose setae. Very few additional penicillate setae beyond rakers riding onto the base of the molar, rather two to four basal molarial ragged setae. Lower lip uniform, inner lobes indistinct or absent, second maxilla - both plates with long apical setae. Maxillae inner plates and the lateral margins of the second maxilla moderately pubescent. Maxilliped inner plate with few distal plumose setae, two or three blunt naked robust setae, few or no medial plumose setae. The outer plate with a distal row of few plumose setae continuous with a distal row of blunt naked tooth like robust setae. Palp articles two and three poorly setose laterally, well to moderately setose medially, article three with a few non comb robust setae near the base of the dactyl. Dactyls of gnathopods with or without recumbent inner tooth like robust seta with stiff spinules or setules at the inner nail articulation, sometimes with additional spinules along the inner dactylar margin. Pleopods similar, peduncles not strongly setose, rami diverse, inner ramus strongly reduced. Urosomite one without an articulated ventro-distal robust seta at the base of the first uropod.

Relationship

The new genus *Neocrypta* is most closely related to *Neoniphargus* (Stebbing), but differs in the following: eyes are absent; the first article of the mandibular palp is relatively long, the second is naked, the third without A or B setae; coxae one to four are not as long, and coxa four less deeply emarginate; gnathopodal palmar robust setae are simple; thoracic segments two to six bear simple rather than dendritic sternal gills; the inner ramus of the pleopods is reduced to one or two articles; the third uropod extends beyond uropods one and two in the intact specimen and is up to 1.5x the length of the first uropod; the telson is cleft to 20% rather than to 50-75%. As well as in the above characteristics, *Neocrypta* differs from *Wesniphargus* (Williams and Barnard) in that rugosities are borne on propodi of both gnathopods, from *Tasniphargus* Williams and Barnard as antennae bear only short, sparse setae, and the basal articles of the primary flagellum of antenna one are short, and from *Yulia* Williams and Barnard in that the pleopod peduncles are not strongly setose, and the outer ramus of male uropod one does not bear a long apical spur.

3.3.3.1 *Neocrypta primaris* n.sp. Figs. 3.89 - 3.93

Etymology

From Latin, *primordius*, the first or most primitive, referring to the type species of the genus and apparently the most plesiomorphic.

Type locality

Limekiln cave (cave WE14) Wellington, New South Wales, 32°33' S, 148°57' E.

Material examined

Holotype (Australian Museum P51361) female 'a' 6.5mm, Allotype (Australian Museum P51362) male 'c' 6.5mm. Others in the type series: female 'b' 7mm, and 10 juvenile specimens. Collected 8 March 1995 by S. Eberhard from among tree roots in a pool, Limekiln cave (cave WE14) Wellington, New South Wales, 32°33' S, 148°57' E.

Diagnosis

Lateral cephalic lobes moderately projecting, antennal sinus moderate, ratio of lengths of peduncular articles of first antenna 10:12:8; ratio of lengths of mandibular palp articles 8:11:12 to 8:13:14, article three linear, setae (C)DE, the inner plate of the first maxilla with two plumose apical setae, inner pate of the second maxilla with two mediodistal submarginal plumose setae. Coxa one tapering apically, second article of the first gnathopod and second and third articles of the second gnathopod without posterior rugose hump, robust setae at palmar corner 4-3 respectively, palmar robust setae sparse to moderate, pereopod six longer than seven, articles two of legs five to seven moderately post ventrally lobate. outer rami of pleopods moderately long, inner rami strongly reduced, of one article, with few marginal setae. Epimera without post ventral teeth, with facial robust setae on the first and second. Uropods one and two with no more than one robust seta row on rami, inner ramus of third uropod reaching m0.1 of the outer ramus. Telson cleft 16%, with mid lateral spination.

Description of holotype (female 'a')

Body: pleon with few dorsal armaments, pleonite five with two mid dorsolateral robust setae, six with one post dorsal robust seta basal to the telson; length 6.5mm. *Head*: rostrum small, eyes absent. *First antenna*: length 0.58x body, 2.2x second antenna, peduncle shorter than flagellum, ratio of article lengths 10:12:8, setae sparse, flagellum of twenty six articles, aesthetascs present on articles three to

twenty five, flagellar segments uniform, sparsely setulate; accessory flagellum two articulate, reaching to M0.5 of the second primary flagellum article. *Second antenna*: length 0.3x body; peduncle 1.9x flagellum, articles four and five subequal - 20:25 - articles three to five with moderate ventral setation; flagellum of eight articles, weakly setose ventrally, aesthetascs absent. *Left mandible*: palp article three longer than two, ratio of lengths of articles 8:11:12, article three linear, facially and apically rugose, setae 5C14D3E, articles one and two naked; incisor with six teeth; lacinia mobilis four teeth; accessory blades of three chisel robust setae and three plumose robust setae, four brushy setae onto the base of the molar; molar triturative without a posterior seta. *Right mandible*: palp article three with setae 13D3E, latero-facially rugose; incisor with five teeth; lacinia bifid, denticulate; accessory blades of two chisel robust setae and two plumose setae, two plumose robust setae onto the molar base; molar triturative with a long posterior pappose seta. *Maxillae*. Left first maxilla: palp article two with a row of two naked and one armed medio-distal slender robust setae and three armed transverse apical robust setae; outer plate with seven apically denticulate robust setae; inner plate with two apical plumose setae. Right first maxilla: palp article two with a mediodistal row of six strong robust setae, naked and armed, and two latero-distal submarginal armed robust setae; the outer plate with seven mostly denticulate robust setae; inner plate with two apical plumose setae and a moderate, simple sub apical seta. Second maxilla: outer plate with one medio-distal naked seta, inner plate apicomedial corner with two weakly submarginal plumose setae. *Maxilliped*: palp article three without inner ventral setae, moderately setate disto-medially, three distolateral setae, two setae basofacial to the dactyl and two accessory spinules on the dactyl, apex moderately produced and rugose; inner plate apex with two thick tooth like robust setae, one distolateral armed and one simple seta, a short stout sub marginal, sub distal seta and one medial plumose seta. *Gnathopods*: coxal plate of first gnathopod broad, apically tapering, with sparse moderate apical setae; article two without posterior rugose extension; article three with a small posterior rugose hump; articles four and five with strong posterior rugose lobes; carpus short, lobe rounded, without apical setae; propodus trapezoidal, as wide as long, the posterior angle sub quadrate with a barely expanded posterior rugose area, palmar corner robust setae one medial, three lateral, palmar robust setae moderate, simple; dactyl with accessory spinules on the inner margin, reaching beyond palmar corner robust

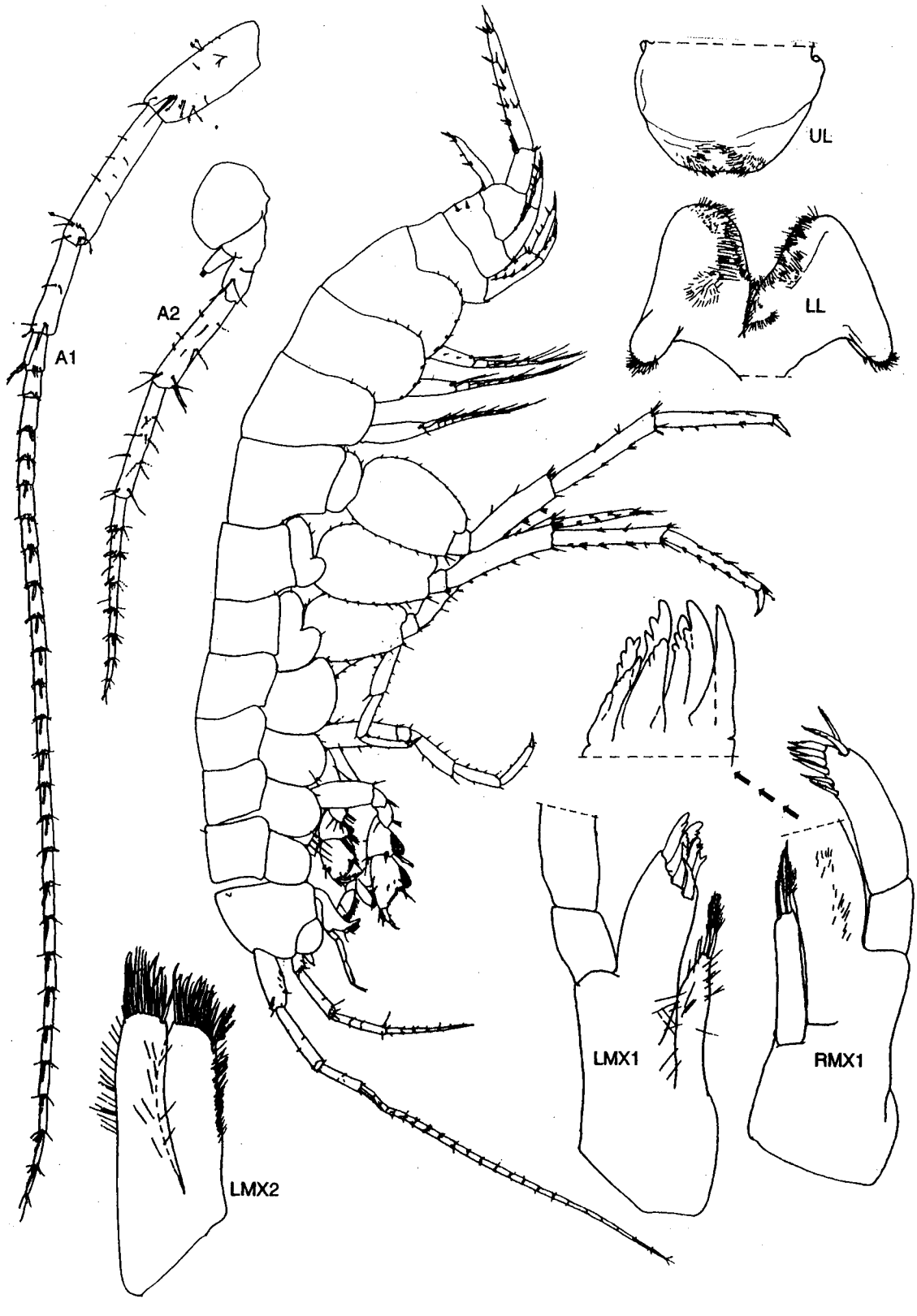

Fig. 3.89. *Neocrypta primaris* n. sp. holotype female 'a'; body, antennae, mouthparts.

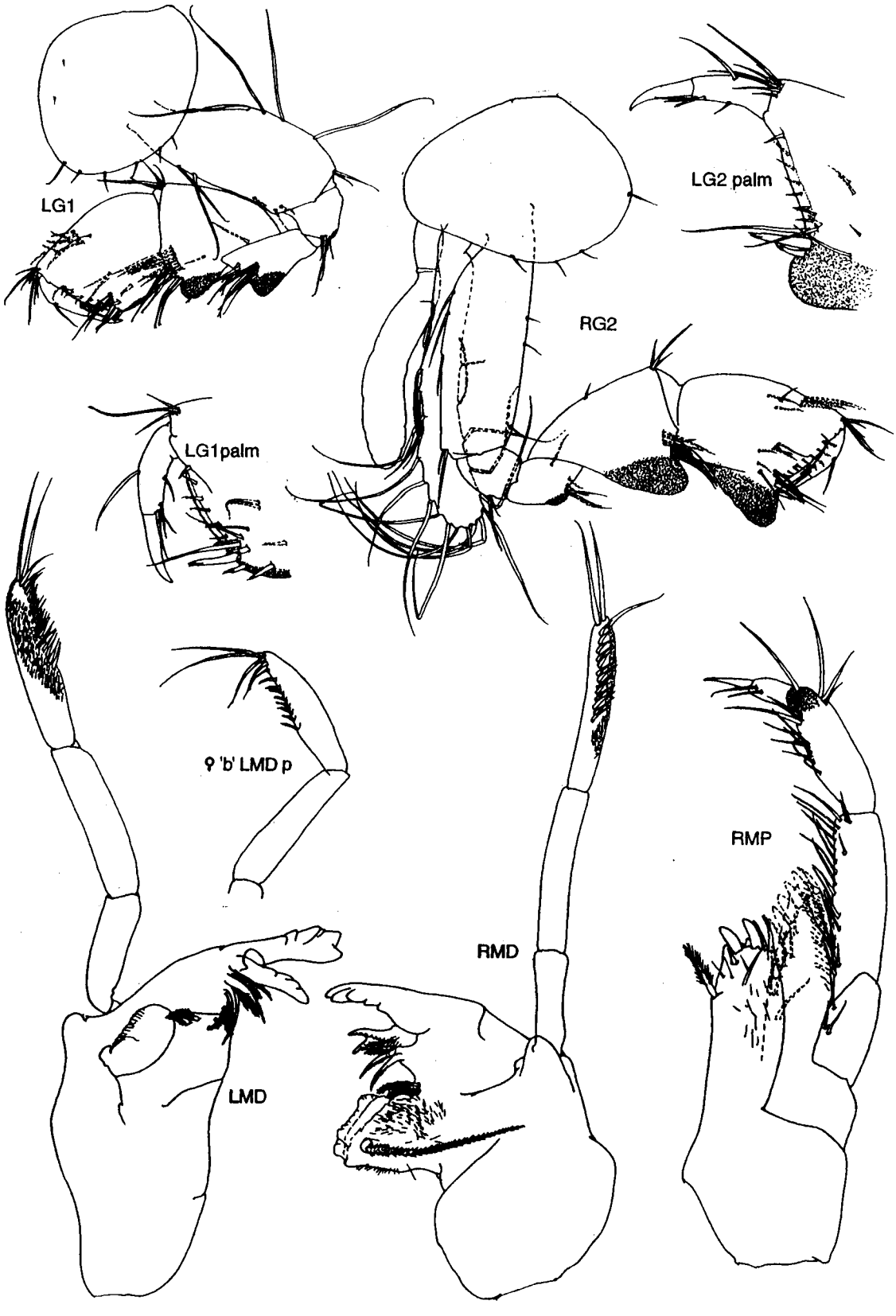

Fig. 3.90. *Neocrypta primaris* n. sp. holotype female 'a'; mandibles, maxilliped, gnathopods (all drawings except those indicated). Female 'b' left mandibular palp.

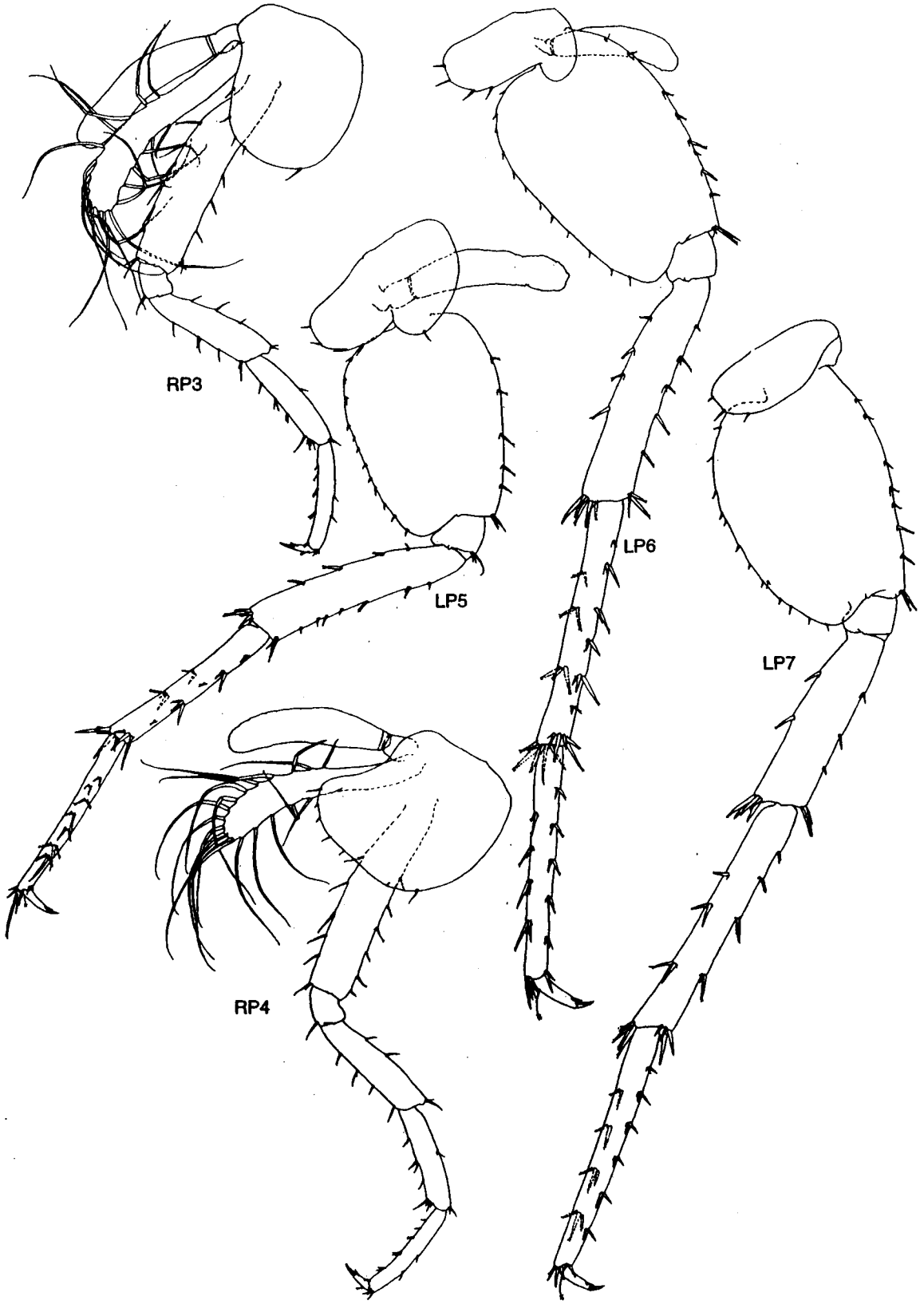

Fig. 3.91. *Neocrypta primaris* n. sp. holotype female 'a'; pereopods.

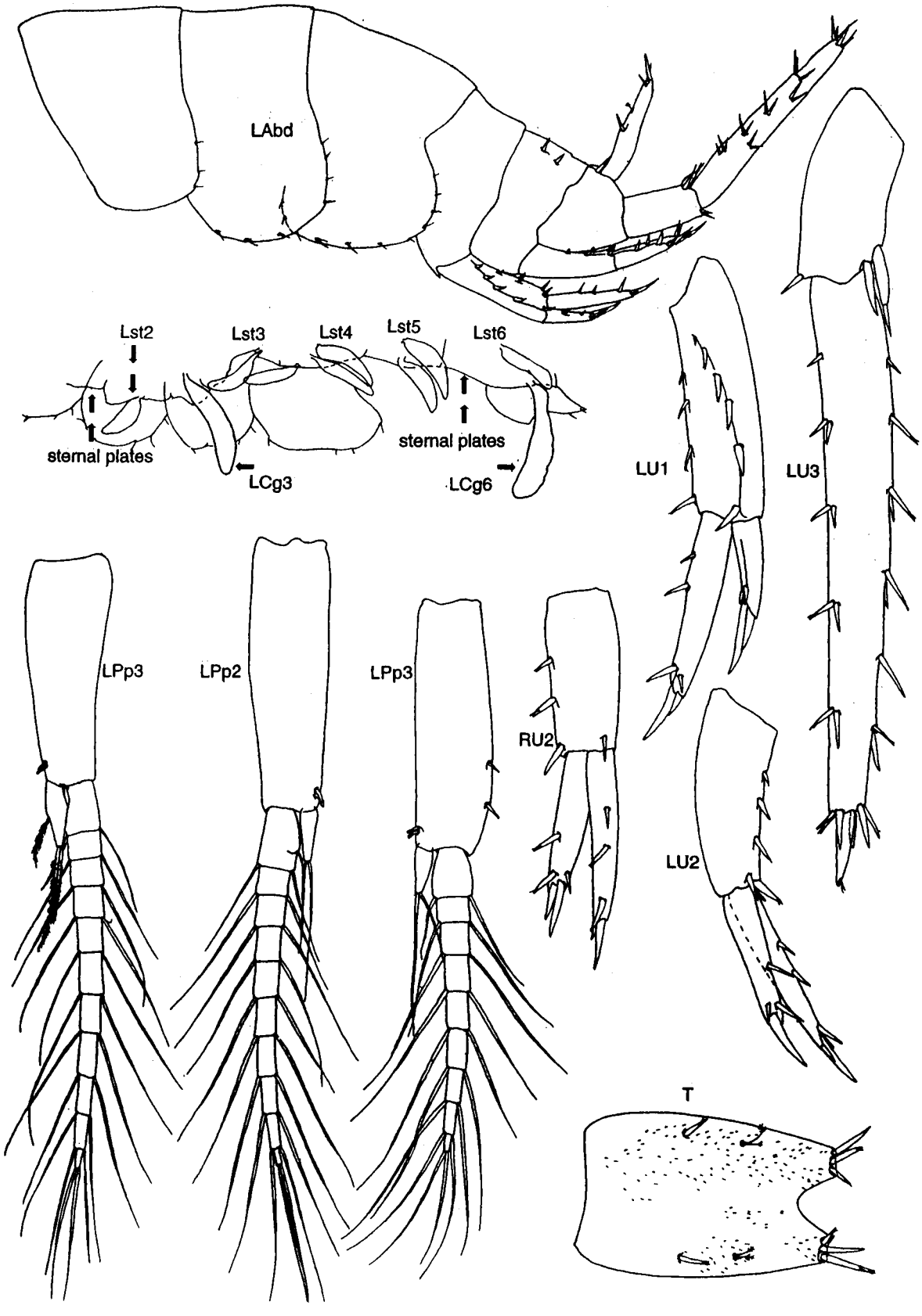

Fig. 3.92. *Neocrypta primaris* n. sp. holotype female 'a'; abdomen, gills, pleopods, uropods, telson.

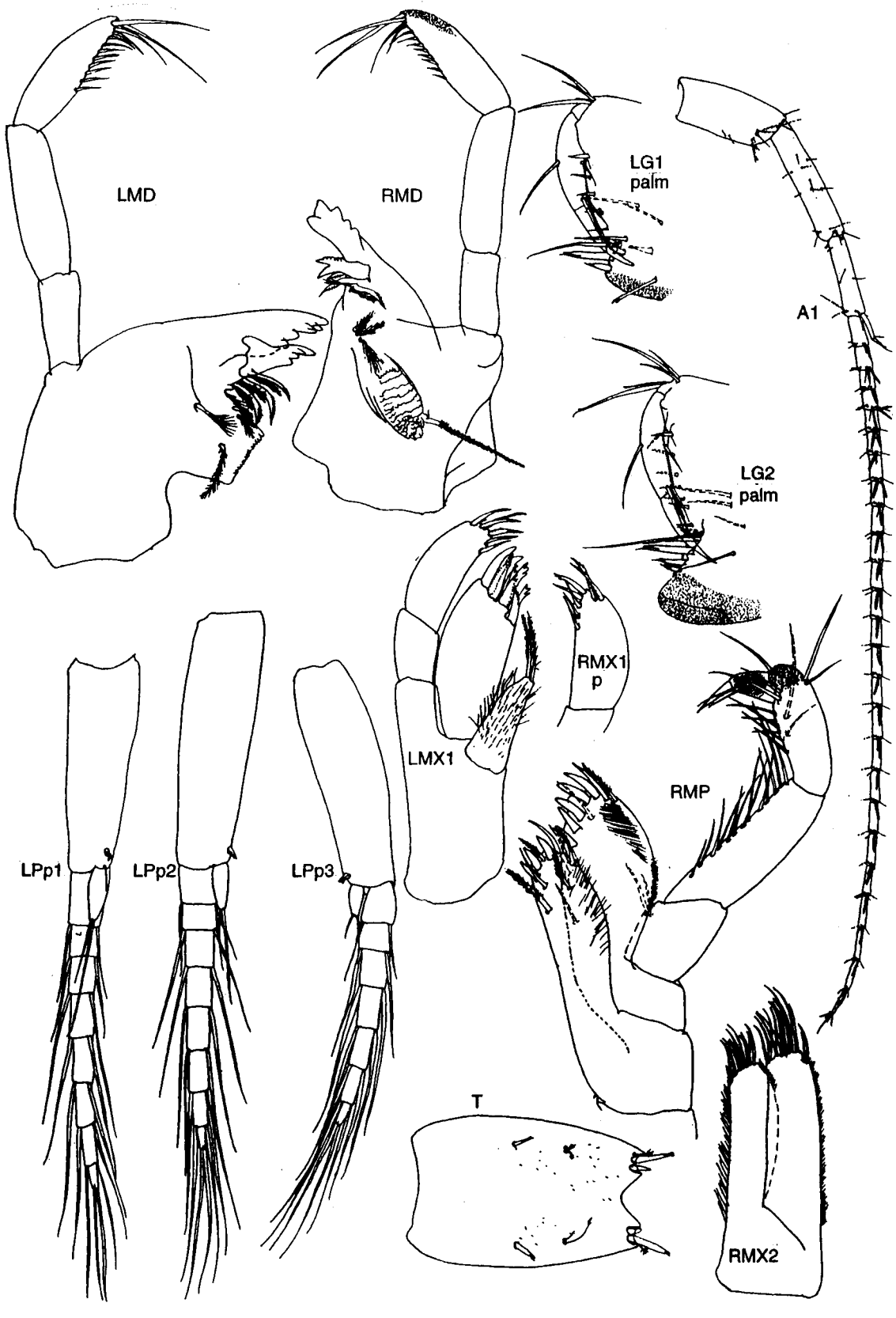

Fig. 3.93. *Neocrypta primaris* n. sp. allotype male 'c'; first antenna, mouthparts, pleopods, telson.

setae. Second gnathopopod: larger than the first; articles two and three without posterior rugose enlargement; article four with a small rugose lobe; carpus and propodus with strong posterior rugose lobes larger than on gnathopod one; palmar corner marked by one medial and two lateral robust setae, palmar robust setae moderately crowded, simple; dactyl with inner marginal accessory setules and small facial setules, reaching the palmar corner robust setae; coxa weakly setose apically, bearing a long sac like gill and long slender setose oostegite. *Pereopods*: coxa three with three small apical, and two moderate posterior setae, bearing a long sac like gill and long narrow setose oostegite; coxa four moderately emarginate with few apical setae; pereopods three and four subequal in length, longer than the second gnathopod, articles four and five moderately setose posteriorly, articles six with robust seta formulae 1-1-3-2 and 1-1-2-3-2 respectively; pereopods five to seven similar, six and seven subequal, longer than five, coxae with 4,3,4 weak robust setae on the ventral margin of the posterior lobe, coxae five and six with moderate sac like gills, articles two expanded posteriorly - 5<6<7 - and moderately lobate post ventrally, with weak post marginal setae; propodi posterior margins lacking long setae except for a long basodactylar seta on leg five. *Gills*: coxae two to five bearing sac like gills; sternal plates two to six each with paired simple gills. *Epimera*: without post ventral teeth, posterior margins slightly to moderately convex with weak setation, ventral margins of epimera two and four with three and seven facial robust setae respectively. *Pleon*: pleonites one to four with no arms; pleonite five with a strong pair of dorsolateral robust setae; pleonite six with a single dorsal robust seta basal to the telson. *Pleopods*: peduncles each with two retinacula; peduncle one with a small distal seta basal to the rami; peduncle three with two laterodistal setae; outer rami of pleopods moderately long with 11,10,9 articles, inner rami reduced to single articles, only the first ramus with a marginal seta. *Uropods*: third uropod long, extending well beyond first and second uropods in the intact specimen; uropod lengths relative to uropod one; uropod two 0.8 to 0.9x, uropod three 1.9x. First uropod peduncle length 1.3x inner ramus, 2.3x outer ramus; the outer margin with one slightly sub-apical distal robust seta and a dorsal row of five robust setae, the inner margin with three short dorsal robust setae and one sub apical robust seta; inner ramus length 1.9x outer ramus, with two medial and four apical robust setae, outer ramus with four apical robust setae only. Second uropod: left peduncle with a row of two short dorsolateral robust setae and one sub

apical robust seta, the inner margin with one sub apical robust seta; right peduncle with an outer marginal row of four short robust setae and one sub apical distal robust seta, the inner margin with only a sub apical distal robust seta; inner ramus length 1.2x outer, with two medial and four apical robust setae; outer ramus with one lateral robust seta and four apical robust setae. Third uropod: peduncle length 0.3x outer ramus, greater than the length of urosomite three, without facial robust setae, with one distolateral robust seta and one distomedial robust seta basal to the inner ramus; proximal article of outer ramus with five lateral transverse rows of 1-2-2-2-2 robust setae and six medial transverse rows of 1-1-2-2-1-2 robust setae and three medial and three lateral distal robust setae; distal article with two small apical setules only; inner ramus with a single apical robust seta, length 0.09x outer ramus. *Telson*: moderately long, 1.7x urosomite three, cleft 16%, apices of lobes bearing three right and four left setae, two robust setae latero-dorsally at M0.4, paired lateral penicillate setules at M0.6, and small setules on the dorsal face.

Description of allotype (male 'c'). *Body*: length 6.5mm. *First antenna*: peduncle article two longest, ratio of lengths of articles 10:12:8; primary flagellum of twenty five articles, all bearing aesthetascs, articles 2,5,7,9,11 each with two distal aesthetascs, article four with three. *Second antenna*: flagellum of seven articles, without aesthetascs. *Mandibles*: left and right palps similar; naked except for apical setae and rugosities, ratio of lengths of articles 8:14:13, setae of third article 8D4E. Left incisor, lacinia mobilis, accessory blades similar to holotype, molar with one anterior plumose seta, two brushy setae leading to the molar and a moderate posterior pappose seta; . Right mandible incisor with five teeth, accessory blades of three chisel robust setae and two plumose setae, with three plumose setae leading to the base of the molar. *First maxilla*: left palp with four slender armed transverse apical robust setae and two distomedial simple slender robust setae; right palp with four slender distomedial robust setae, and apical slightly stouter distally armed robust seta, and two slender latero-distal armed robust setae; inner plate of both first maxillae with two apical plumose setae. *Second maxilla*: outer plate with two subdistal lateral short robust setae, inner plate without two weak submarginal apicomedial plumose setae. *Maxilliped*: outer plate medial submargin with a row of simple and plumose setae; mid medial to apical face a row of five long naked tooth like robust setae; distolateral margin with slender robust seta and plumose seta. *Pleopods*: peduncles without arms except a small simple seta basal to the inner

ramus on the first pleopod; inner rami each of one article; outer rami of 8, 8, 7 articles. *Telson*: length 1.5x width; cleft 9%; apices each with one short medial and one longer lateral robust seta and a single lateral penicillate setule; dorsolateral robust setae at M0.4; paired penicillate setules on each side at M0.7; the disto-dorsal surface with scattered very small setules.

Description of female 'b'. *Body*: length 7mm. *First antenna*: with twenty five flagellar articles. *Second antenna*: flagellum of seven articles. *Left mandible*: palp third article with small rugosities, setae 9D3E. *Right mandible*: palp article three rugose, setae 8D5E. *Pleon*: pleonite five with two dorsolateral robust setae, pleonite six with one dorsal robust seta basal to telson. *First uropod*: peduncle lateral margin with four dorsal and one apical short robust setae; medial margin with two dorsal and one slightly sub apical robust seta; inner ramus with two medial and four apical robust setae; outer ramus with two lateral, one distomedial and four apical robust setae. *Second uropod*: peduncle lateral margin with two dorsal plus one apical robust seta, medial margin with one small mid dorsal and one apical robust seta; inner ramus with one medial and four apical robust setae, outer ramus with one lateral and four apical robust setae. *Third uropod*: peduncle with only distal robust setae, inner ramus with one apical robust seta, outer ramus proximal article with three lateral ranks of 2-2-2 and three distal robust setae, and four medial ranks of 4-3-3-4 and two distal robust setae; distal article with one small apical spinule. *Telson*: bearing dorsolateral robust setae at M0.5 on either side, paired dorsolateral penicillate setules at M0.7, and with two left and three right apical robust setae.

Distribution

Limekiln Cave, Wellington, New South Wales, 32°33' S, 148°57' E.

3.3.3.2 *Neocrypta robinae* n. sp. Figs. 3.94 - 3.96

Etymology

Named for Robyn Bradbury in recognition of her indirect support of amphipod studies.

Type locality

Diprotodon Cave, Cave number CN-10, Canomodine, New South Wales, 33°30' S, 148°52' E.

Material examined

Holotype (Australian Museum P51363) male 6mm. Collected by S. Eberhard, 2 April 1995.

Diagnosis

Lateral cephalic lobes moderately projecting, antennal sinus moderate, first antenna peduncle ratio of articles 26:24:13, mandibular palp ratio of articles 8:16:16 to 8:18:17, article three weakly falcate, setae DE, first maxillae inner plates with two plumose apical setae, inner plate of second maxilla with two distomedial submarginal plumose setae, coxa one very weakly tapering apically, gnathopod one articles two and three without posterior rugose hump, gnathopod two articles three and four without rugose hump, palmar corner robust setae 3-3, robust setae along the palm moderately dense, pereopod six longer than seven, articles two of legs five to seven weakly post ventrally lobate. Rami of pleopods reduced; inner rami of pleopod one with two articles on the right, others with only one article, each with a single marginal seta. Epimera with a small post ventral tooth like on the second epimeron only, each with ventro-facial robust setae. Rami of the first and second uropods without dorsal robust setae, the inner ramus of uropod three 0.1x the length of the outer ramus. Telson cleft 12%, without mid lateral spination.

Description of holotype (male)

Body: pleon not armed dorsally except for a single dorsal robust seta adjacent the base of the telson; length 6mm. *Head*: rostrum small, eyes absent. *First antenna*: length 0.4x body, 1.2x second antenna, peduncle subequal to the length of the flagellum - 63:65 - ratio of lengths of the articles 10:9:5, flagellum of eleven articles, uniform and sparsely setulate, articles one to eight with aesthetascs in pairs, nine to eleven with single aesthetascs, accessory flagellum of two articles, reaching to the end of the first article of the primary flagellum. *Second antenna*: 0.28x

length of body, peduncle much longer than flagellum - 79:26 - articles four and five subequal - 27:28 - articles three to five with moderate ventral setation; flagellum of four articles, weakly setose ventrally, without aesthetascs. *Left mandible*: palp; ratio of lengths of articles 8:16:16, article three weakly falcate, setae 17D5E, apex rugose, articles one and two naked; slender seta at the base of the palp; incisor with five teeth; lacinia mobilis four teeth and fine posterior basal setules; accessory blades of three chisel robust setae and three interraker plumose robust setae, with four brushy setae to the base of the molar; molar triturative, with a short posterior pappose seta. *Right mandible*: palp article three with setae 17D5E, apex rugose; incisor with five teeth; lacinia bifid and denticulate, with an area of setules at the base; accessory blades of two chisel robust setae and one plumose seta, with a short plumose and two brushy setae onto the base of the molar; molar triturative with a long posterior pappose seta. *Maxillae*. Left first maxilla palp article two with one apical and one sub-apical armed and one naked robust seta, one distolateral plumose seta and two disto medial naked setae; outer plate with seven denticulate robust setae, the inner plate with two apical plumose setae. Right first maxilla palp article two with a row of four submarginal medio-distal to apical stout robust setae, the apical two terminally armed, a similar distolateral robust seta and a single disto-facial seta; outer plate bearing seven denticulate robust setae; inner plate with two plumose apical setae. Second maxilla: outer plate with a small spinule and moderate seta disto-laterally, the inner plate with two submarginal disto-medial plumose setae. *Maxilliped*: Palp article three without basomedial and with few distomedial setae, two long setae facio basal to the apex, and a ventral row of three setae basal to the dactyl; apex moderately produced and rugose, dactyl facially pubescent with two accessory spinules basal to the nail; article two moderately to well setose medially; apex of inner plate with two thick tooth like robust setae, a stout plumose seta and a naked seta, two ventro-facial setae and one medio-facial seta; outer plate with an apical transverse row of three slender and one stout pappose robust setae, a barely facial medial row of four basally pappose moderate robust setae, a distofacial slender seta and five basomedial setae arranged 1-2-2. *Gnathopods*: coxal plate of gnathopod one with one post ventral, one anteroventral and two mid facial setae as well as several small facial setules; articles two and three without posterior rugose extension, article four with a small posterior rugose lobe; carpus short, strongly lobate and rugose posteriorly, the lobe rounded, without

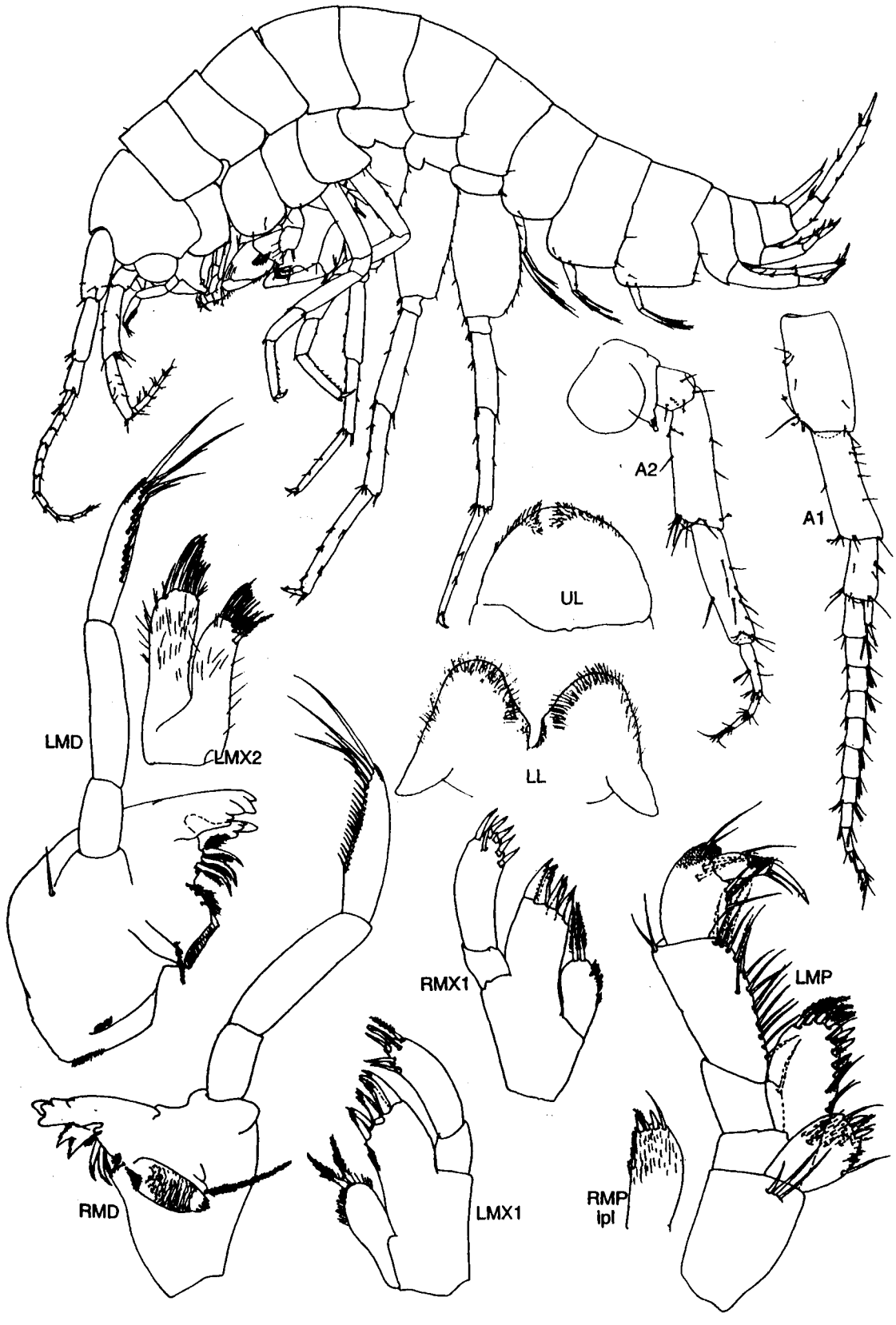

Fig. 3.94. *Neocrypta robinae* n. sp. holotype male 6mm; body, antennae, mouthparts.

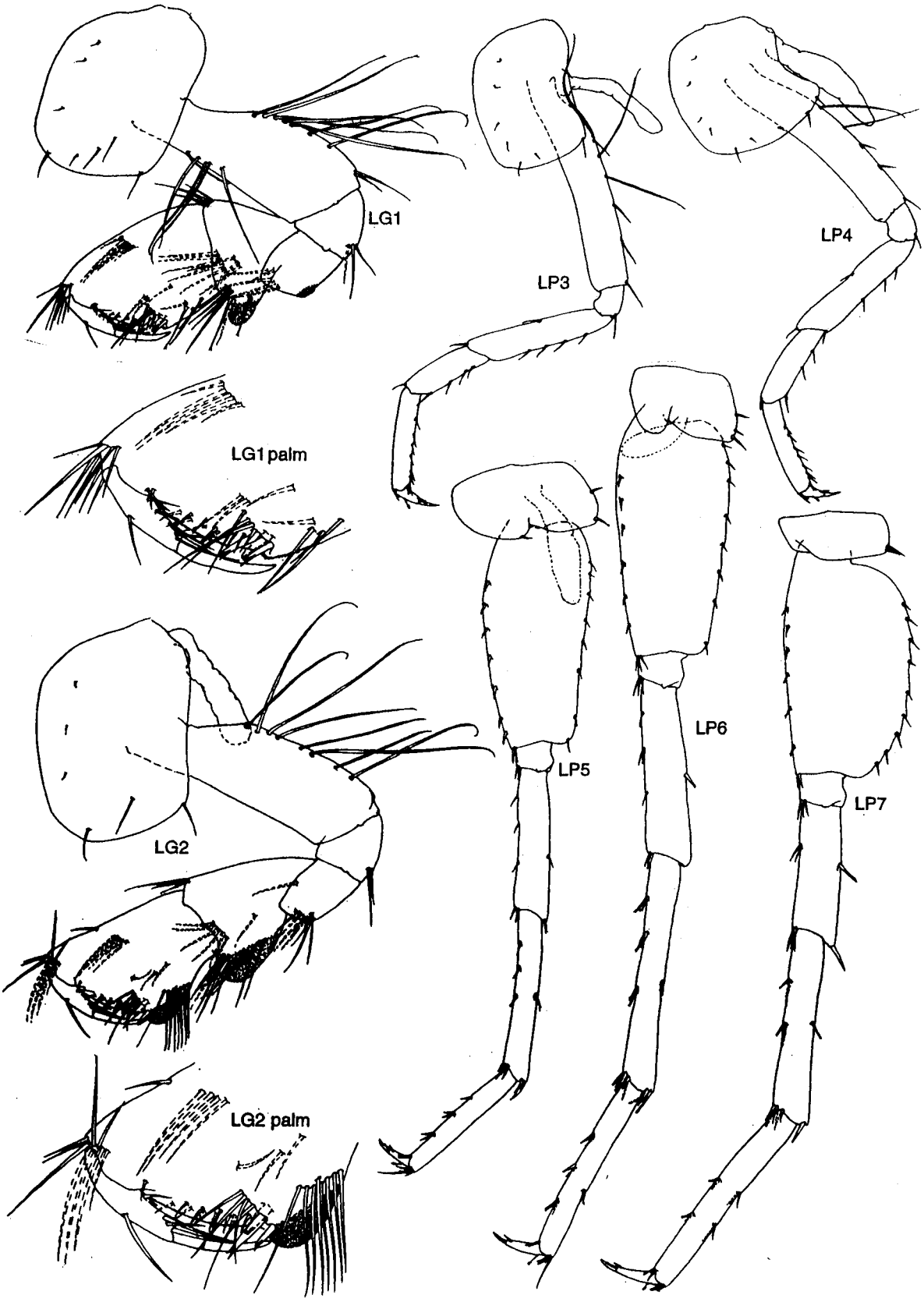

Fig. 3.95. *Neocrypta robinae* n. sp. holotype male 6mm; legs.

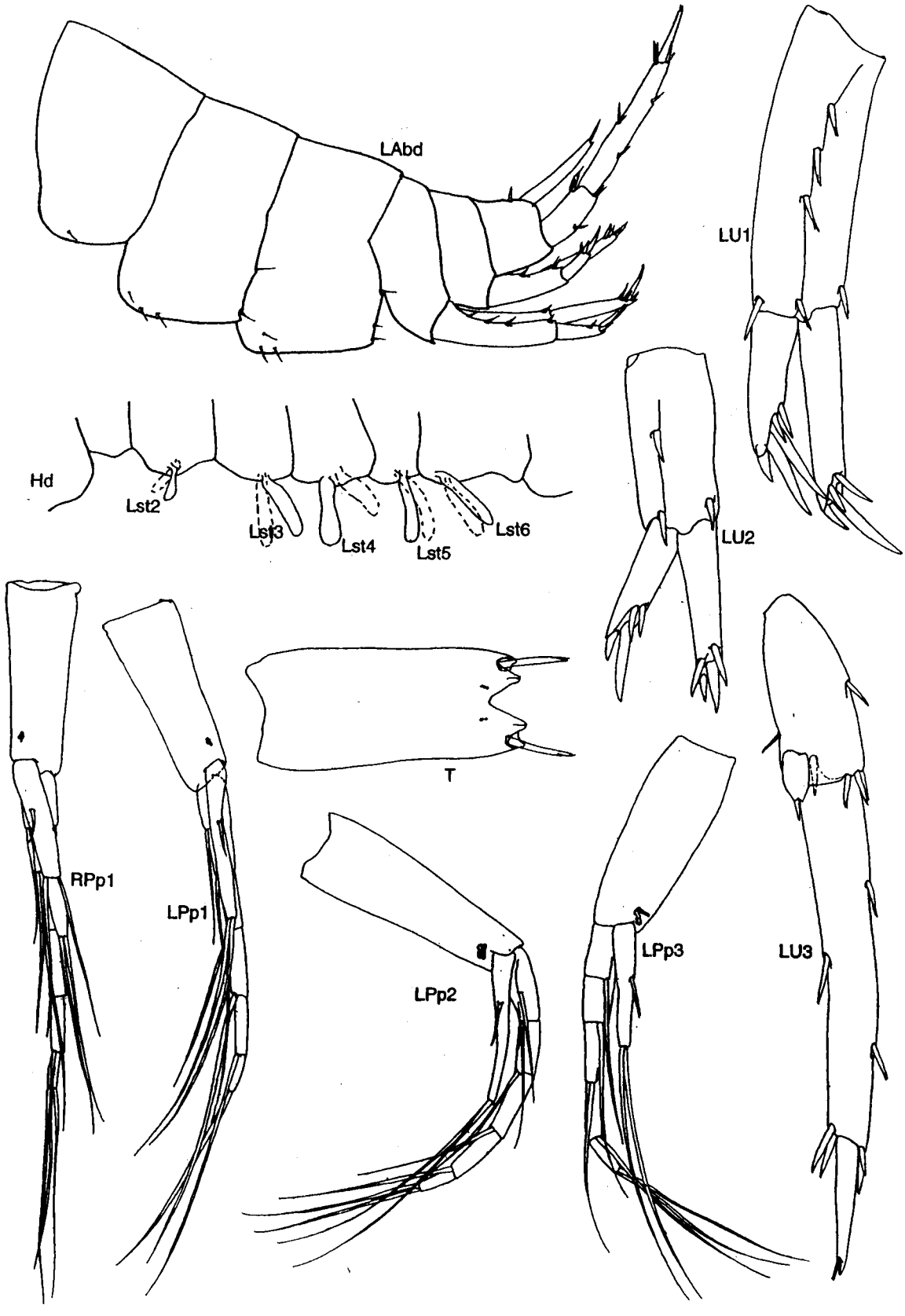

Fig. 3.96. *Neocrypta robinae* n. sp. holotype male 6mm; abdomen, gills, pleopods, uropods, telson.

apical setae; propodus trapezoidal, longer than wide, the post-lateral edge subquadrate, faintly rugose, with one medial and two lateral palmar corner robust setae; robust setae along the palm moderately crowded; dactyl with accessory spinules and a small recumbent robust seta on the inner margin, reaching beyond the palmar corner. Second gnathopod: slightly larger than gnathopod one; article two with a small posterior rugose hump, articles three and four without; carpal lobe broader than gnathopod one; propodus with distinct posterior rugose lobe, palmar corner with one medial, two lateral robust setae, the palm moderately crowded with robust setae; dactyl with a small proximal recumbent robust seta and accessory setules on the inner margin, reaching to palmar corner robust setae; coxa sparsely setulose apically, bearing a small sac like gill. *Pereopods*: coxae three and four with sparse, weak apical setae; coxa four weakly emarginate; pereopods three and four subequal, longer than gnathopod two, articles three and four weakly spinose posteriorly, propodi with evenly spaced single posterior robust setae; pereopods five to seven similar, leg six longest, five and seven subequal, coxae with 2-3-2 robust setae on the posterior margins, second articles expanded moderately, sub quadrate to ovate, weakly post ventrally lobate, with weak marginal setation; propodi lacking strong setae on the posterior margins except for long sub-dactylar setae on legs five and six. *Gills*: coxae two to six with sac like gills; sternites two to six with paired simple medial gills. *Epimera*: second epimeron only with a small post ventral tooth; posterior margins of E1-2 almost straight, of E3 convex, the posterior margins weakly setulate; first epimeron with a single mid facial robust seta, the second and third with one antero-facial and two mid ventral robust setae. *Pleon*: pleonites one to six without post marginal setae or robust setae, six with a single post dorsal robust seta adjacent the telson. *Pleopods*: two retinacula each, peduncles all naked; pleopods reduced, right pleopod one with two articles on the inner ramus, all other pleopods with one moderately elongate inner article, each with a single medial marginal seta; outer rami with 6-5-5 articles. *Uropods*: third uropod extending well beyond uropods one and two in the intact specimen; uropod lengths relative to uropod one, uropod two 0.68x, uropod three 1.4x; first uropod peduncle 1.4x medial ramus, 2x lateral ramus, the outer margin with one slightly sub apical distal robust seta and one ventrodistal robust seta, dorsal margin with three robust setae, medial margin with one sub apical robust seta, rami of unequal length - medial 1.4x lateral - without marginal robust setae, both with four apical

robust setae; second uropod peduncle slightly longer than rami - 1.5x lateral, 1.2x medial - with one short dorsolateral robust seta plus a slightly sub apical robust seta, and one subdistal medial robust seta; rami without marginal robust setae, both with four apical robust setae; third uropod peduncle as long as urosomite three, 0.4x outer ramus, with one medial and one laterofacial robust seta, three distolateral and one distoventral robust seta; proximal article of outer ramus with one mid-medial and two medio-distal robust setae, two lateral and two distolateral robust setae; distal article length 0.27x proximal, with two small apical setules; inner ramus small, 0.1x length outer ramus, with one small apical robust seta. *Telson*: moderately long, 1.6x urosomite three, longer than broad, length 2.1x width, cleft 12%, apices with a single robust seta set in a notch, single penicillate setules either side at M0.88

Relationship. *N. robinae* differs from *N. primaris* in: the short length of its antennae, which also have fewer flagellar articles; lacking C but with greater numbers of D and E setae on the mandibular palp; less rugosity of the first gnathopod, and with greater numbers of palmar robust setae on both gnathopods; second article of pereopods five to seven less posteriorly expanded; outer rami of pleopods with fewer articles; telson cleft less and narrower. *N. robinae* differs from *N. simoni* in: first antenna shorter but with a greater number of flagellar articles; second antenna without aesthetascs; mandibular palp bearing many more D and E setae; left first maxilla palp not narrowed; first gnathopod less rugose, both gnathopods with more spinous palms; outer rami of pleopods with more articles; telson less cleft and narrow. *N. robinae* differs from *N. georginae* in: second antenna flagellum of less articles, and without aesthetascs; mandibular palp with more D and E setae; first gnathopod less rugose and without facial rugosities; outer rami of the pleopods with more articles; uropods are less spinous; telson not tumid, and longer.

Distribution

Diprotodon Cv., Canomodine, New South Wales, 33°30' S, 148°52' E.

3.3.3.3 *Neocrypta moniae* n.sp. Figs. 3.97 - 3.100

Etymology

Named for Melissa Bradbury in recognition of her indirect support of amphipod research and contributions in field collections.

Type locality

Bowan Park, New South Wales, Cave BP 13, 31°54' S, 148°05'E.

Material examined

Holotype (Australian Museum P51364) female 6.5mm. collected by S.Eberhard 13 March 1995.

Diagnosis

Lateral cephalic lobes weakly projecting, antennal sinus weak, eyes absent, ratio of lengths of peduncular articles of first antenna 10:11:8, ratio of lengths of mandibular palp articles 8:11:13, article three almost linear, with DE setae. The inner plate of the first maxilla with two apical plumose setae, inner plate of the second maxilla with one member of the distomedial slightly sub marginal, coxa one tapering apically, articles two to four of both gnathopods bearing posterior rugose lobes, three robust setae at the palmar corners, robust setae along the palms sparse on first, moderate on the second gnathopod. Pereopod six longer than seven, legs five to seven moderately lobate post-ventrally on the second article. Outer ramus of pleopods of moderate length, of 9,8,8 articles, inner rami reduced to one article each, without marginal setae. Epimera without post ventral teeth, with facial robust setae on some, margins of rami of uropods one and two with one row of dorsal robust setae only, the lateral ramus of uropod one without dorsal robust setae, inner ramus of third uropod reaching to M0.09 of outer. Telson cleft 16%, bearing mid lateral dorsal spination.

Description of holotype (female)

Body: pleon with few dorsal arms, pleonites one to four with few setae, pleonite five with three lateral robust setae, pleonite six with one distolateral robust seta, length. 5.5mm. *Head*: rostrum small, eyes absent. *First antenna*: long, length 0.7x body, 2.4x second antenna, the peduncle shorter than the flagellum, ratio of lengths of articles 23:26:19, setae sparse, flagellum of twenty two articles, aesthetascs present on articles six to twenty two, flagellar segments uniform, sparsely setulate; accessory flagellum two articulate, reaching to M0.5 of the second article of the

primary flagellum. *Second antenna*: length 0.3x body, peduncle longer than flagellum - 1.9x - article four slightly shorter than five - 21:24 - articles three to five with moderate ventral setation; flagellum of seven articles, weakly setose ventrally. *Left mandible*: palp article three longer than two - 25:20 - linear and disto-facially rugose, setae 14D3E; incisor with five teeth, lacinia mobilis four; six slender naked setae basal to the incisor; accessory blades of three rakers and four interraker plumose setae, five brushy setae onto the base of the molar; molar triturative with a short posterior pappose seta. *Right mandible*: palp article three with 15D4E setae, the third article facially rugose; incisor with five teeth; lacinia mobilis bifid, denticulate anteriorly, posteriorly bearing long incisive edge, two slender naked setae and a plumose robust seta basal to the mandible; accessory blades of three rakers, five interraker plumose setae, and a short hooked seta; molar triturative with a long posterior pappose seta. *Maxillae*. Left first maxilla with two apical and three apico-medial robust setae and one ventrofacial sub apical robust seta; two robust setae naked, the others armed basally or apically with long or short setules; outer plate with seven apically dentate strong robust setae; inner plate two plumose apical setae. Right first maxilla palp article two with a row of four stout, medio-distal to distal, apically armed robust setae, one similar apicolateral robust seta and one medio-distal naked robust seta; outer plate with seven denticulate apical robust setae; inner plate with two apical plumose setae. Second maxilla outer plate with two setae on the apicolateral margin; inner plate apicomedial corner with one submarginal thick seta and one plumose seta. *Maxilliped*: palp article three without setae on the inner ventral face, the outer apex with two medial and two lateral setae basal to a strongly produced rugose apical lobe; dactyl with two accessory robust setae basal to the nail, medially rugose; inner plate apex with two thick naked tooth like robust setae, one distal and one apico-lateral plumose seta, a slender distal seta, two medial submarginal, and one mid facial setae, with a single naked basal seta; outer plate with a row of six slender naked setae extending from the baso-medial face to the mid distal face, a row of seven blunt naked tooth like robust setae from the mid medial margin across the apical face almost to the lateral apex, continuous with a pair of distolateral plumose setae, the disto-medial and apical margin broadly scalloped. *Gnathopods*: coxal plate of the first gnathopod with four short to moderate length apical setae; articles two to four with progressively enlarged posterior rugose hump, the fourth forming a strong lobe; carpus short, posteriorly

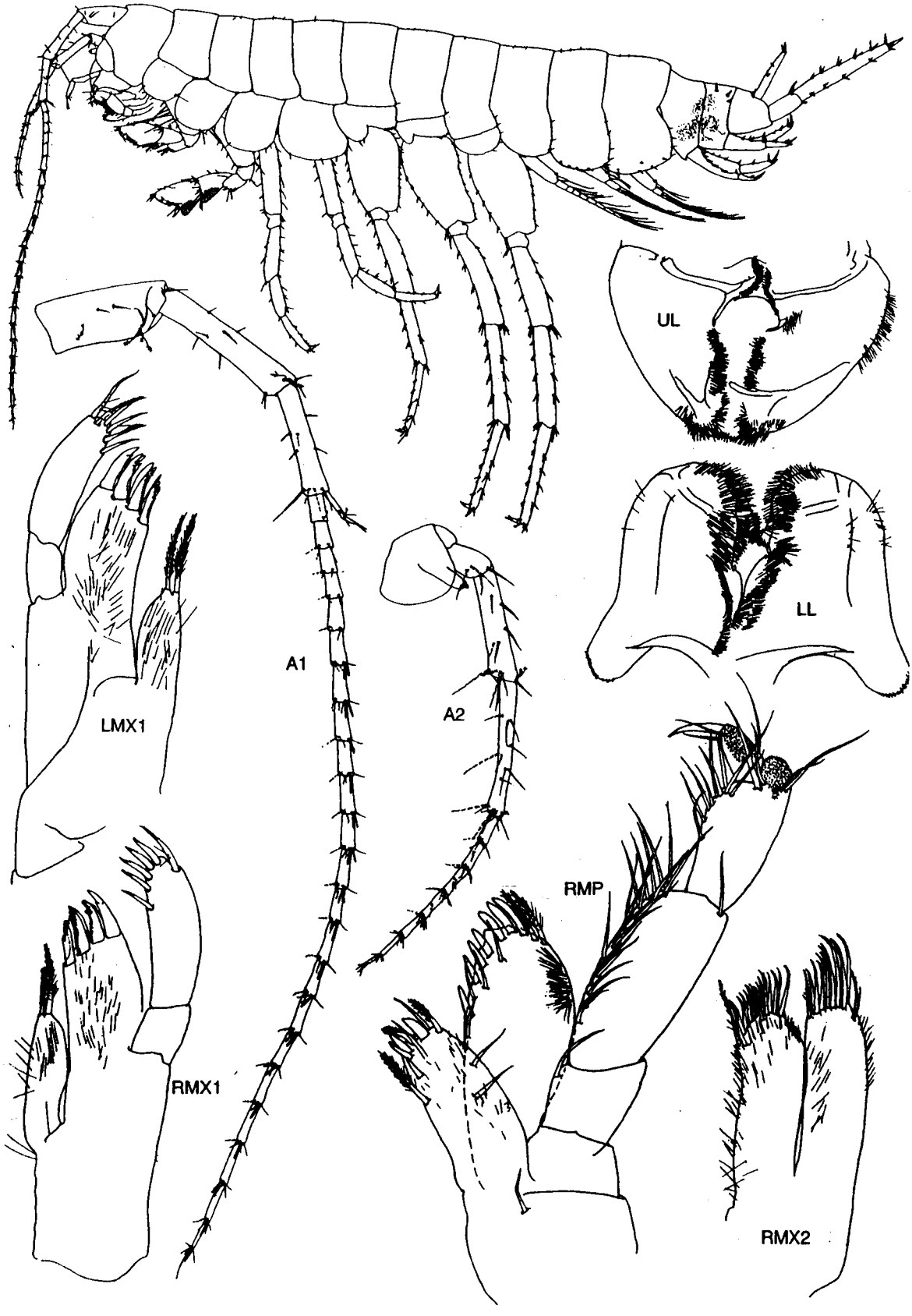

Fig. 3.97. *Neocrypta moniae* n. sp. holotype female 6.5mm; whole, antennae, mouthparts.

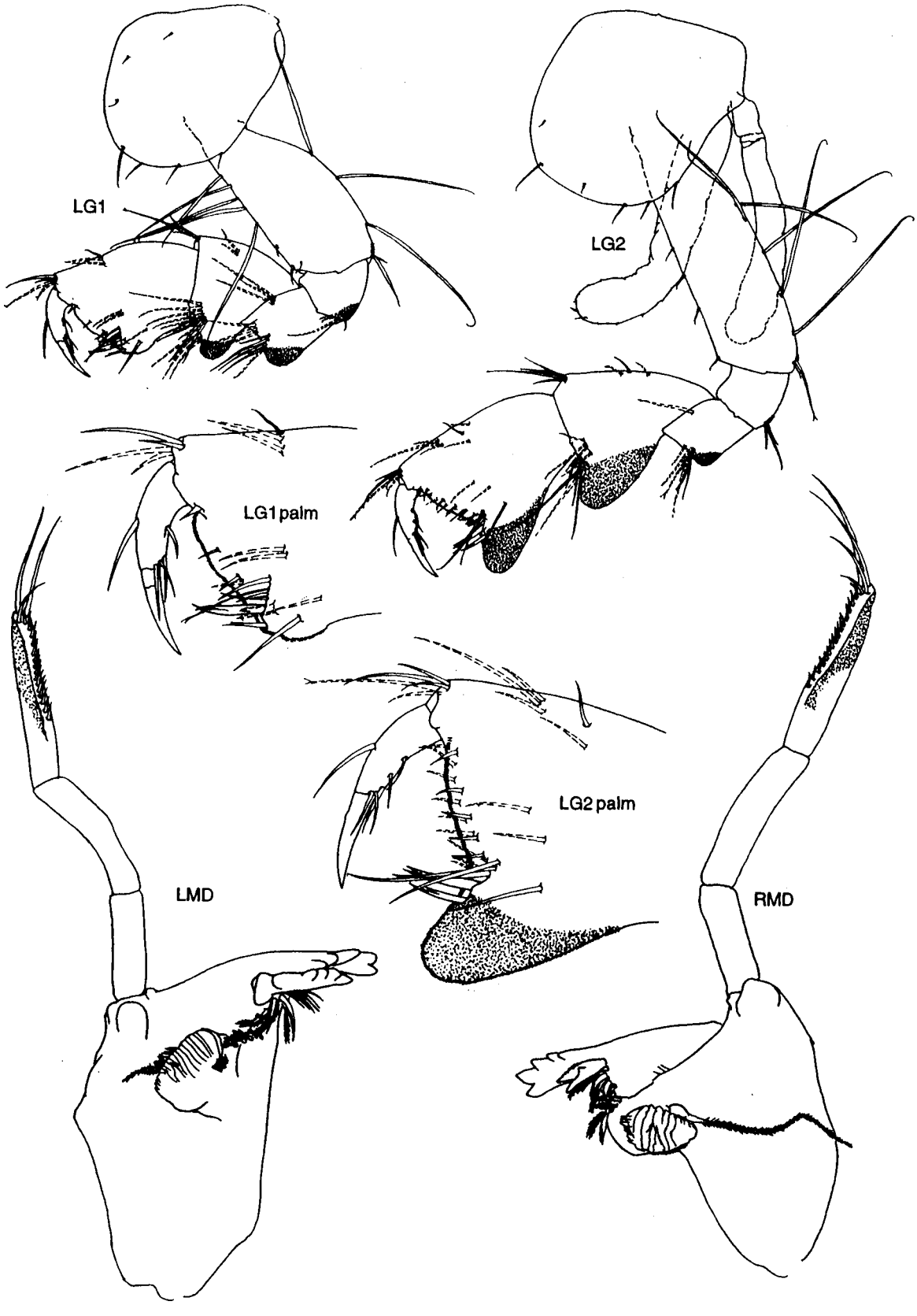

Fig. 3.98. *Neocrypta moniae* n. sp. holotype female 6.5mm; mandibles, gnathopods.

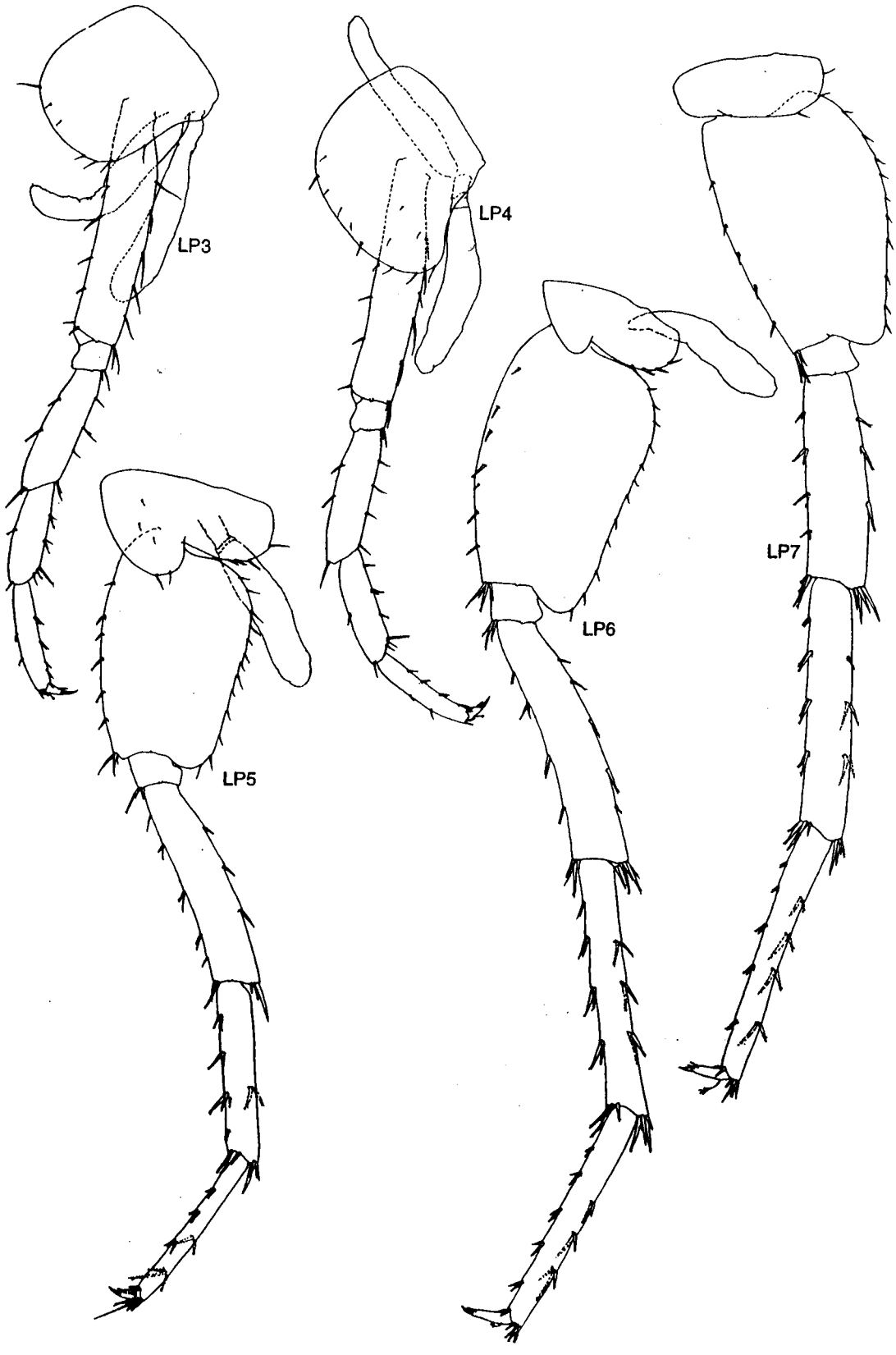

Fig. 3.99. *Neocrypta moniae* n. sp. holotype female 6.5mm; pereopods.

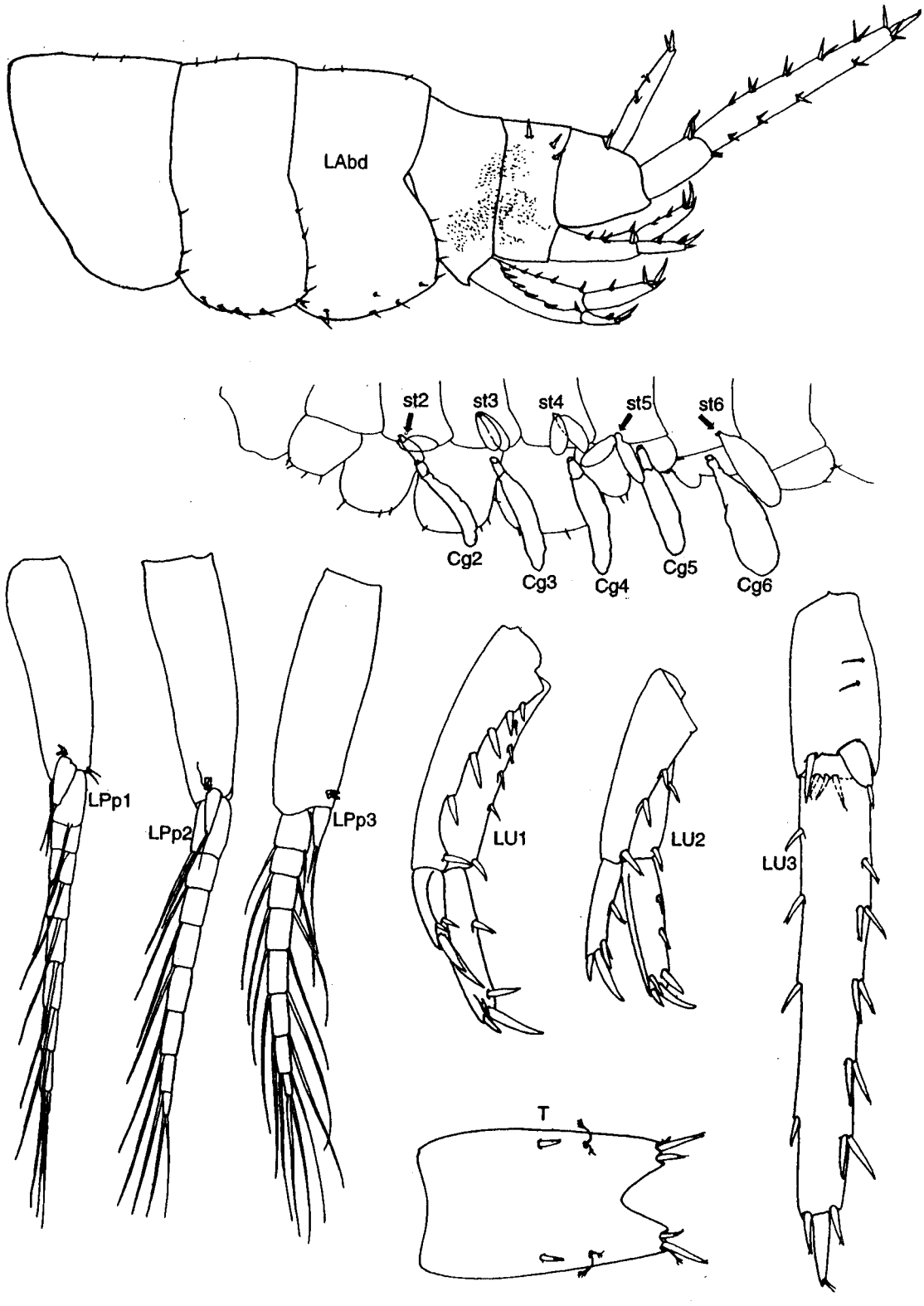

Fig. 3.100. *Neocrypta moniae* n. sp. holotype female 6.5mm; abdomen, gills, pleopods, uropods, telson.

lobate, the lobe rounded, without apical setae and rugose; propodus trapezoidal, slightly longer than wide, the posterior angle rounded, with a small rugose hump, robust setae of the palmar corner one medial and two lateral, the dactylus reaching the corner robust setae, with several accessory spinules along the inner margin, but without a recumbent robust seta. Second gnathopod moderately larger than the first; posterior lobe of the fourth article smaller; carpal lobe larger; propodus with a strong rugose posterior lobe, palmar corner with one medial and two lateral robust setae, dactylus with inner marginal spinules, without recumbent robust seta, reaching robust setae of the palmar corner; coxa bearing slender oostegite and sac like gill, with few short apical setae. *Pereopods*: coxa three with a sparse apical row of short to moderate setae and single posterior seta; coxa four weakly emarginate, with one anteroventral and four post ventral setae, several small facial setules and a long oostegite and sac like gill; pereopods three and four longer than second gnathopod, subequal, articles four and five spinous posteriorly, articles six with 2-2-1-1 and 2 locking, and 1-2-2-1 and 2 locking robust setae, respectively; pereopods five to seven similar; coxae with 4,4,3 robust setae on the ventral margins of the posterior lobes; second articles expanded posteriorly - 5>6=7 - and moderately lobate, with short posterior setae; propodi of legs five and six with long setae basal to the dactyls. *Gills*: coxae two to six with sac like gills; sternal plates two to six with simple gills attached to the mid lateral edge. *Epimera*: without post ventral teeth, posterior margins moderately convex with 3,4,4 setae, and 0,5,6 ventrofacial robust setae. *Pleon*: pleonites one to four with few posterior setae; pleonite five with three dorso-lateral robust setae, six with a single dorsolateral robust seta basal to the telson, pleonites four and five bearing areas of tiny facial setules. *Urosomite one* at the base of uropod one bearing a robust seta like extension. *Pleopods*: two retinacula each; peduncle of pleopod one only with two distal setae at the base of the outer ramus; inner rami reduced to a single article each; outer rami with 9,8,8 articles. *Uropods*: third uropod extending well beyond first and second uropods in the intact specimen; lengths relative to uropod one - uropod two = 0.8x, uropod three = 1.6x; first uropod peduncle length 1.7x medial ramus, 3.1x lateral ramus, the outer margin five short robust setae plus a sub apical distal robust seta, medial margin with four robust setae plus an apical robust seta; rami strongly unequal, the medial 1.8x lateral, with reduced spination, only the medial ramus with a single mid medial, short robust seta; both rami with four apical

robust setae: second uropod peduncle length 1.4x medial ramus, 2x lateral ramus, with two plus one sub apical lateral robust setae, and one plus one apico-medial robust setae; rami with two medial robust setae on the medial ramus and one lateral robust seta on the lateral ramus, both rami with four apical robust setae; third uropod peduncle length less than the third urosomite - 33:38 - and 0.36x the length of the outer ramus, with two small baso-facial setae, one ventrodistal and a row of three distolateral robust setae; the proximal article of the outer ramus with four approximately evenly distributed lateral robust setae, five transverse medial sets of 1-2-2-2-2 robust setae and single distal lateral and medial robust setae; the second article with a small pair of apical setules; the inner ramus length 0.09x outer ramus, with a single apical robust seta. *Telson*: moderately long, 1.3x urosomite three, length 1.7x width; cleft 16% with a lateral penicillate setule and two robust setae in small notches dorsal on each lobe, a medio facial robust seta on each side at M0.5, and paired dorso-lateral penicillate setules at M0.65 on each side.

Relationship

N. moniae differs from *N. primaris* in: denser medial setae on the maxillipedal palp; denser palmar robust setae; less posterior expansion of the second article of pereopods five to seven; pleopods with fewer articles of the outer ramus; telson less tumid and shorter. *N. moniae* differs from *N. robinae* in: longer antennae with more articles; less D and E setae on the mandibular palp; left first maxilla palp broad; maxillipedal palp second article with dense medial setae; greater posterior expansion of the second article of pereopods five to seven; outer rami of pleopods with more articles; uropods one and two more spinous; telson more cleft and broader. *N. moniae* differs from *N. simoni* in: antennal flagellum longer and with more articles; aesthetascs never paired; mandibular palp with many more D setae; left first maxilla palp not narrowed; maxillipedal palp second article with denser medial setation; article two of pereopods five to seven more expanded posteriorly; outer rami of pleopods with greater numbers of articles; uropods more spinous; telson less cleft, less tumid and more slender. *N. moniae* differs from *N. georginae* in: flagellum of first antenna longer, both antennae with more flagellar articles; mandibular palp with more D setae, less E setae; setae of medial margin of maxillipedal palp denser; first gnathopod less rugose; article two of pereopods five to seven more expanded; pleopod outer rami with more articles; first and second uropods more spinous; telson more cleft, less tumid, more slender.

Distribution

Cave BP13, Bowan Park, New South Wales, 31°54' S, 148°05' E.

3.3.3.4 *Neocrypta georginae* n.sp. Figs. 3.101 - 3.104

Etymology

Named for Georgina Bradbury in recognition of her assistance in field work.

Type locality

From a pool in the dark zone, Apple Tree Cave, Copperhania, Abercrombie, New South Wales; Cave A 79, 33°55' S, 149°22' E.

Material examined

Holotype (Australian Museum P51365) female 'b' 5.5mm, Allotype (Australian Museum P51366) male 'a' 5mm, five other small specimens in the type series. Collected by S. Eberhard 16 June 1995.

Diagnosis

Lateral cephalic lobes moderately projecting, antennal sinus weak, ratio of lengths of peduncles of first antenna 10:10:7, ratio of lengths of mandibular palp articles 8:13:14 to 8:14:15, article three weakly falcate, setae DE. Inner plate of first maxillae with two and three apical plumose setae, inner plate of second maxilla without sub marginal medial seta. Coxa one apically tapered, articles two to six of both gnathopods with posterior rugose projections, three robust setae at corners of palms, length of pereopod six equal to seven, articles two of pereopods five to seven moderately to weakly lobate. Rami of pleopods reduced, inner rami each of one article without marginal setae. Epimera without post ventral teeth and ventrofacial robust setae, spination of the rami of the first and second uropods reduced to a single robust seta for each pair, inner ramus of the third uropod 0.11x length of outer ramus. Telson cleft 11% with only a single mid lateral robust seta on one side.

Description of holotype (female)

Body: pereion with few armaments, pleonites one to four with sparse short dorsal setae, pleonite five with a distal transverse row of three dorsal to dorsolateral robust setae, six with a single mid dorsal robust seta; length 5.5mm. *Head*: rostrum small,

eyes absent. *First antenna*: moderately long, 0.42x body, 1.7x second, peduncle shorter than flagellum - 71: 116, - relative lengths of articles 10:11:7, flagellum of twelve articles, segments uniform, sparsely setulate, aesthetascs present on articles two to eleven; accessory flagellum two articulate, reaching to M0.3 of the second article of the primary flagellum. *Second antenna*: length 0.23x body, peduncle longer than flagellum - 73:40 - article four shorter than five - 22:26 - articles three to five with moderate ventral setation; flagellum of six articles, weakly setose ventrally, article six with a small apical aesthetasc. *Left mandible*: palp article three sub equal to two, ratio of lengths 8:14:15, weakly falcate medially and distally rugose, setae 8D4E, first and second articles naked; incisor with five teeth; lacinia mobilis five teeth and four long basal setules; accessory blades of three chisel robust setae and two plumose robust setae, several fine setules basal to the molar; molar triturative with a short pappose posterior seta. *Right mandible*: palp article three slightly longer than three, ratio of lengths 8:13:14, medially rugose, setae 8D4E, first and second articles naked; incisor with five teeth; lacinia mobilis bifid, denticulate, basally setose; accessory blades two chisel robust setae and two plumose robust setae, two brushy setae basal to molar; molar triturative with a long posterior pappose seta. *Maxillae*: palp of left first maxilla with five thin apical robust setae and one medial sub apical robust seta; outer plate with seven denticulate strong robust setae; inner plate with two plumose apical setae; right first maxilla with three apical and one medial sub apical thick robust setae, one facial and one ventral simple seta, a long disto-facial strong naked seta and disto-lateral slender robust seta; outer plate with seven denticulate strong robust setae; inner plate with three apical plumose setae; second maxilla with long curved terminal setae, inner distal margin without a submarginal seta. *Maxilliped*: palp article three without ranks of fine setae on the inner basal face, with moderate distomedial setation, a pair of ventrofacial setae basal to the dactyl, without lateral setation, the apex strongly produced and rugose, the dactyl facially rugose with a pair of accessory spinules basal to the nail; article two naked laterally with a medial row of long naked setae, outer plate with a row of basomedial simple setae, a distomedial to apical row of six submarginal to facial tooth like robust setae and two distolateral plumose setae, apex of the inner plate with two moderate naked tooth like robust setae and a brushy seta, disto-laterally a slender simple seta, two medio facial slender robust setae and a submarginal disto medial short robust seta. *First*

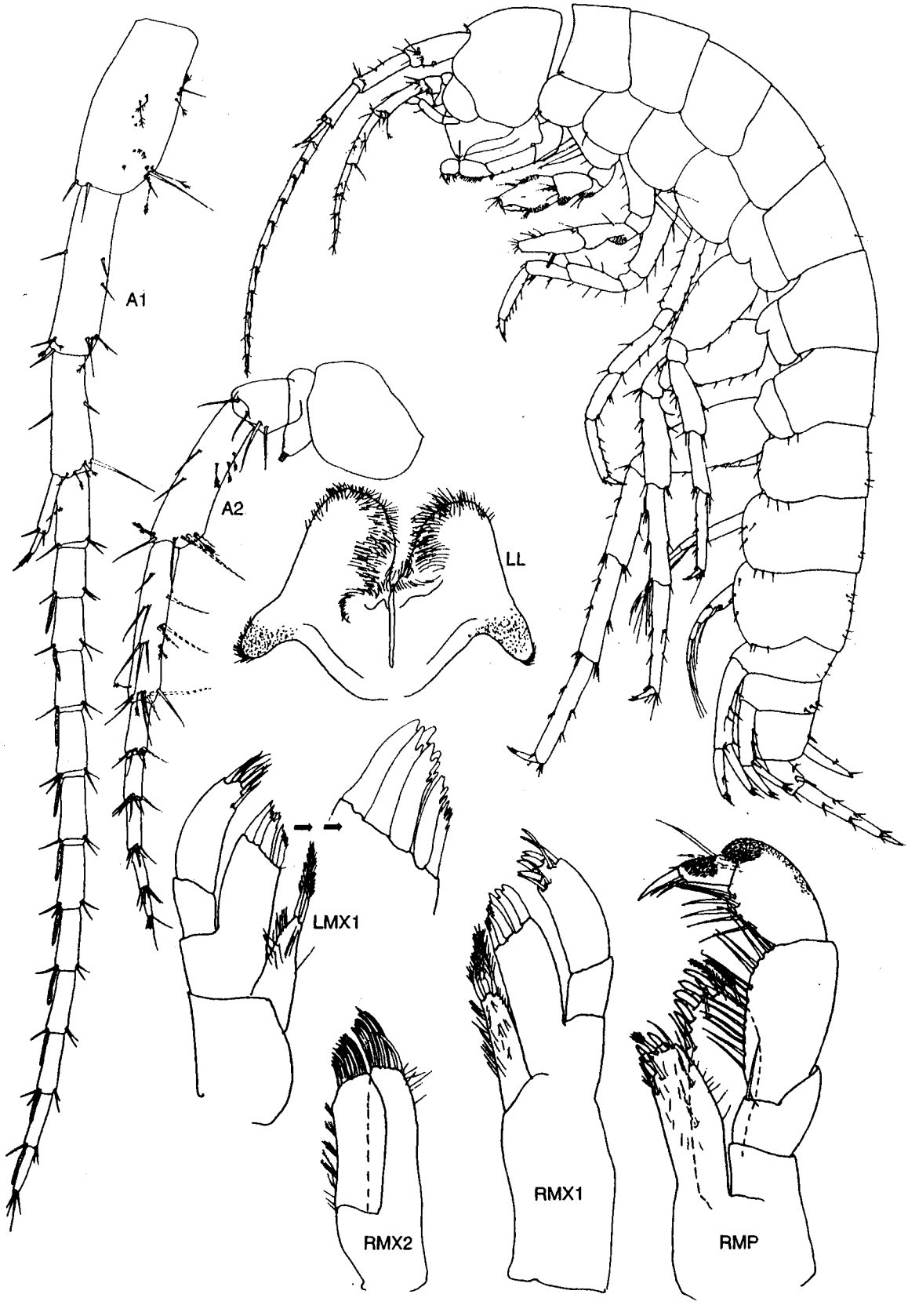

Fig. 3.101. *Neocrypta georginae* n. sp. holotype female 'b' 5.5mm; whole, antennae, mouthparts.

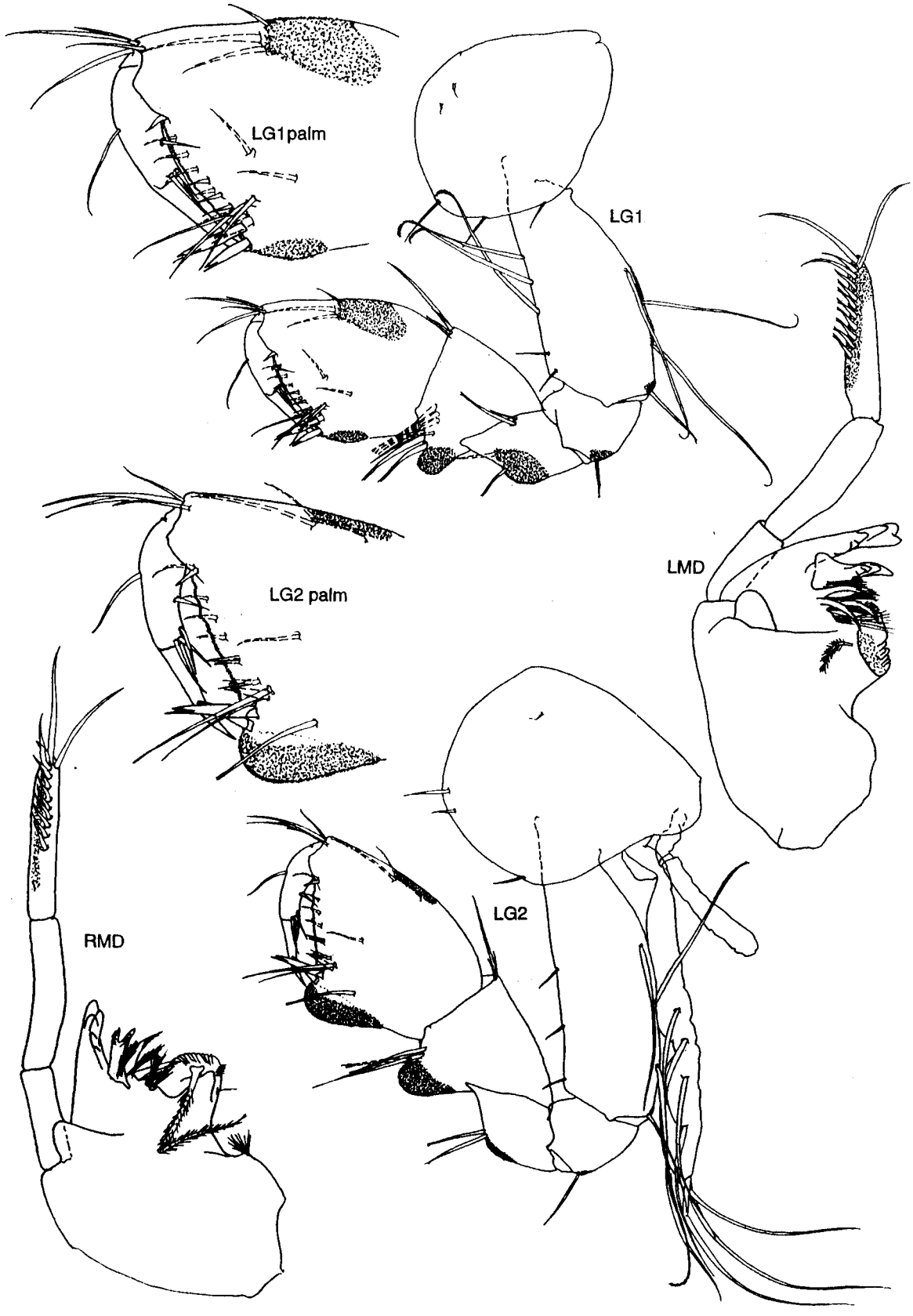

Fig. 3.102. *Neocrypta georginae* n. sp. holotype female 'b' 5.5mm; mandibles, gnathopods.

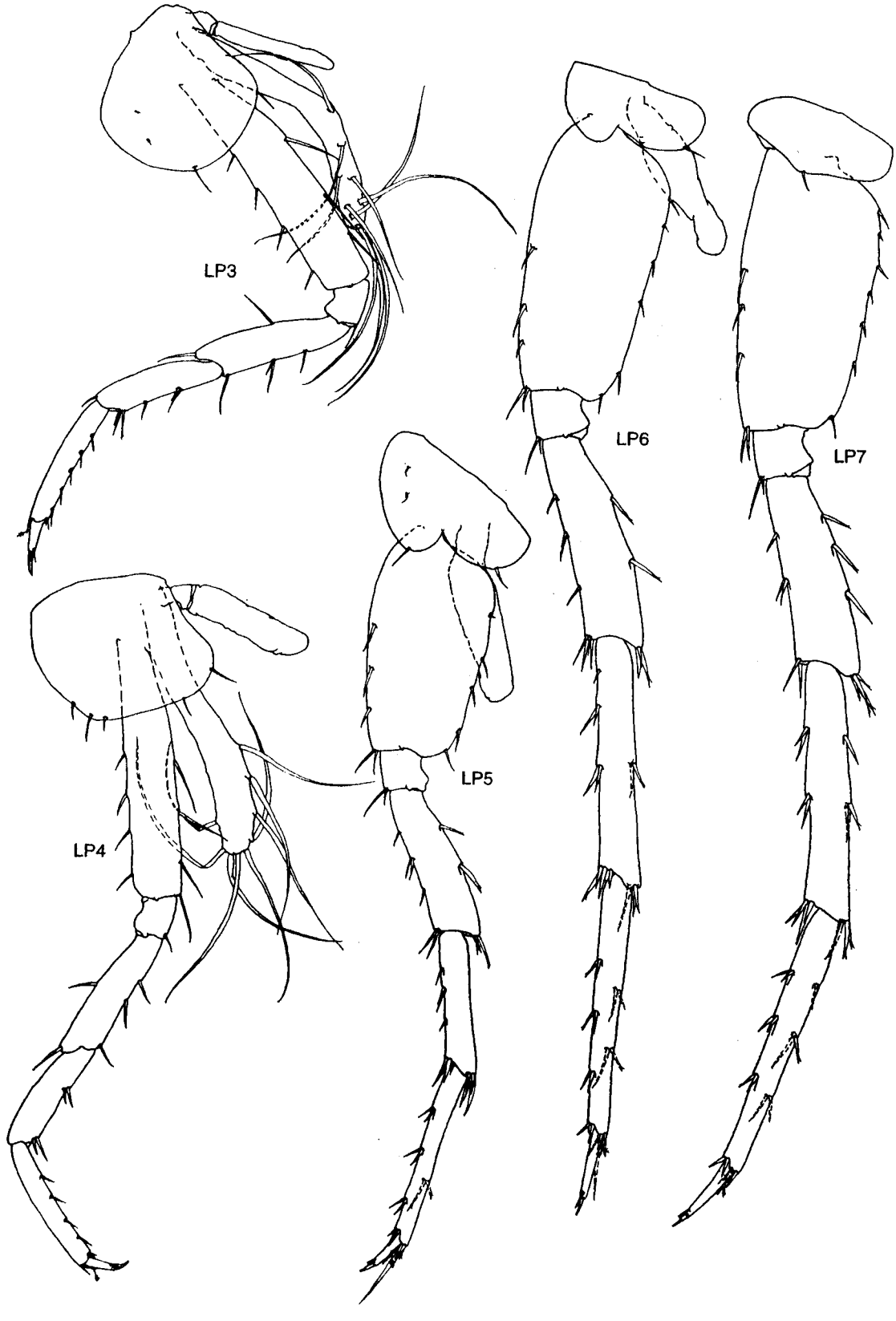

Fig. 3.103. *Neocrypta georginae* n. sp. holotype female 'b' 5.5mm; pereopods.

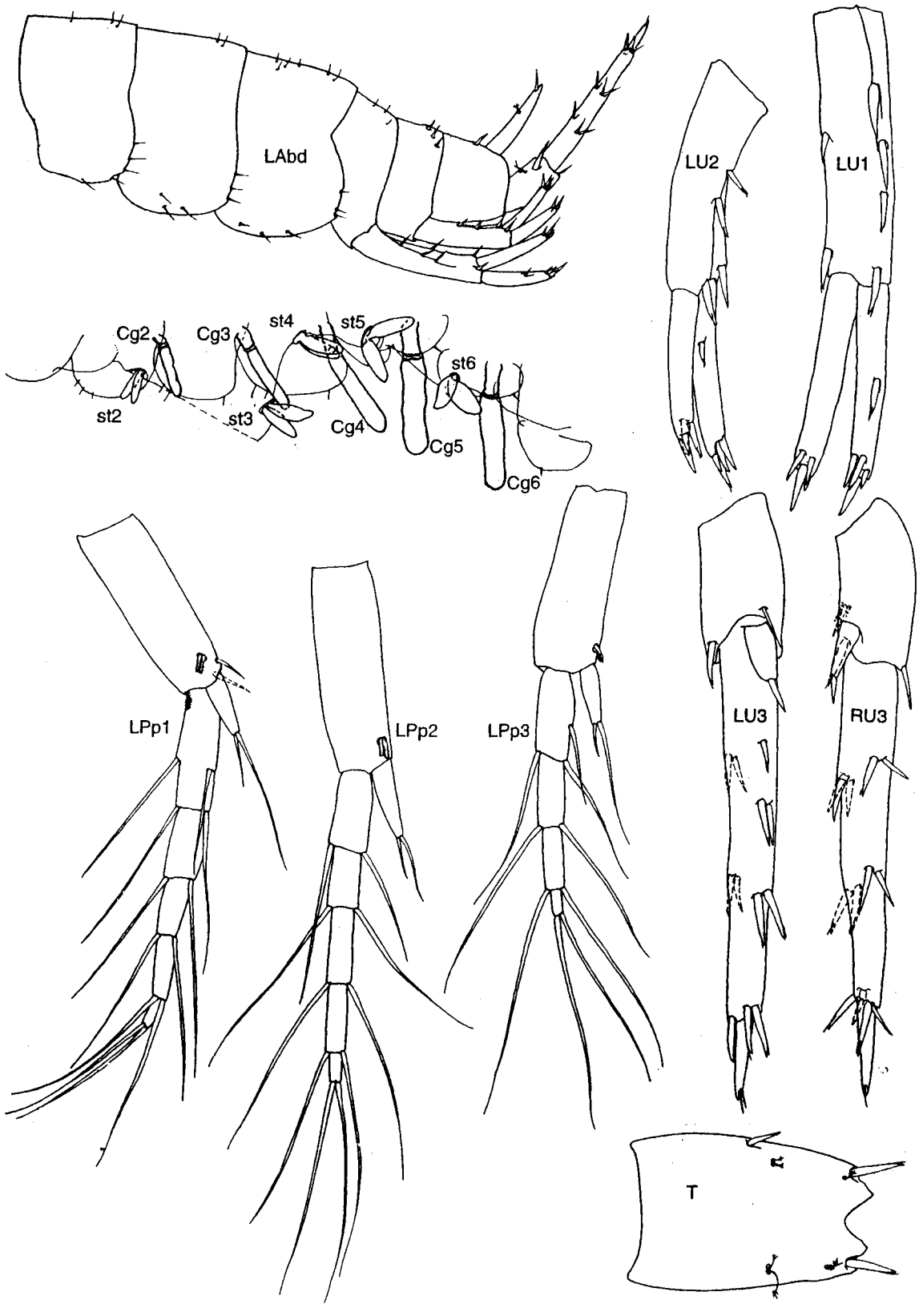

Fig. 3.104. *Neocrypta georginae* n. sp. holotype female 'b' 5.5mm; abdomen, gills, pleopods, uropods, telson.

gnathopod: coxal plate with three moderate distal setae, article two with three posterior rugose keel like extensions, article three with a small posterior rugose hump, article four with a distinct posterior rugose lobe; carpus short with a distinct rugose lobe, rounded and without apical setation; propodus with a small posterior rugose keel and a mid dorso-facial area of rugosity, trapezoidal, longer than wide with two lateral and one facial palmar corner robust setae, palm with moderately crowded simple robust setae, dactyl with accessory inner edge spinules, reaching to the palmar corner. *Second gnathopod*: slightly larger than first, articles two to four with small posterior rugose humps; carpus and propodus with strong rugose lobes; carpus short, lobe larger than on gnathopod one; propodus with a small mid dorsal area of rugosity, palmar corner marked with two lateral and one medial robust seta, palmar robust setae moderately sparse and simple, dactyl with accessory inner margin setules, reaching beyond palmar corner robust setae; coxa sparsely setose apically, bearing a short slender sac like gill and long narrow oostegite. *Pereopods*: coxae three and four weakly setate apically, coxa four very weakly emarginate, both bearing slender sac like gills and long slender oostegites; pereopods three and four subequal, longer than gnathopod two, articles four and five sparsely spinose posteriorly, articles six with 1-1-1-1 and 1-1-1-1-1 posterior setae respectively; pereopods five to seven similar, five shorter than six and seven, coxae with 1,1,nil weak posterior robust setae, articles two posteriorly expanded, weakly post ventrally lobate, with sparse moderate to weak marginal setae; propodi with few posterior setae, but pereopods five and six with long baso-dactylar seta. *Gills*: coxae two to six bearing slender to moderate sac like gills; sternites two to six each with a pair of simple gills attached to the mid medial area of each segment. *Epimera*: without post ventral teeth, posterior margins convex, with few moderate setae, the ventral faces with 1,3,4 facial robust setae. *Pleon*: pleonites one to four with sparse dorsal setae; pleonite five with a transverse dorsal row of three moderate robust setae; six with a single dorsal robust seta basal to the telson. *Pleopods*: each with two retinacula; peduncle one with two apicomedial setae, rami strongly reduced, outer rami of 5,5,4 articles, inner rami each of one article, without marginal setae. *Uropods*: uropod three extending beyond one and two in the intact specimen; lengths relative to uropod one, uropod two 0.8x, uropod three 1.3x; uropod one peduncle length 1.3x medial ramus, 1.4x lateral ramus, outer margin with three dorsal robust setae and one subdistal robust seta, inner margin with one

dorsal robust seta and one subdistal robust seta; rami of subequal length, inner ramus without marginal robust setae and four apical robust setae, outer ramus with one lateral marginal robust seta and four apical robust setae; second uropod peduncle length 1.2x medial ramus, 1.5x lateral ramus; outer margin with two dorsal robust setae and one subdistal robust seta, inner margin with only a sub apical robust seta; inner ramus with one lateral robust seta and four apical robust setae, outer ramus without marginal robust setae and with four terminal robust setae; uropod three peduncle length almost as long as urosomite three, 0.29x outer ramus, the left uropod without facial robust setae on the peduncle, with a moderate dorsal robust seta and a simple seta basal to the inner ramus; outer ramus with transverse rows of 2-2 lateral and 1-2-2 medial robust setae, and one distolateral and two distomedial robust setae basal to the distal article; distal article with two small apical setules; inner ramus 0.11x length of outer ramus, with a single apical robust seta; right third uropod with three small ventro-facial setae, a moderate robust seta adjacent the base of the inner ramus, and one disto-dorsal robust seta; outer ramus with transverse rows of 2-2 lateral and 3-2 medial robust setae and paired disto-lateral and disto-medial robust setae basal to the distal article; distal article with one small apical seta; inner ramus with a single apical robust seta. *Telson*: moderately long, as long as urosomite three, length 1.5x width; cleft 11%; apices with one robust seta, the right side with a single penicillate setule, the left with two; a single latero dorsal robust seta on the right side only, at M0.5; paired lateral penicillate setules at M0.6 on either side.

Description of allotype (male 'a')

Body: length 5mm. *First antenna*: peduncle sparsely setulate, relative lengths of articles 10:9:7; accessory flagellum of two articles reaching to M0.3 of the second article of the primary flagellum; primary flagellum of twelve articles, all but articles one and twelve bearing single aesthetascs. *Second antenna*: peduncle longer than flagellum, relative lengths of articles four and five 27:24; flagellum of four articles , the first relatively long, the last bearing a small apical aesthetasc. *Left mandible*: palp relative lengths of articles 8:13:14, third article rugose, setae 10D3E; incisor with five teeth, lacinia mobilis with four teeth and four fine basal robust setae; accessory blades of two robust setae and two plumose setae, with one large bent brushy seta onto the base of the mandible; mandible triturative, with a short posterior pappose seta. *Right mandible*: palp ratio of lengths of articles 8:14:15,

article two with one mediodistal seta, setae of third article 8D4E; incisor with five teeth, lacinia mobilis bifid with fine basal and facial setae, accessory blades of two robust setae and two plumose setae; two brushy setae onto the base of the molar; molar triturative with a long posterior pappose seta. *Left first maxilla*: inner plate with two plumose apical setae; outer plate with seven denticulate robust setae; palp with three slender apical robust setae, two distofacial slender setae and two mediodistal slender robust setae. *Right first maxilla*: inner plate with two plumose apical setae; outer plate with seven denticulate robust setae; palp article two with a mediodistal to apicolateral row of five moderately broad robust setae, the most lateral armed with setules, and a single distofacial broad naked seta. *Second maxilla*: similar to female except for the presence of two mediodistal plumose setae. *Maxilliped*: inner plate with two broad naked and one moderate plumose apical robust seta, one apicolateral long curved robust seta, one distomedial plumose seta and two distofacial stout robust setae. *Pleopods*: peduncle of each with two retinacula and one mediodistal seta; inner rami of each one article only; outer rami of 6,5,4 articles respectively. *Uropod one*: without a basal robust seta on urosomite one; peduncle with three dorsolateral, one apicolateral, one dorsomedial and one apicomedial robust seta; rami with one lateral robust seta each and four apical robust setae. *Uropod two*: peduncle with two dorsolateral and one apicolateral and apicomedial robust seta; rami without marginal robust setae, each with four apical robust setae. *Uropod three*: relative lengths of articles; peduncle 28, inner ramus 8, outer ramus proximal article 62, distal article 15; peduncle bearing single lateral and medial distal robust setae and three small dorso-facial setae; inner ramus with one apical robust seta; outer ramus proximal article with transverse rows of 2-2 plus one distal lateral robust setae and 2-2 plus two distal medial robust setae; distal article with two small apical setules. *Telson*: moderately long, length approximately equal to urosomite three; cleft about 11%; lobes slightly tumid basally; one apical robust seta on either lobe; a pair of lateral penicillate setules at M0.6 on either side.

Relationship

N. georginae differs from *N. primaris* in: antennae short, with less flagellar articles; second antenna with an apical aesthetasc; mandibular palp bears less D setae, but more E setae; first gnathopod bearing facial rugosities; posterior expansion of second article of pereopods five to seven slight; pleopod outer rami with fewer articles; telson cleft 11%.

Distribution

Apple Tree Cave, cave A79, Copperhania, Abercrombie, New South Wales, 33°55' S, 149°22' E.

3.3.3.5 *Neocrypta annae* n.sp. Figs. 3.105 - 3.108

Etymology

Named for Anne Williams in recognition of her years of indirect support of amphipod studies.

Type locality

Cave BP-6, Bowan Park, New South Wales, 31°54' S, 148°05' E.

Material examined

Holotype (Australian Museum P51367) male 4.5mm

Collected by S.Eberhard 13 March 1995.

Diagnosis

Lateral cephalic lobes weak, antennal sinus weak, ratio of lengths of peduncular articles of first antenna 10:11:7, ratio of lengths of mandibular palp articles 8:11:13 to 8:14:17, the third palp article weakly falcate, bearing DE setae, the inner plate of the first maxilla with two apical plumose setae, inner plate of the second maxilla with submarginal medial setae. Coxa one weakly tapering, second article of gnathopod one and second and third articles of gnathopod two without posterior rugose lobe, three robust setae at the palmar corners, robust setae along the palms sparse, pereopod six longer than seven, the second articles of legs five to seven moderately lobate post-ventrally. Rami of pleopods reduced, inner rami of one article only, without marginal setae, epimera without post ventral teeth, second and third epimera with ventrofacial robust setae, rami of uropods one and two with one or no dorsal robust seta rows, the inner ramus of uropod three 0.09x length of outer ramus. Telson cleft 20%, with mid lateral spination

Description of holotype (male)

Body: pleon with few dorsal arms, pleonites one to four with few setae, pleonite five with two distolateral robust setae, pleonite six with one mid dorsolateral robust seta basal to the telson, length 4.5mm. *Head*: rostrum small, eyes absent. *First antenna*: length 0.56x body, 2.1x second antenna, peduncle shorter than flagellum; ratio of

lengths of peduncular articles 25:27:18, with sparse setae; flagellum of seventeen articles, uniform and sparsely setulate, aesthetascs present on articles four to seventeen; accessory flagellum two articulate, extending to M0.5 of the second primary flagellum article. *Second antenna*: length: 0.27x body; the peduncle much longer than flagellum - 68:35 - articles four and five subequal in length, articles three to five with moderate ventral setation; flagellum of five articles, weakly setose ventrally, aesthetascs absent. *Left mandible*: palp article three 1.2x article two, weakly falcate, with setae 6D3E, articles one and two naked; incisor with five teeth; lacinia mobilis with four; three chisel robust seta accessory blades with three interraker plumose setae and one naked robust seta at the base of the incisor, two brushy setae leading to the molar; molar triturative with a short anterior raker blade, no pappose seta. *Right mandible*: palp with setae 6D3E; incisor with six teeth; lacinia mobilis bifid, denticulate; accessory blades of two chisel robust setae and two plumose setae, four brushy setae basal to the molar; molar triturative with a long posterior pappose seta. *Maxillae*. Left first maxilla: palp with three thin medio distal to apical robust setae and one similar latero-distal robust seta; outer plate with seven denticulate strong apical robust setae; inner plate with two apical plumose setae. Right first maxilla: palp with a mediodistal row of four robust setae and two distolateral long robust seta setae, the distal with apical armaments; outer plate with seven denticulate robust setae, the inner plate with two plumose apical setae. Second maxilla: both plates with long curved apical setae; outer plate distolateral margin with a single small seta; inner plate with two medio distal submarginal slender setae. *Maxilliped*: palp article two moderately setose medially, article three with two slender setae basal to the dactyl, a row of five mediodistal setae, two accessory spinules adjacent the nail, the apex moderately lobate and rugose; inner plate apex with two thick naked robust setae, two plumose and one long naked setae a disto medial plumose seta and two ventrofacial naked setae; outer plate bearing a distolateral plumose robust seta, three slender setae, one naked tooth like robust seta continuous with a row of stout naked sub marginal medial robust setae and a basal row of four slender robust setae. *First gnathopod*: coxal plate with a row of three moderate length apical setae, article two without posterior rugose extension, article three with a small post distal rugose lobe, articles four to six with substantial posterior rugose lobes; carpus short, without apical setae on the posterior lobe; propodus trapezoidal, wider than long, posterior rugose lobe keel-

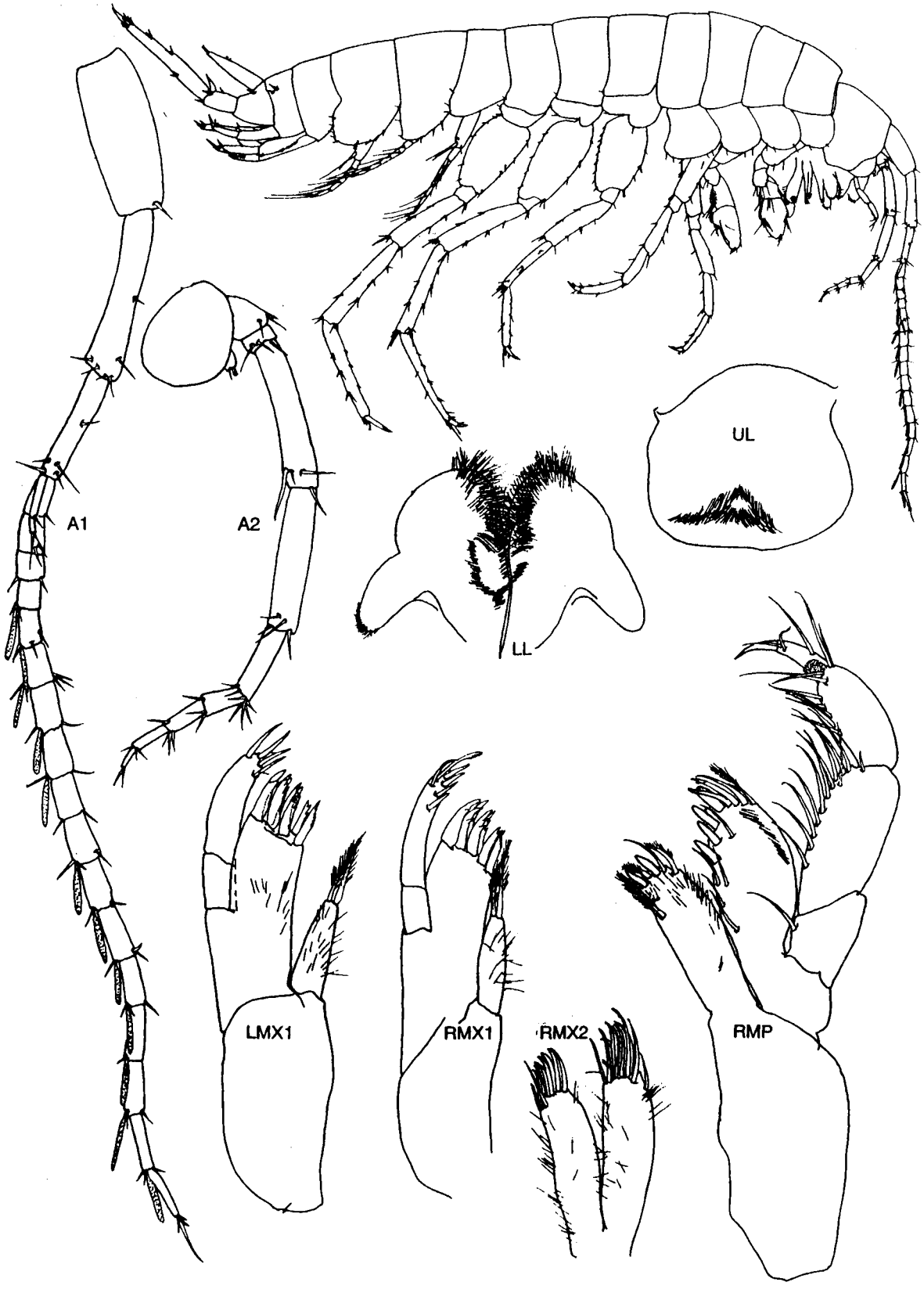

Fig. 3.105. *Neocrypta annae* n. sp. holotype male 4.5mm; whole, antennae, mouthparts.

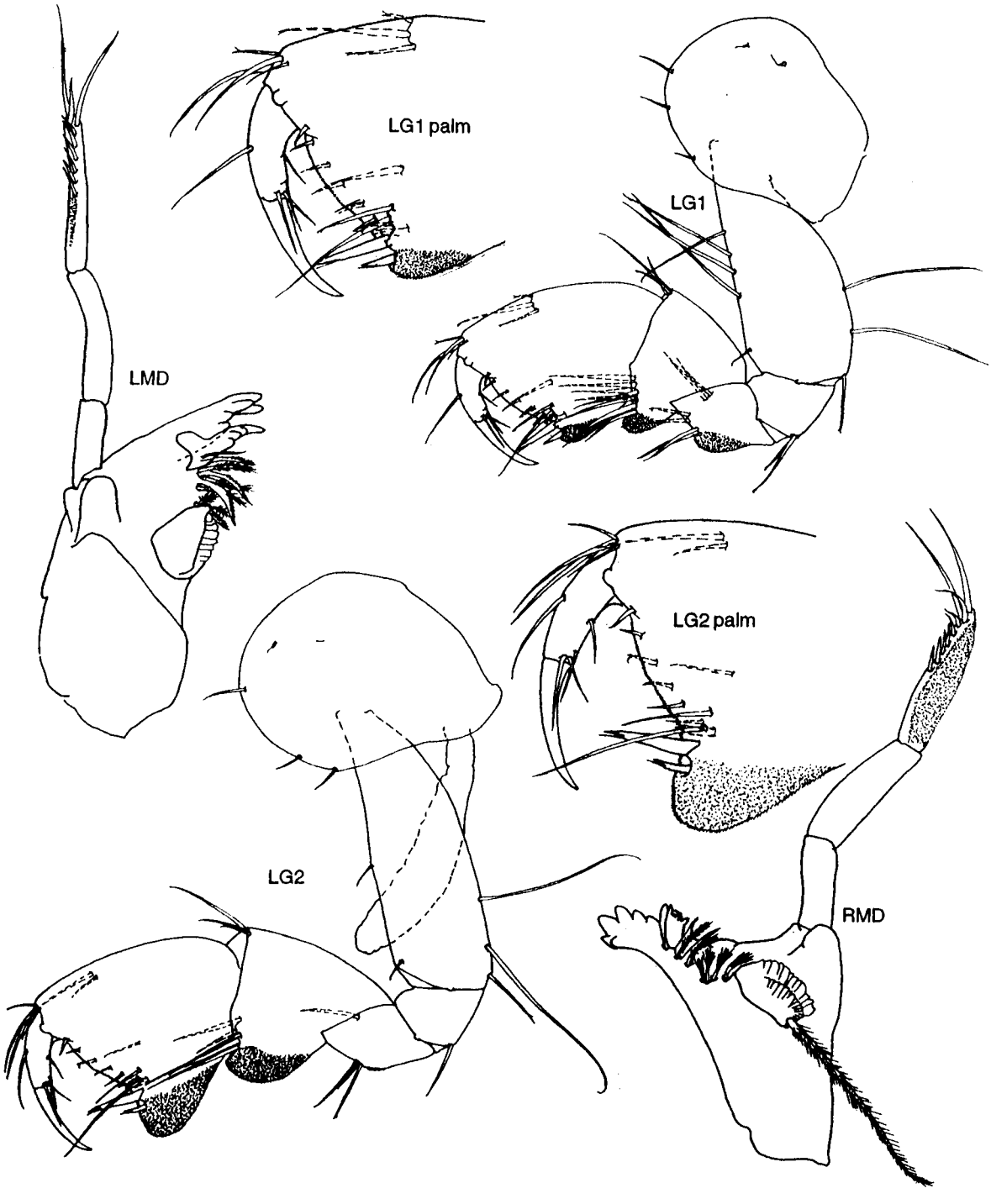

Fig. 3.106. *Neocrypta annae* n. sp. holotype male 4.5mm; mandibles, gnathopods.

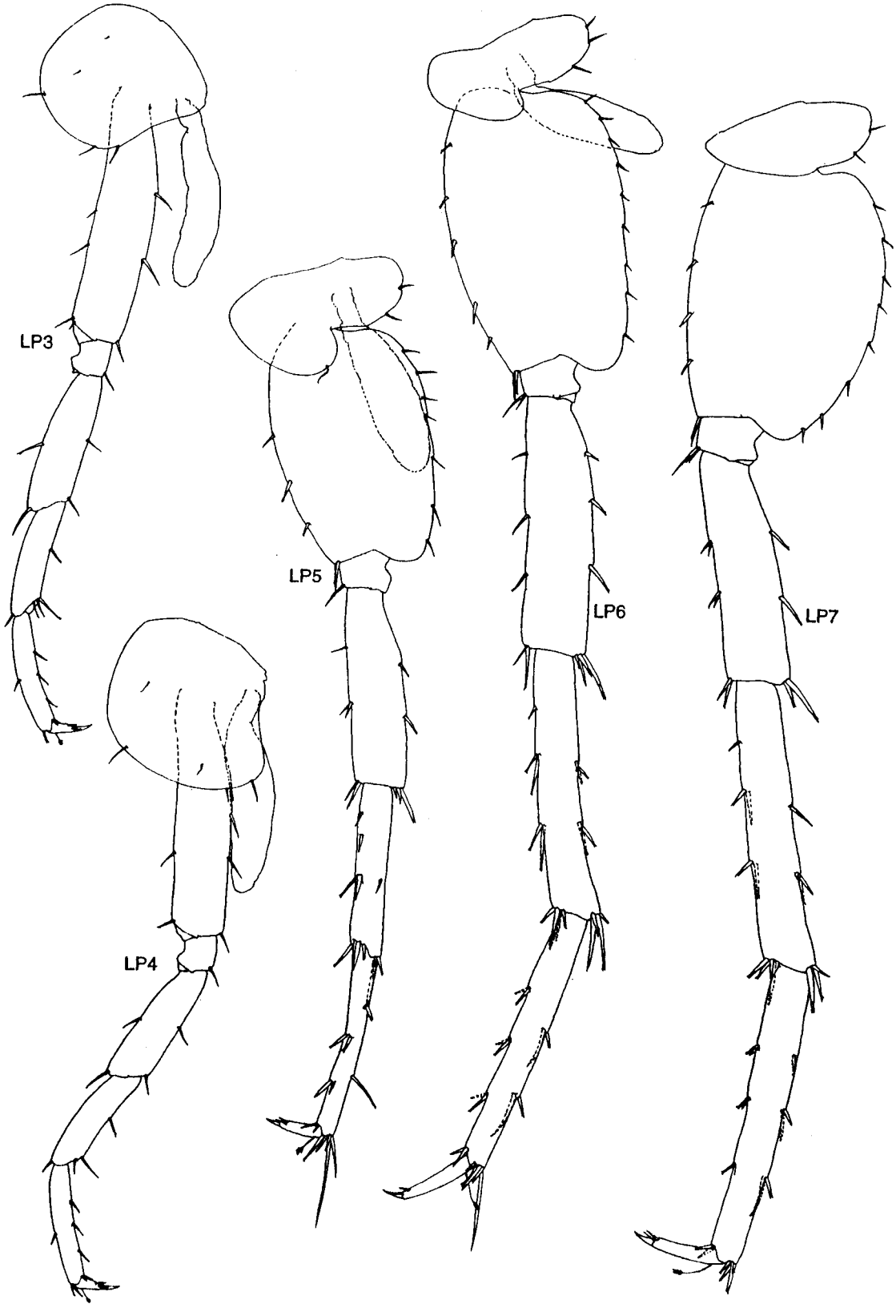

Fig. 3.107. *Neocrypta annae* n. sp. holotype male 4.5mm; pereopods.

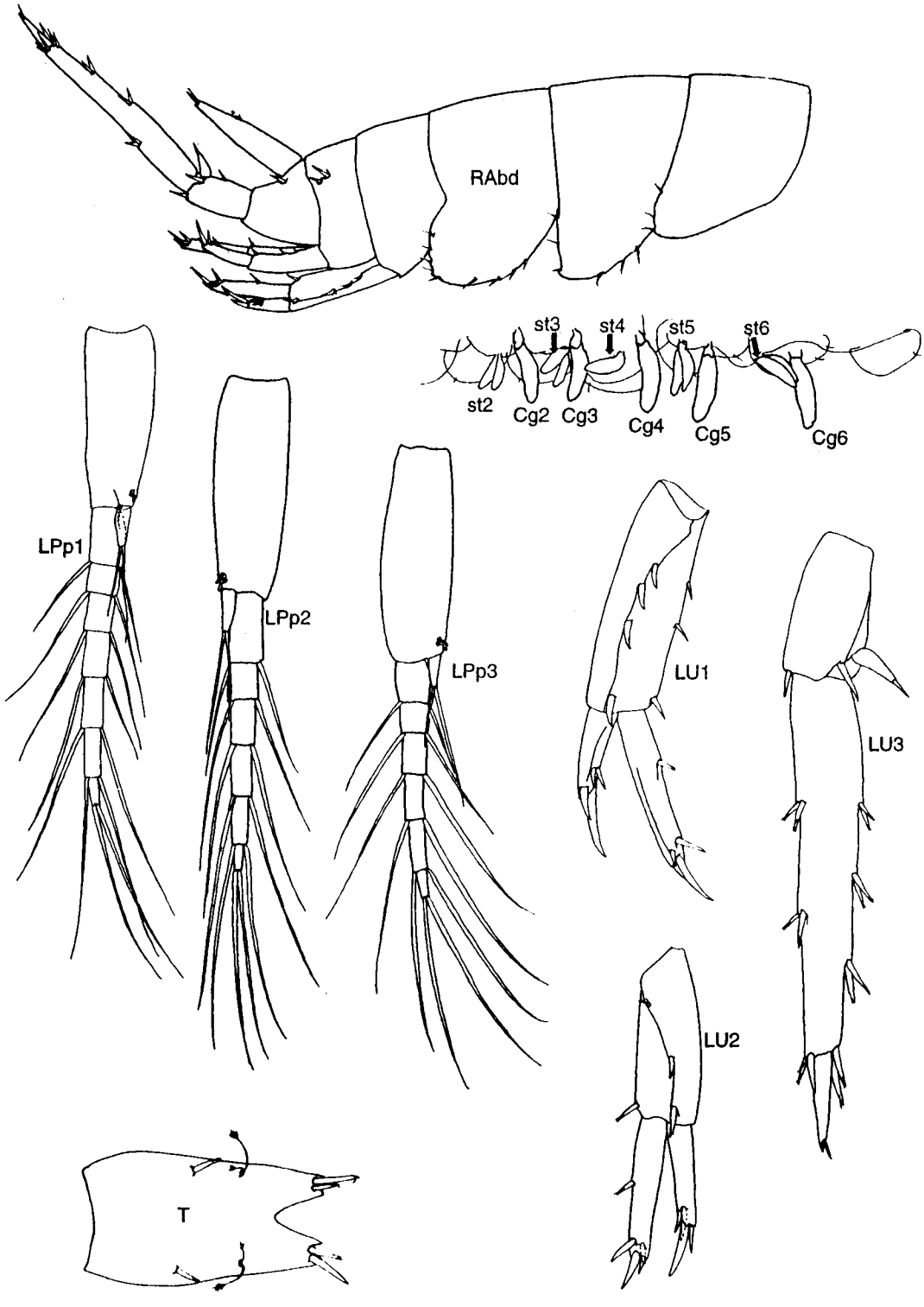

Fig. 3.108. *Neocrypta annae* n. sp. holotype male 4.5mm; abdomen, gills, pleopods, uropods, telson.

like, few, simple palmar robust setae, palmar corner marked by one medial and two lateral robust setae, dactylus with two inner accessory setae and stiff spinules at the inner nail articulation; dactylus reaching slightly beyond the palmar corner robust setae. *Second gnathopod*: slightly larger than the first; coxa sparsely setose apically, bearing a slender sac like gill; articles two and three without posterior rugosities; article four with only a small mid marginal posterior rugose extension; carpus and propodus strongly lobate; palmar corner with one medial and two lateral stout robust setae, robust setae of palm sparse; dactyl with inner accessory setae, reaching to palmar corner robust setae. *Pereopods*: coxae three and four with three weak apical setae only; coxa four weakly emarginate, with a few small facial setules; pereopods three and four subequal, slightly longer than the second gnathopod, articles four and five spinose posteriorly, articles six with posterior robust setae 1-1-1 and 1-1-1; pereopods five to seven similar, coxae with 2-3-2 weak to moderate posterior robust setae, articles two expanded, ovate - P5<6<7 - post-ventrally moderately lobate, with small marginal setae, posterior margins of propodi lacking long setae except for long sub-dactylar setae on legs five and six, dactyls without additional accessory spinules. *Gills*: coxae two to six with sac like gills; sternites two to six with paired medial simple gills. *Epimera*: without post ventral teeth; posterior margins of E1 convex, E2 straight, E3 broadly convex, with 3,3,4 posterior setae; ventrofacial robust setae = 0,3,5. *Pleon*: pleonites one to four naked, five with two distolateral robust setae, pleonite six with one mid lateral robust seta basal to the telson. *Pleopods*: each with two retinacula, peduncles otherwise naked except for a single small seta basal to the inner ramus of the first pleopod; rami diverse, both reduced, inner rami reduced to a single article only, without marginal setation, outer rami each of six articles. *Uropods*: third uropod strongly elongate, extending well beyond first and second uropods in the intact specimen; uropod lengths relative to the first uropod two 0.8x, uropod three 1.7x. First uropod: peduncle length 1.3x medial, 2.3x lateral rami; apicodistal robust seta of outer margin slightly sub-apical, with a row of three short dorsal robust setae; medial margin with two robust setae plus the apical robust seta; rami unequal, medial 1.8x lateral, only the medial ramus with a single medial short robust seta, both rami with four terminal robust setae. Second uropod: peduncle longer than rami, 1.2x medial, 1.7x lateral ramus, with two short dorsolateral robust setae plus a distal sub-apical robust seta; rami unequal, medial ramus 1.4x lateral, only the

medial ramus with a single medial robust seta, both rami with four apical robust setae. Third uropod: long, peduncle length 0.9x length of urosomite one, 0.3x length of outer ramus, bearing single distolateral and disto medial robust setae; outer ramus proximal article without setae, with two trans-lateral rows of 2-2 robust setae, three trans-medial rows of 2-2-2 robust setae, three distolateral and two distomedial robust setae, second article short, 0.2x length of the first, with two small apical setules; inner ramus short, 0.09x length of the outer ramus, with a single apical robust seta. *Telson*: moderately long, 2x urosomite three, 1.8x longer than broad, cleft 20%, apices with one long and one short robust seta, single dorso-lateral robust setae at M0.4 on either side and a pair of lateral penicillate setules at M0.6 on either side.

Relationship

N. annae differs from *N. primaris* in: first and second antennae shorter with fewer articles; mandibular palp without C setae, less D and E setae; palp of right first maxilla narrow; first gnathopod more rugose; second article of pereopods five to seven less expanded posteriorly; outer rami of pleopods with fewer articles; uropods one and two with fewer robust setae; telson more deeply cleft, less tumid and narrower. *N. annae* differs from *N. moniae* in: first and second antennae with less flagellar articles, shorter; mandibular palp with few D setae; palp of right first maxilla narrow; medial margin of article two of maxillipedal palp less setose; first gnathopod with little rugosity; outer rami of pleopods with fewer articles; uropods one and two with fewer robust setae; telson more deeply cleft. *N. annae* differs from *N. robinae* in: first antenna longer, with more flagellar articles; second antenna longer, but with the same number of articles; mandibular palp bearing fewer D and E setae; palp of right first maxilla narrow; first gnathopod bearing moderate rugosities; second article of pereopods five to seven more expanded; telson cleft much more deeply, and broader. *N. annae* differs from *N. simoni* in: flagellum of first antenna longer and with more articles; second antenna without aesthetascs; mandibular palp with more D setae; right rather than left first maxilla palp narrow; first gnathopod more rugose; outer rami of pleopods of more articles; telson less tumid. *N. annae* differs from *N. georginae* in: first antenna longer and with a greater number of articles; second antenna with less articles and without apical aesthetasc; mandibular palp with less D setae; palp of right maxilla narrow; first gnathopod without facial rugosities; second article of pereopods five to seven more

expanded posteriorly; first and second uropods less spinous; telson more deeply cleft, less tumid and more slender.

Distribution

Cave BP6, Bowan Park, New South Wales, 31°54' S, 148°05' E.

3.3.3.6 *Neocrypta simoni* n.sp. Figs. 3.109 - 3.112

Etymology

Named for Simon Williams in acknowledgment of his indirect contributions to the study of amphipods.

Type locality

Paradox Cave (Cave J-48), Jenolan, New South Wales, 33°49' S, 150°02' E

Material examined

Holotype (Australian Museum P51368) female 'a' 4mm, Allotype (Australian Museum P51369) male 'b' 3mm. Collected 9 March 1993 by S Eberhard.

Diagnosis

Lateral cephalic lobes moderately projecting, antennal sinus moderate, ratio of lengths of peduncular articles of first antenna 10:8:5, ratio of lengths of mandibular palp articles 8:12:10 to 8:13:12, third article linear, setae DE. Inner plate of first maxilla with two plumose apical setae, inner plate of second maxilla with one mediodistal seta submarginal. Coxa one tapering apically, articles two to four of both gnathopods with posterior rugose lobe, robust setae of the palmar corner 3-2, palmar robust setae short and sparse, pereopod six subequal to seven,, second article of pereopods five to seven weakly post ventrally lobate. Rami of both pleopods strongly reduced, inner rami of one article only, without marginal setation. Epimera without post ventral teeth, rami of pleopods one and two without dorsal robust seta rows, inner ramus of third uropod 0.13x length of outer ramus. Telson cleft 20%, without mid lateral spination.

Description of holotype (female 'a')

Body: pereon and pleon without dorsal armaments except for a single small dorsolateral robust seta on pleonite six basal to the telson; length 4mm. *Head*: rostrum small, eyes absent. *First antenna*: moderate length, 0.56x body, 1.5x second antenna, peduncle shorter than flagellum, ratio of lengths of articles 10:8:5,

setae sparse; flagellum of eight articles, segments uniform, sparsely setulate, bearing single aesthetascs on articles three to six and a pair on article seven; accessory flagellum of two articles reaching to M0.2 of article two of the primary flagellum. *Second antenna*: length 0.4x body, peduncle much longer than flagellum - 80:30 - articles four and five subequal in length - 27:24 - articles three to five with moderate ventral setation; flagellum four articulate, weakly setose bearing a single small apical aesthetasc on article four. *Left mandible*: palp article three shorter than two - 23:26 - linear, with 3D4E setae, disto-laterally rugose, articles one and two naked; incisor with six teeth; lacinia mobilis four teeth; accessory blades of three chisel robust setae and two plumose robust setae; molar triturative with a short posterior pappose seta. *Right mandible*: palp article three setae 3D4E, disto-laterally rugose; incisor with five teeth; lacinia mobilis bifid, denticulate; no accessory robust setae, but three very short setae onto the base of the molar; molar bearing a hooked brushy basal seta and long posterior pappose seta. *Maxillae*: palp of left first maxilla slender, bearing four thin apical robust setae and a ventro-facial seta, outer plate with seven denticulate robust setae, inner plate with two apical plumose setae; right first maxilla palp broad, with four thick medio-distal to apical robust setae and one ventro-facial seta; outer plate with seven strong denticulate robust setae, inner plate with two plumose apical setae; second maxillae: both plates with long curved apical setae; inner plate bearing one subdistal medial plumose seta and one simple disto facial submarginal seta. *Maxilliped*: palp article three without thin basomedial setae, with two facial setae basal to the dactyl, and a single distolateral seta at the base of the strongly produced rugose apex; dactyl facially rugose, with two accessory setules on the inner distal margin; inner plate apex with two thick tooth like robust setae, one pappose robust seta and a long lateral seta, inner margin with one plumose seta, ventro-distal face with two simple setae; outer plate with three naked baso-facial setae, medial submarginal pappose and naked robust setae, a ventro-facial long seta, one naked and two long pappose robust setae apically. *First gnathopod*: coxal plate with two marginal and one ventro-facial setae; articles two and three with small posterior rugose lobes; articles four and five with strong posterior rugose lobes; article six with a small area of posterior rugosity; carpus short, rugose lobe rounded, without apical setae; propodus trapezoidal, longer than wide, the posterior angle subquadrate, palmar corner robust setae two lateral and one medial, palm with moderate numbers of simple setae,

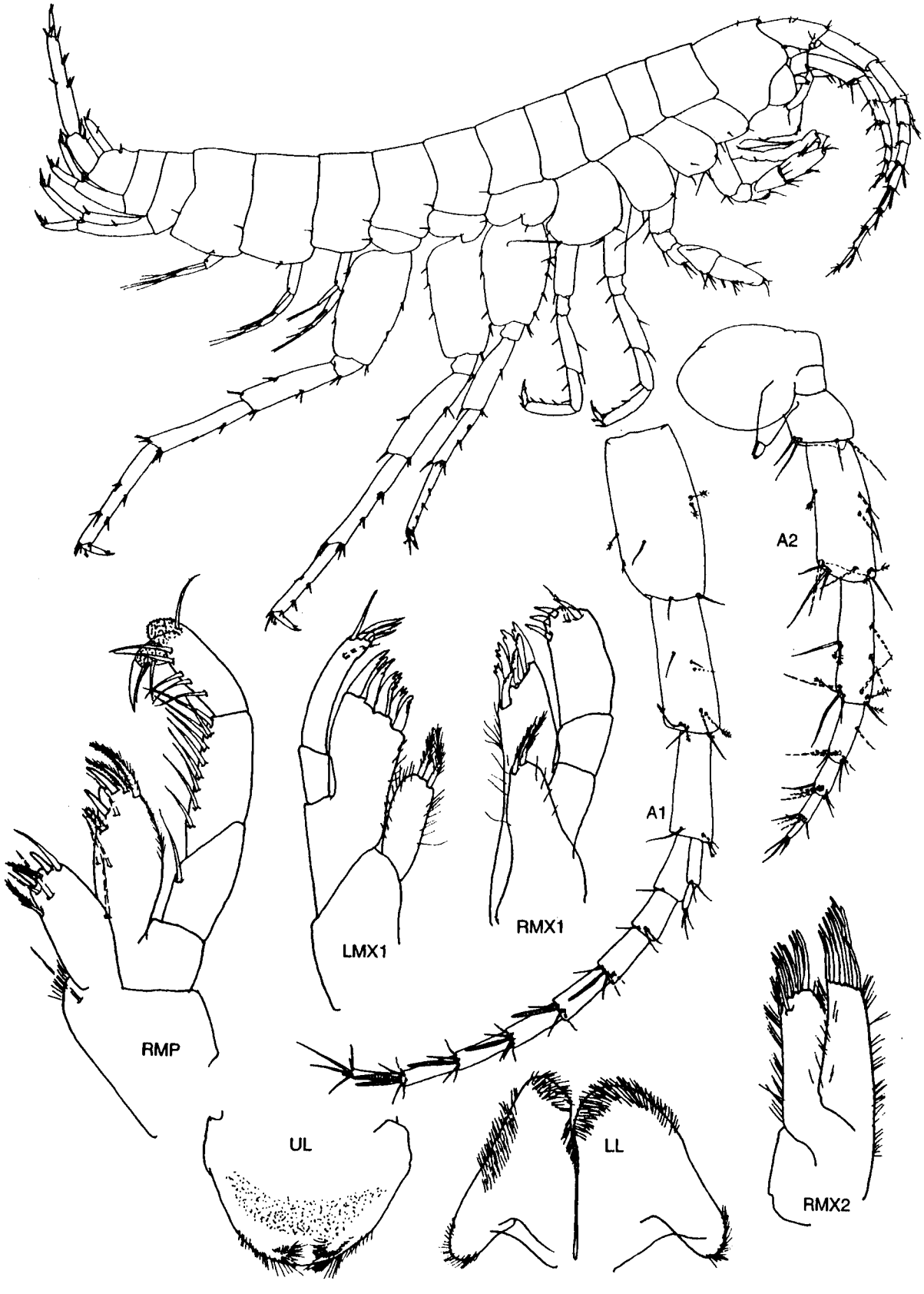

Fig. 3.109. *Neocrypta simoni* n. sp. holotype female 'a' 4.0mm; whole, antennae, mouthparts.

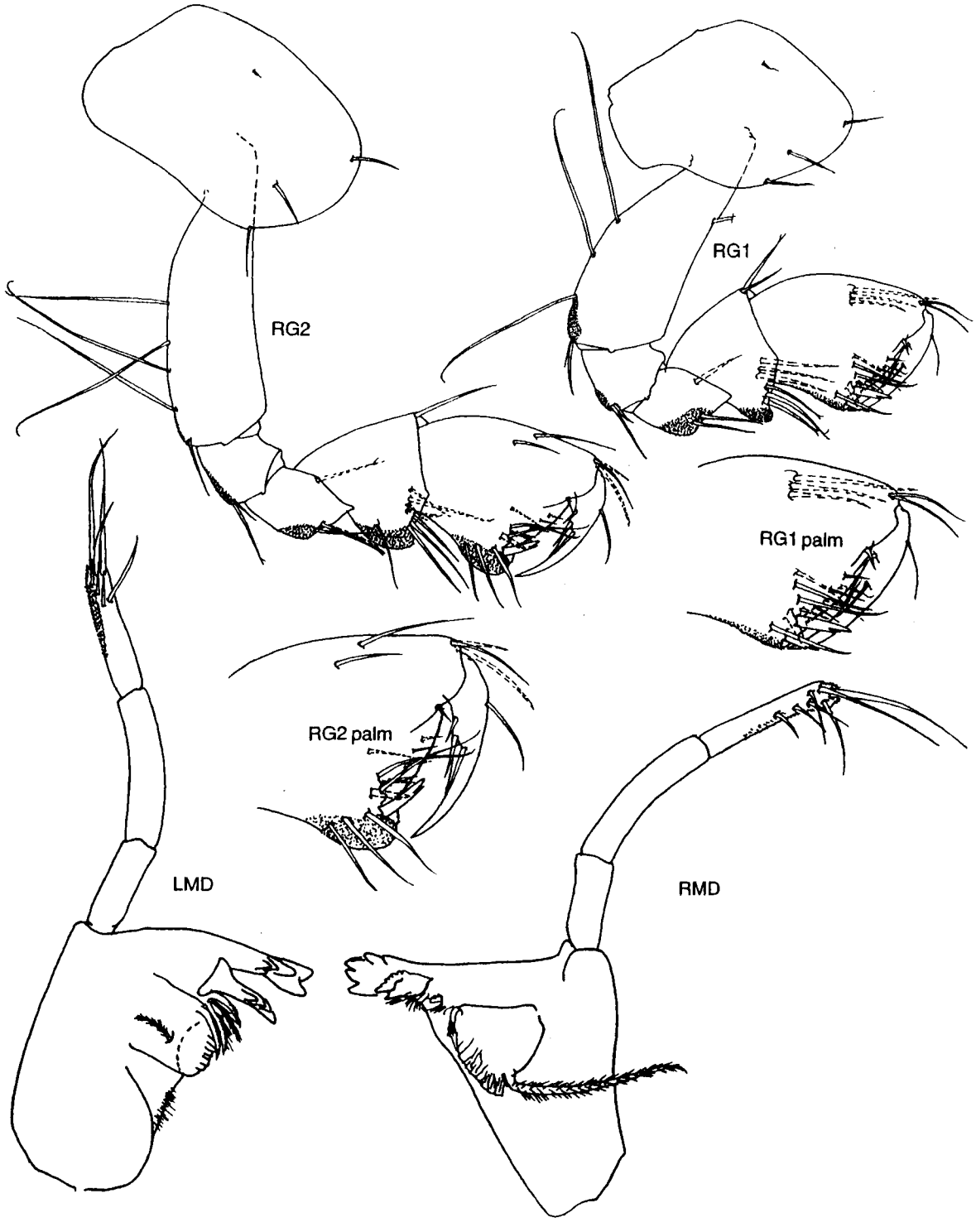

Fig. 3.110. *Neocrypta simoni* n. sp. holotype female 'a' 4.0mm; mandibles, gnathopods.

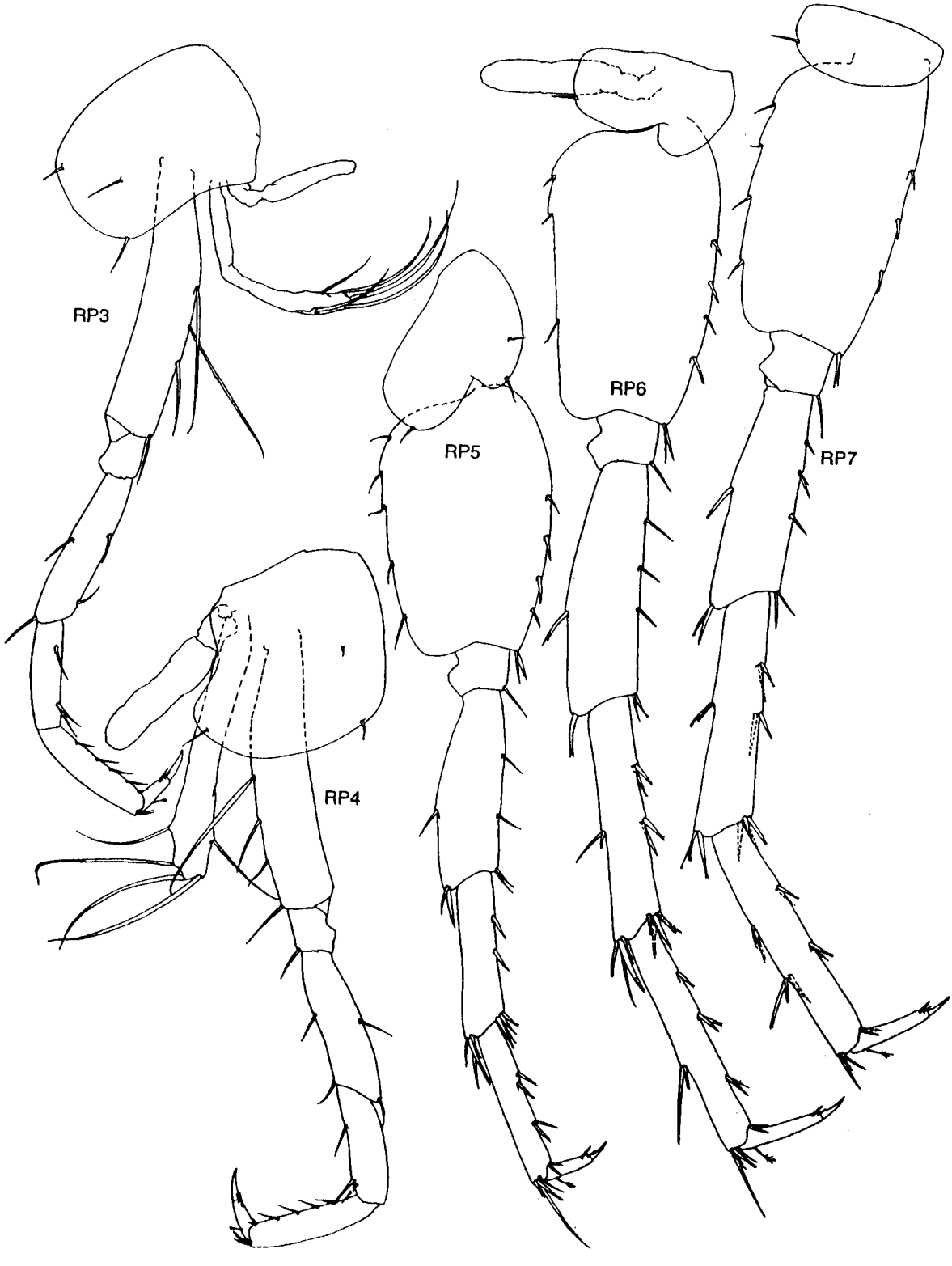

Fig. 3.111. *Neocrypta simoni* n. sp. holotype female 'a' 4.0mm; pereopods.

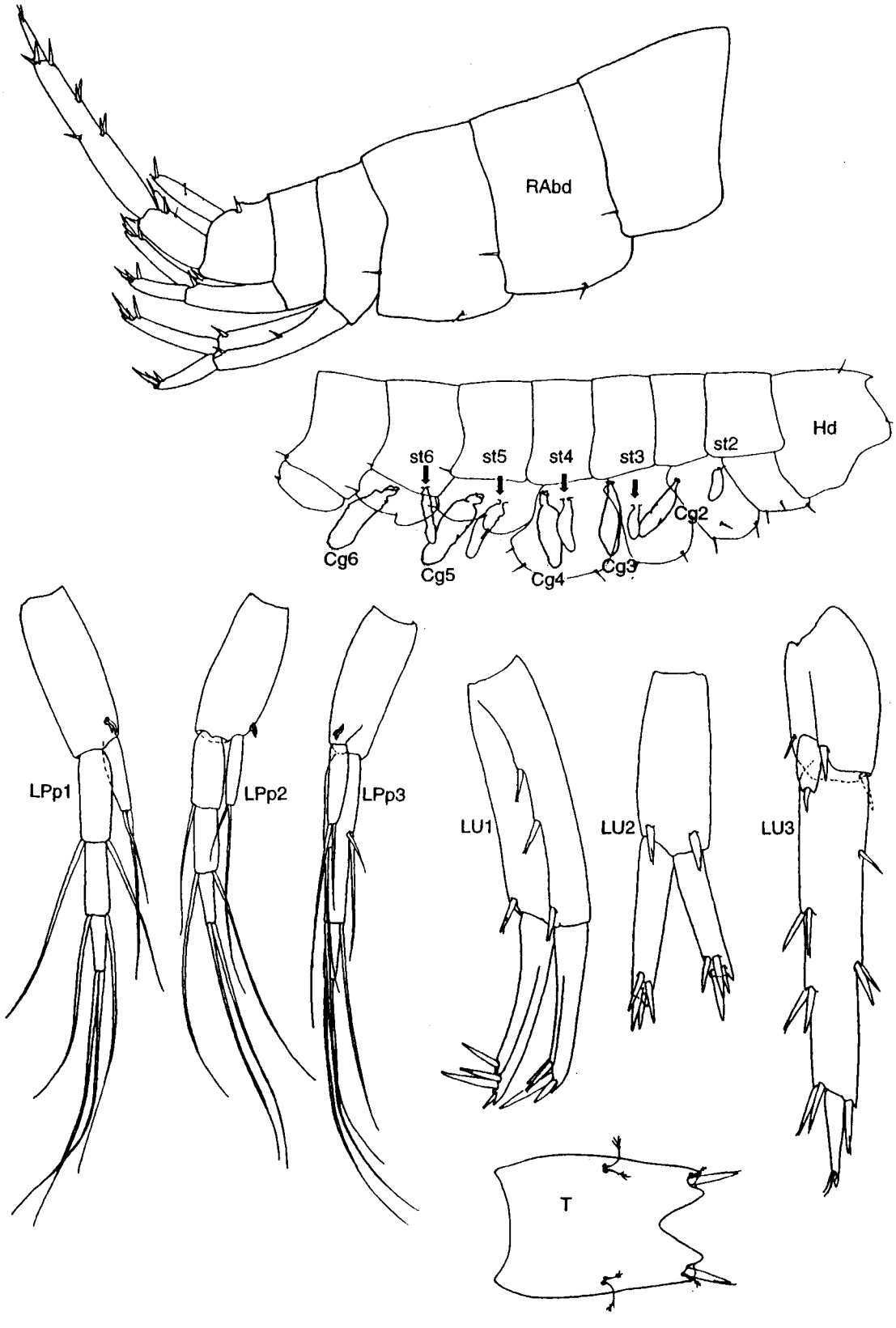

Fig. 3.112. *Neocrypta simoni* n. sp. holotype female 'a' 4.0mm; abdomen, gills, pleopods, uropods, telson.

dactyl with recumbent inner tooth like robust seta, and reaching to the palmar corner. *Second gnathopod*: slightly larger than the first; articles two to four all with posterior rugosities; article four posteriorly lobate, but less so than on the first gnathopod; carpal lobe larger than on the first; posterior proposal margin strongly lobate and rugose; palmar corner marked with one medial and one lateral robust seta; dactyl with an inner accessory setule, and reaching beyond the robust setae of the palmar corner; coxa sparsely setose apically with a sac like gill and slender oostegite. *Pereopods*: coxae three and four with sparse apical setation, coxa four moderately emarginate, both bearing slender sac like gill and oostegite; pereopods three and four subequal, longer than gnathopod two, articles three and four weakly setose and spinose, both propodi with the posterior robust seta formula 1-1-1-1; pereopods five to seven similar, coxae each with only a single weak posterior robust seta, article two expanded posteriorly, weakly lobate, with few moderate marginal setae, propodi with few posterior setae. *Gills*: sac like simple gills present on coxae two to six; sternites two to six bearing paired simple non-dendritic gills on each segment. *Epimera*: without post-ventral teeth, posterior margins almost straight, each with a single seta only, and single mid ventro-facial robust setae on epimera two and three. *Pleon*: pleonites one to five naked; six with a single dorsolateral robust seta basal to the telson. *Pleopods*: each with two retinaculae; peduncles without setae or robust setae; rami reduced, outer rami each with three articles, the third outer ramus with a single additional distal seta on the first article; inner rami of one article each, without marginal setae. *Uropods*: uropod three strongly extended, well beyond uropods one and two in the intact specimen; uropod lengths relative to uropod one uropod two 0.78x, uropod three 1.3x. First uropod: peduncle length 1.3x medial, and 1.5x lateral ramus, outer margin with a row of two short dorsal robust setae plus a sub apical distal robust seta, medial margin with a sub apical robust seta only; both rami without marginal robust setae, each with four apical robust setae. Second uropod: peduncle 1.3x medial, 1.5x lateral ramus, outer and inner margins with one sub apical distal robust seta; rami without marginal robust setae, each with four apical robust setae. Third uropod: peduncle length 0.35x outer ramus, as long as urosomite three with one small facial seta, a medio-distal robust seta adjacent the base of the inner ramus, and disto-lateral robust seta; outer ramus proximal article with two transverse medial rows of two robust setae each, two transverse lateral rows of one and two robust setae, and two medial and

one lateral distal robust setae basal to the distal article; distal article length 0.26x proximal, with two fine apical setules; inner ramus small, 0.13x outer ramus with a single apical robust seta. *Telson*: moderately long, longer than urosomite three, length 1.3x width; cleft 20%; apices each with a single robust seta set in a small notch, and a single lateral penicillate setule; without other dorsal spination or setation except for a pair of penicillate setules on either side at M0.49.

Description of allotype (male 'b')

Body: length 3.5mm. *First antenna*: primary flagellum of eight articles, aesthetascs present on articles three to eight, those on articles three and four paired; accessory flagellum of two articles, reaching to M0.4 of the second article of the primary flagellum. *Second antenna*: flagellum of four articles, the fourth with a small apical aesthetasc. *Mandibles*: similar to female. *Gnathopods*: similar to female. *Pereopods*: leg three second article lacking one long posterior seta, similarly article five with one less posterior seta; other pereopods also less setose than female. *Pleopods*: similar to female, peduncles each with two retinacula, outer rami with 3-3-2 articles, inner rami each with one article. *Uropods*: first uropod peduncle with one lateral robust seta only; second uropod similarly naked; third uropod peduncle similar to female, outer ramus proximal article with only one lateral robust seta. *Telson*: similar to female.

Relationship

N. simoni differs from *N. primus* in: antennae shorter with few flagellar articles; second antenna bearing apical aesthetasc; mandibular palp with less D setae; left first maxilla palp narrow; article two of pereopods five to seven less broadly expanded; outer rami of pleopods with fewer articles; uropods one and two with fewer robust setae; telson cleft more deeply. *N. simoni* differs from *N. georginae* in: first antenna longest but with fewer articles, some aesthetascs paired; second antenna shorter, with aesthetasc on last article; mandibular palp with fewer D setae; palp of left first maxilla narrow; first gnathopod without facial rugosities; outer rami of pleopods with fewer articles; uropods less spinous; telson cleft more deeply.

Distribution

Paradox Cave (J48), Jenolan, New South Wales, 33°49' S, 150°02' E.

3.3.4 *Wombeyanus* n.gen.

Etymology

Named for the type locality: Wombeyan Cave, N.S.W.

Type species

Wombeyanus botulosus n. sp.

Diagnosis

Pleonites with weak dorsal arms, rostrum small, lateral cephalic lobes weakly projecting, antennal sinus weak, without eyes. First antenna elongate, longer than the second, the ratio of peduncular articles 10:8:5, the accessory flagellum two articulate, calceoli present. The flagellum of the second antenna shorter than the peduncle, with prominent calceoli present. The ratio of lengths of articles of the mandibular palp equals 8:20:20 on the left mandible, 8:15:16 on the right, the second article poorly setose, the third weakly falcate, setae of the third article are BCDE. The labium lacks inner lobes. Inner plates of the maxillae are not setose medially, the first maxilla inner plate ovato-triangular with two apical plumose setae, the outer plate with seven terminal robust setae, the palps asymmetric. The second maxilla lacks an oblique row of facial setae but the two most medial setae of the inner plate are slightly sub marginal. The third article of the maxillipedal palp bears an extended rugose apical lobe. Coxae one to four moderately elongate, sparsely setose ventrally, coxae one to three without posterior robust setae, coxa one weakly tapering apically, coxa four moderately emarginate, coxae five to seven much shorter than coxa four. Gnathopods small, without sexual dimorphism, carpi short, with a strong posterior rugose lobe, articles two to four also bearing rugosities on the post-distal corner, palms transverse to slightly oblique, rugose post-distally, palmar robust setae not bifid nor dense nor bearing triggers, robust setae at palmar corner three or four. Pereopods three and four with robust seta sets on the posterior of article six evenly spaced, pereopods five to seven moderately elongate, six longer than seven, article two of pereopods five to seven broadly expanded, least on six, ovate, and post-ventrally lobate, articles four with few setae, except for an elongate baso-dactylar seta on pereopod five, the anterior margins of article six with 5-6-5 robust seta sets as well as locking robust setae. Dactyls of pereopods with one marginal and one facial setule. Gills present on coxae two to six, absent from coxa seven. Sternal gills present on segments two to six, simple sausage like, attached to

the antero or mid-lateral edge of each segment. Pleopods similar; each with two retinaculae, without accessory retinaculae; the rami subequal, medial setae of the inner ramus of each bifid. Epimera without posterior teeth; ventro-facial robust setae present on epimera two and three; the posterior margins with few setae. Robust setae of uropods one and two all short. Peduncles of uropods one and two with a single robust seta on the apico medial corner, the rami extending unequally, margins with few robust setae or setae, basofacial arms of the first uropod absent, the third uropod strongly extended, parviramous, the peduncle relatively short, robust setae of the outer ramus arranged in multiples in lateral and medial rows, the outer ramus with two articles, the second short, medial setae absent from the first article, without plumose setae , the inner ramus very short, with two apical robust setae. The telson short, cleft about 46%, the lobes not laterally tumid, with only apical spination, and a pair of lateral penicillate setules at M0.75.

Additional description

Upper lip uniform, rounded but weakly asymmetrical below, mandible accessory blades (rakers) with interraker plumose setae, few additional penicillate setae beyond rakers riding onto the base of the molar, with two bent basal molarial ragged setae. The lower lip uniform, the inner lobes absent. Both plates of the second maxilla with long apical setae. Maxilla inner plates and the lateral margins of the second maxilla moderately pubescent. Maxillipedal inner plate with a distal row of a few plumose setae, three blunt naked robust setae, reduced medial row of plumose setae, the outer plate with a few distal plumose setae, continuous with a medio-distal row of blunt naked tooth like robust setae, palp articles two and three poorly setose laterally, well setose medially, article three with several long robust setae near the base of the dactyl. Dactyls of gnathopods without a recumbent inner tooth like robust seta, with stiff spinules or setules at the inner nail articulation, and without additional spinules along the inner dactylar margin. Gnathopod one without an enlarged rastellate seta on the fourth article. Pleopods similar, the peduncles with few or no setae, and rami extending sub equally. Urosomite one at the base of the first uropod with a moderate ventrodistal robust seta.

Sexual attributes

Oostegites moderately broad, calceoli absent on female antennae. Sexual differences in appendages minor.

Relationship

The genus is most similar to *Neoniphargus*, but differs from that genus in lacking eyes, the first antenna is only moderately longer than the second, the first article of the mandibular palp is relatively longer, there are fewer robust setae at the palmar corners, robust setae along the palm are not dense nor bearing triggers, posterior expansion of the second article is least on pereopod six rather than five, sternal gills are neither dendritic nor bearing lumps, marginal spination of the rami of the first and second uropods is reduced, the telson is cleft 46% rather than 60%, and the lateral penicillate setules are placed more posteriorly, the ventrodistal robust seta on the first urosomite at the base of the first uropod is moderately long rather than short, and in the female is paired on the right side. The genus differs from *Wesniphargus* in the absence of lumps on sternal gills, presence of rugosities on the propodi of both gnathopods, lack of coxal gill seven, and asymmetry of the palps of the first maxillae. *Wombeyanus* differs from *Tasniphargus* in the absence of long, dense setae or cojoint first articles on the first antenna, as well as absence of dendricity of the sternal gills. *Wombeyanus* differs from *Yulia* in the lack of dense setae on the pleopod peduncles and absence of an elongate spur on the outer ramus of the first uropod of the male, as well as the absence of dendritic sternal gills. *Wombeyanus* differs from *Neocrypta* in the presence of calceoli on the flagellum of the second antenna; the first article of the mandibular palp is relatively short, the second slightly setose, the third bears B and C setae; coxa four is moderately rather than weakly emarginate; pleopods are not reduced, inner and outer rami being subequal; telson is short rather than long, and cleft 46% rather than 20% or less.

3.3.4.1 *Wombeyanus botulosus* n.sp. Figs. 3.113 - 3.116

Etymology

From *botulosus* L. meaning sausage: named for the simple, sausage-like sternal gills.

Type locality

Bullio Cave (2W2) part of the Wombeyan Cave system, New South Wales, 34°19' S, 149°59' E.

Material examined

Holotype (Australian Museum P51370)male 'x' 7.5mm, Allotype (Australian Museum P51371) female 'y' 7.5mm., other in the type series; male 7.5mm. Collected by T. Dennis on 5 April 1986.

Diagnosis

As in the genus.

Description of holotype (male 'x')

Body: pleon not armed dorsally, pleonites 1-4 with few setae, pleonites five and six with one robust seta on each side, length 7.5mm. *Head*: rostrum small, eyes absent. *First antenna*: long, 0.55x body length, 1.9x the second antenna; the peduncle length less than the flagellum, the ratio of lengths 10:8:5, setae sparse, the third article bearing a single medial calceolus at M0.7; flagellum of twenty six uniform, sparsely setulate articles, calceoli present on articles 2, 4, 5, 7, and 9, and aesthetascs on articles 3 to 26 excepting articles 8 and 25; accessory flagellum of two articles, extending to M0.7 of the second article of the primary flagellum. *Second antenna*: length about 0.3x body, peduncle approximately 1.9x the length of the flagellum, peduncular articles 4-5 subequal in length, articles 3-5 bearing moderate ventral setation; flagellum of ten weakly setate articles of which articles 1-7 bear calceoli, the distal three with a single aesthetasc each. *Left mandible*: palp articles two and three equal in length, article two with 4 inner marginal setae, article three weakly falcate, bearing 2B5C23D3E setae; incisor with five teeth; lacinia mobilis with four teeth and a few fine basofacial setae; three chisel robust seta accessory blades and three interraker plumose setae; molar bearing a moderate posterior pappose seta as well as two brushy and one naked basal setae. *Right mandible*: palp articles two and three equal in length, article two bearing four medial setae, setae of article three 2B6C23D3E; incisor bearing five teeth; lacinia

mobilis bifid and denticulate with a few medial setules; accessory blades of two blunt chisel robust setae bearing distal rugosities, two bent brushy setae onto the base of the molar; molar barely triturative, bearing a long pappose posterior seta, and a few medio-basal setules. *Maxillae*: left first maxilla; palp article two with a row of four apicomedial and apical slender robust setae, three facial robust setae and one plumose distolateral seta, the outer plate nine terminal robust setae most denticulate, and the inner plate two plumose setae; right first maxilla, palp article two with five thick apico-medial robust setae, one apico-lateral plumose seta, and two sub terminal apico-lateral facial setae, the inner plate with two plumose apical setae; second maxilla outer plate apical margin with one small spinule, inner plate apico-medial corner with two weakly submarginal plumose setae and one slender naked seta. *Maxilliped*: palp article three without ranks of thin setae on the inner ventral face, with four elongate apico-lateral setae, the apex strongly produced and rugose, the dactylar face and medio-facial area of article three also rugose; inner plate with three thick tooth like robust setae, six plumose setae, and a single naked facial sub terminal seta apically, a medial row of three plumose setae, lacking medial ventro-facial robust setae, the peduncle bearing four slender medial setae basal to the inner plate, and one lateral seta; outer plate with two facial and two ventro-facial setae at M0.4 and M0.6 respectively, a row of six submarginal medio distal blunt tooth like robust setae, one plumose one armed and one naked terminal setae, and one naked ventro distal seta. *First gnathopod*: coxal plate with a sparse row of short apical setae; fourth article bearing a small barely rugose posterior hump; carpus short, strongly lobate, the lobe rounded, without apical setae, and rugose; propodus trapezoidal, slightly longer than wide, the posterior angle with three short medial robust setae and two long, strong lateral robust setae, rounded and thus bearing a small rugose lobe, palm transverse, slightly convex, the dactylus with accessory spinules on the inner margin, and reaching to the palmar corner robust setae. *Second gnathopod*: slightly larger than the first; the carpal lobe broader; the palmar corner more lobate, with two short medial robust setae and three lateral robust setae, dactylus bearing inner margin accessory spinules, and reaching to the palmar corner robust setae; coxa sparsely setulose apically, bearing a sac like gill. *Pereopods*: coxa three with a sparse row of short apical setae, coxa four moderately emarginate with three anteroventral setae and five posterior setae, pereopods three and four subequal in length, longer than the second gnathopod,

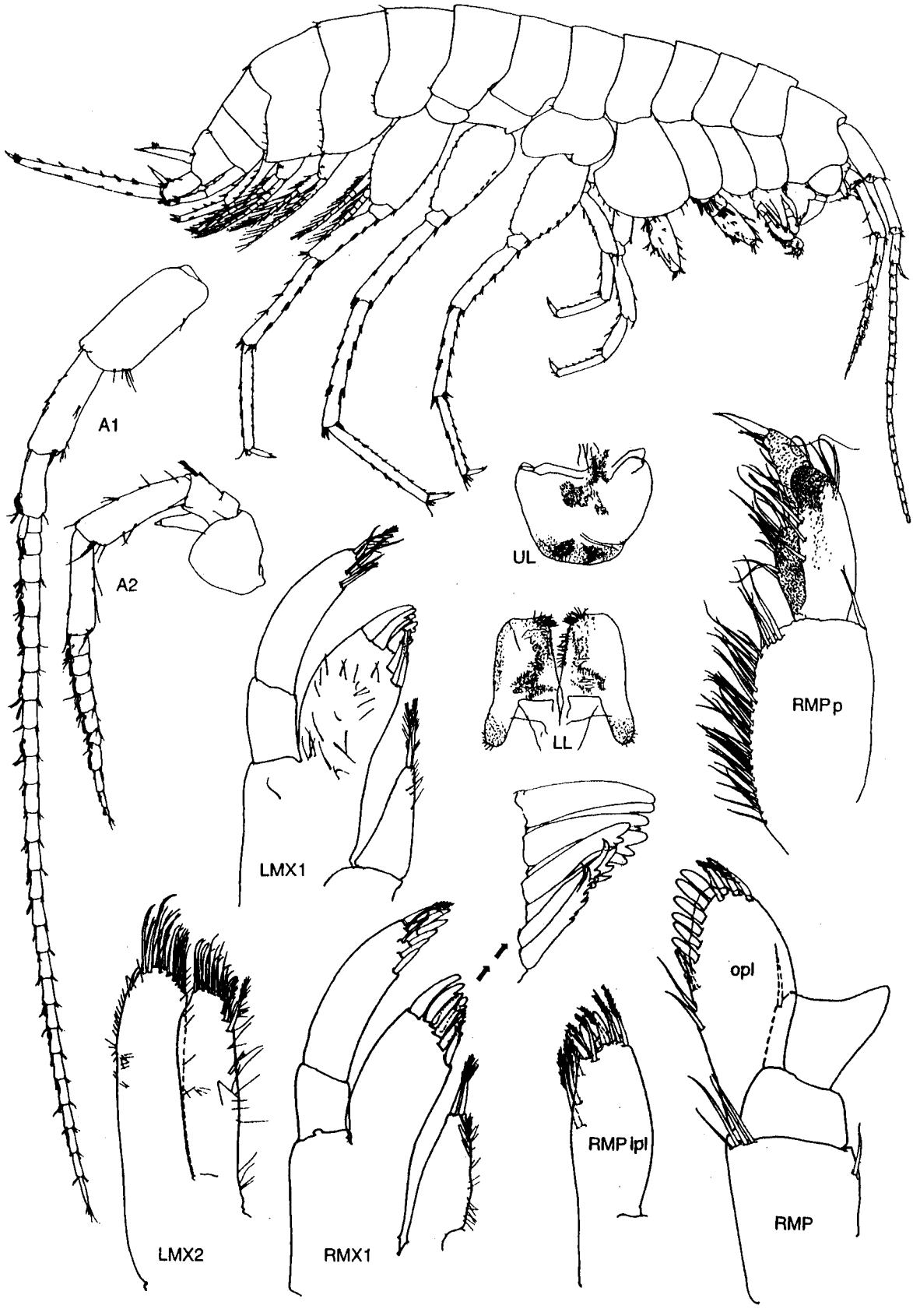

Fig. 3.113. *Wombeyanus botulosus* n. sp. holotype male 'x' 7.5m; whole, antennae, mouthparts.

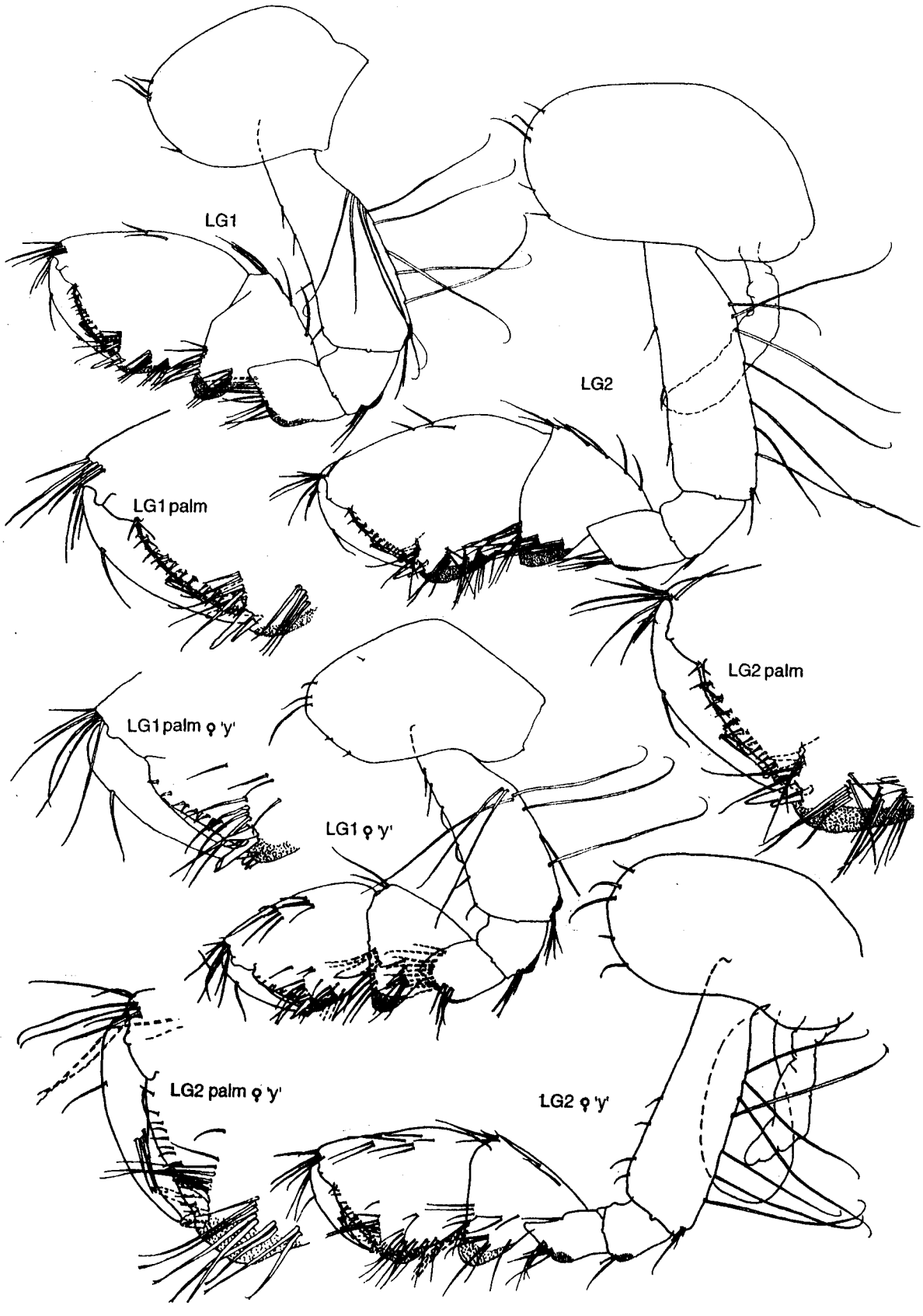

Fig. 3.114. *Wombeyanus botulosus* n. sp. holotype male 'x' 7.5mm; gnathopods (all drawings except those indicated). Allotype female 'y' 7.5mm gnathopods.

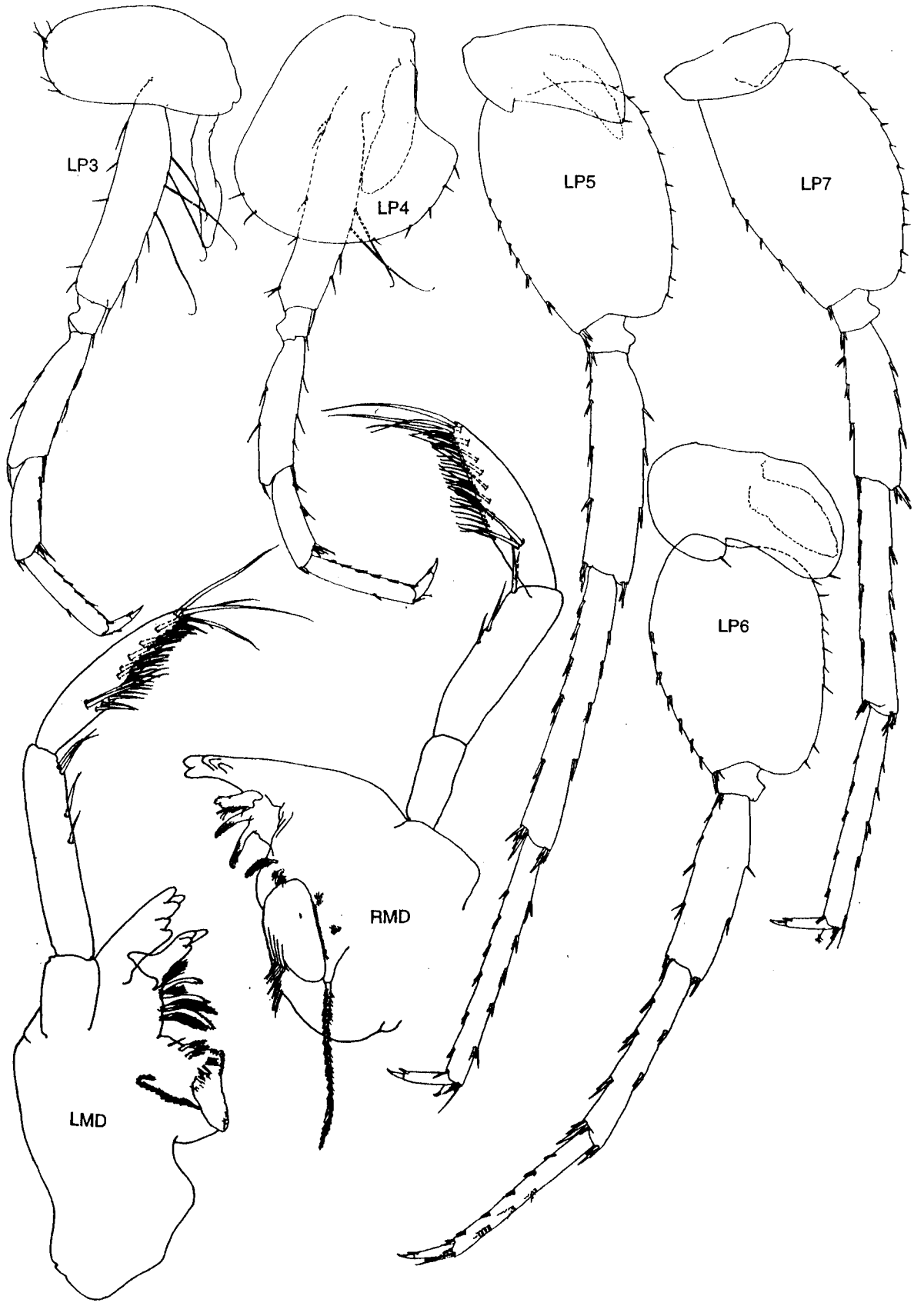

Fig. 3.115. *Wombeyanus botulosus* n. sp. holotype male 'x' 7.5mm; mandibles, pereopods.

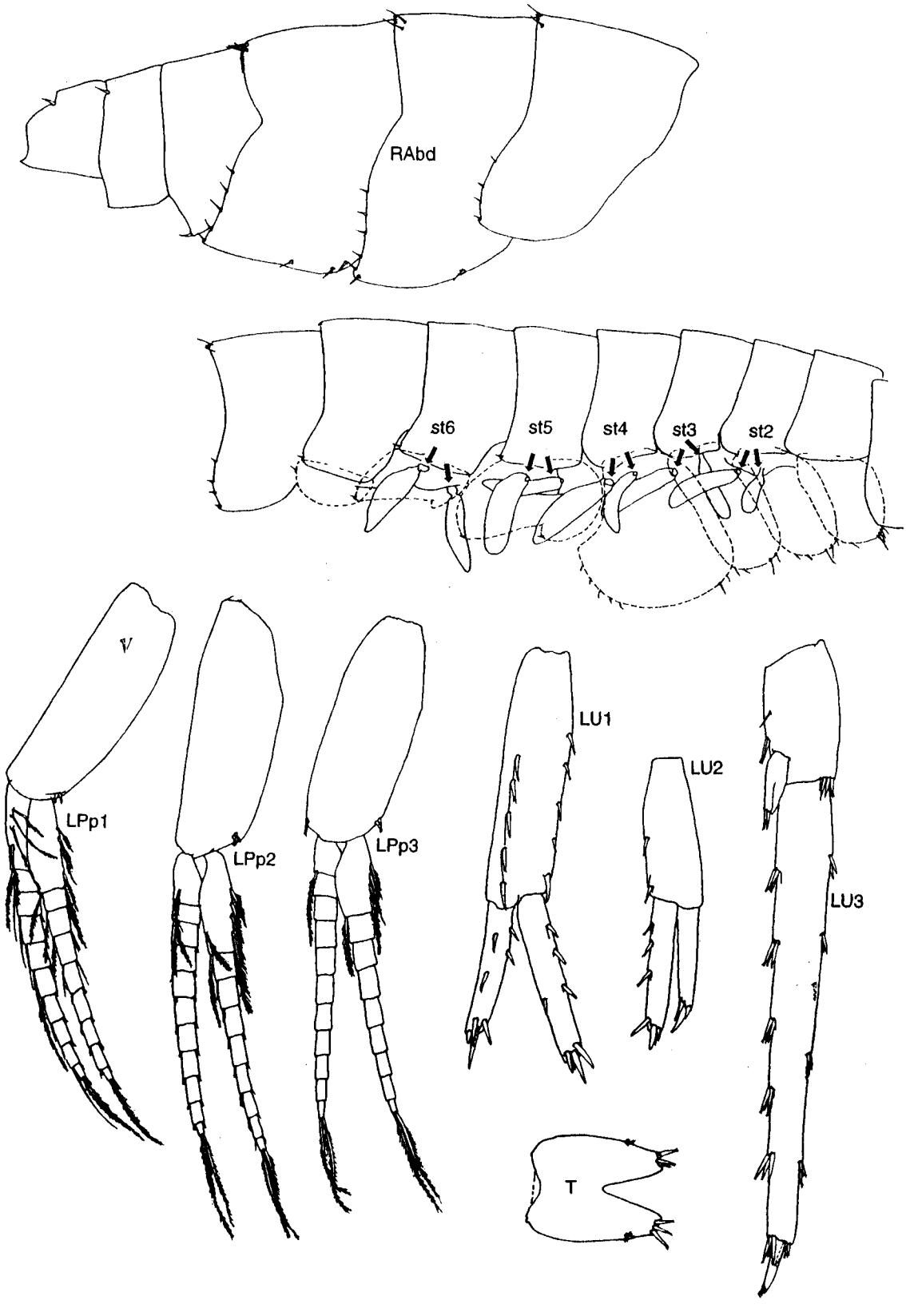

Fig. 3.116. *Wombeyanus botulosus* n. sp. holotype male 'x' 7.5mm; abdomen, gills, pleopods, uropods, telson.

articles four and five spinous posteriorly, article six of the third leg bearing 2-2-2-2-2 posterior robust setae, and of the fourth leg 1-2-2-2-2-2 posterior robust setae; pereopods five, six and seven similar, the coxae each bearing a weak posterior robust seta, the second articles expanded posteriorly, that of the sixth leg slightly narrower than the other two, ovate, post ventrally moderately lobate, with short marginal setae, the posterior margins of the propodi without long setae except at the base of the dactyls, the dactyls a single facial and medial setule and without additional setules. *Gills*: coxae two to six each bearing a single, sac like gill; sternal plates two to six each bearing a single simple, non dendritic gill. *Epimera*: one to three without post-ventral teeth, although the third slightly acuminate; the first epimeron with no ventral robust setae, the second with two - one on the mid-anterior margin and one posterior-, the third with two antero-ventral and one mid-ventral slightly facial robust setae, the posterior margins sinuous and with few setae. *Pleon*: pleonites one to three, bearing 2, 2, 3 post-dorsal marginal setae as well as fine marginal teeth; urosomite one without dorsal armaments; urosomites five and six each bearing a single dorso lateral seta posteriorly. *Pleopods*: each with two retinacula and no accessory retinacula; peduncles naked except for three small basofacial setules on the first, and two small setae distolateral on the third; first article of the inner rami of each bearing terminally bifid basomedial setae and an additional ordinary plumose seta, rami of 9-9, 11-9, 11-9 lateral and medial articles respectively. *Uropods*: third uropod extending well beyond uropods one and two in the whole animal; uropod lengths relative to uropod one; uropod two 0.65x, uropod three 1.5x; first uropod peduncle length 1.4x medial and 1.8x lateral rami, the lateral margin without an apicodistal robust seta, with a row of five dorsal robust setae, the medial margin bearing five robust setae, rami of unequal length, both with two rows of short marginal robust setae, and four apical robust setae; second uropod peduncle approximately the same length as the medial ramus, with two short dorsolateral robust setae including the apical robust seta, outer ramus slightly shorter than the inner, only the medial ramus with three medio-lateral robust setae, both rami with four terminal robust setae; third uropod peduncle as long as urosomite three, 0.5x the length of the outer ramus, bearing one facial and two disto-medial robust setae and a disto-lateral row of five robust setae, the outer ramus of two articles, proximal article with transverse rows of robust setae arranged laterally 2-2-1-3-3 and medially 3-3-3-3-3, without setae, and lateral and medial

groups of three terminal robust setae, the distal article short, approximately 0.12x proximal, three fine apical setules, the inner ramus short, 0.27x outer, with two simple apical setae only. *Telson*: moderate length, approximately equal to the length of the peduncle of the third uropod, length 1.25x width; cleft 46%; apices with three short robust setae in a row, no other robust setae, and a pair of penicillate setules dorsolaterally at M0.75.

Description of allotype (female 'y')

Body: length 7.5mm. *First antenna*: peduncle ratio of lengths 10:9:6; primary flagellum of twenty three articles, aesthetascs present on articles four to twenty. *Second antenna*: peduncle articles three to five sparsely setulate, lengths of articles four and five equal; flagellum of eight articles. *Left mandible*: incisor with four teeth; lacinia mobilis four teeth, and a group of basofacial setae; accessory blades of thee chisel robust setae and three plumose setae; two bent brushy setae onto the base of the molar; molar triturative with a moderate posterior pappose seta; palp of three articles, ratio of lengths 8:20:21, article two with two medial setae, article three with setae 2B3C14D3E. *Right mandible*: incisor with four teeth; lacinia mobilis bifid and facially setose; accessory blades of two rakers and two plumose setae; three bent brushy setae onto the base of the molar; molar triturative, with a long posterior pappose seta; palp ratio of lengths of articles 8:22:23, second article with two medial setae, third article with setae 2B3C14D3E. *Left first maxilla*: palp with three slender apical robust setae, one with setules, two medio-distal and one apico-facial robust setae and two disto-facial setae; outer plate with nine denticulate robust setae; inner plate with two apical plumose setae. *Right first maxilla*: palp with one stout setulate apical robust seta, an oblique distal row of five stout articulated robust setae, and a single apico facial slender seta. *First gnathopod*: coxa with few apical setae; articles two to four with small posterior rugose lobes; carpus short with strong posterior rugose lobe; propodus trapezoidal, longer than wide, with small rugose posterior lobe, the rugosities extending to the corner robust setae; palmar corner with two small medial and two lateral robust setae, palm slightly oblique, straight, with few simple robust setae; dactyl with three accessory spinules on the inner margin and stiff spinules at the inner nail articulation. *Second gnathopod*: coxa with few apical setae, bearing sac like gill and simple oostegite; articles three and four with small posterior rugose lobes; carpus with strong posterior rugose lobe; propodus with moderate posterior rugose lobe, palmar corner

with two medial and three lateral robust setae, palm slightly convex and oblique, with moderate numbers of simple robust setae, dactylus with three accessory spinules on the inner margin and two stiff spinules at the inner nail articulation, and reaching the palmar corner robust setae. *Pereopods*: pereopod three similar to male, with few apical coxal setae, coxa bearing a broad oostegite; pereopod four about the same length as three, coxa deeply emarginate, bearing a broad oostegite. *Pleopods*: peduncle of first ploepod naked, lateral ramus with eleven articles, inner with eight; second pleopod rami with ten and nine articles respectively; peduncle of third pleopod with two mid medial and two distolateral setae, rami of ten and eight articles respectively. *Uropods*: first uropod peduncle with three dorsomedial setae including the apical seta and four dorsolateral and one apicolateral setae, the outer ramus with two basomedial and two lateral robust setae, the inner with three medial and one lateral robust setae, each with four apical robust setae; second uropod peduncle with two dorsolateral and one apicolateral robust setae, and one dorsomedial and one apicomedial robust setae, each with four apical robust setae; third uropod parviramous, peduncle with three latero- and two mediodistal robust setae and four setae basal to the inner ramus; inner ramus short with only a single apical robust seta; outer ramus proximal article with transverse lateral robust seta groups 2-2-2-2-3 and three distolateral robust setae, the medial margin with 2-3-2-2-2-2 and five distomedial robust setae, distal article with a pair of small apical spinules, ratio of lengths of articles; peduncle 20, outer ramus proximal article 62, distal 8, inner ramus 10. *Telson*: similar to male, both lobes with two rather than three apical robust setae; lateral penicillate setules at M0.6.

Distribution

Bullio Cave, cave 2W2, Wombeyan Cave system, New South Wales, 34°19' S, 149°59' E

3.3.5 *Jasptorus* n. gen.

Etymology

Named for the type locality and the lumpy sternal gills; *torus* (Latin) protuberance or bulge.

Type species

Jasptorus solepti n.sp.

Diagnosis

Eyes absent; the first antenna long, peduncle article one subequal with article two, calceoli present on peduncle and flagellum; second antenna peduncle longer than flagellum, calceoli present on flagellum. Second article of mandibular palp relatively short and poorly setose, setae of the third article BCDE. Inner plate of the first maxilla with two apical plumose setae, outer plate with nine robust setae, distal robust setae of the right palp articulated not fused. Coxae one to four sparsely setose ventrally; robust setae at the corner of the palm of both gnathopods four or more, palmar robust setae not crowded or bifid; dactyls of pereopods without additional facial setules; coxal gill seven absent, sternal gills on segments two to six, and lumpy, not fully dendritic. Epimera without post ventral teeth or facial robust setae or setae near the ventral margin. First uropod without an elongate robust seta at the apico-medial corner; both rami of first and second uropods with one robust seta row each, the third uropod strongly extended and without plumose setae. Telson of moderate length, cleft about 56%, the lobes moderately tumid, with only apical spination.

Additional description

Accessory blades (rakers) on mandibles with interraker plumose setae; additional penicillate setae beyond rakers and riding onto base of molar, with ragged bent molarial setae and pappose seta. Lower lip uniform, inner lobes absent,. Both plates of maxilla two with long apical setae; inner plate of maxilla one and outer plate of maxilla two covered with pubescence. Maxillipedal inner plate with a distal row of few plumose setae and two blunt naked robust setae, a medial baso-facial to mid-facial row of five plumose setae and a pair of blunt naked tooth like robust setae; palp articles two and three naked laterally, well setose medially, article three with two pairs of non-comb robust setae near the base of the dactyl, the apex produced and rugose, the dactyl rugose. Dactyls of gnathopods without recumbent

inner tooth like robust seta, with stiff spinules at the inner nail articulation, with additional spinules along the inner dactylar margin. Pleopods similar; peduncles bearing few setae, rami extending equally. Ventrodistal robust seta on urosomite one at the base of uropod one moderate to long.

Relationship

This genus bears lumpy sternal gills, a characteristic of *Wesniphargus* and is closest to that genus among the family. However, *Jasptorus* differs from *Wesniphargus* in: absence of eyes; shorter first peduncular article of the first antenna; sparse rather than moderate setation of the second article of the mandibular palp; asymmetry of the palp of the first maxillae; coxa one tapers apically, and the third coxa ovate rather than sub rectangular; propodi of gnathopods expanded apically, bearing posterior rugosities; palmar robust setae lacking triggers; second articles of pereopods five to seven moderately or weakly expanded posteriorly; third uropod distinctly parviramous, the outer ramus strongly extended and without medial plumose setae; telson cleft 56% rather than 85% and basally tumid. *Jasptorus* differs from *Tasniphargus* in the absence of eyes and of long dense setae and elongate basal flagellar articles on the first antenna, the presence of calceoli (on both antennae), presence of B and absence of A setae on the third article of the mandibular palp, nine rather than seven robust setae on the outer plate of the first maxilla; absence of triggers on palmar robust setae; coxal gill six not significantly reduced, sternal gills not dendritic; epimera without post-ventral teeth; clear asymmetry of rami of uropods one and two; telson slightly tumid laterally. *Jasptorus* differs from *Neoniphargus* in the absence of eyes; sternal gills not dendritic; inner plate of first maxilla not ovate; dactyl of maxillipedal palp rugose as well as apex; palmar robust setae without triggers; corner robust setae of palms four or more rather than six or more; pereopods elongate and slender; disto-dorsal robust setae of peduncles of uropods one and two sub apical; rami of uropods asymmetric, with few marginal robust setae; lobes of telson tumid basally. *Jasptorus* differs from *Yulia* in the absence of eyes; lack of long dense antennal setae; first antenna flagellar articles equal, not fused; C setae present on mandibular palp; inner plate of first maxilla with two rather than four apical setae; coxae poorly setose ventrally; robust setae of palmar corners four rather than eight; palmar robust setae not dense, bifid or with triggers; coxa seven without gill; sternal gills lumpy rather than

dendritic; peduncles of pleopods with no or very few setae; rami of uropods one and two unequal; third uropod strongly extended; telson moderately tumid.

3.3.5.1 *Jasptorus solepti* n.sp. Figs. 3.117 - 3.119

Etymology

Named for the slender form of the body: *soma* body, *leptos* thin.

Type locality

Cave WJ-10, Wee Jasper, New South Wales, 35°07'S, 148°41' E.

Material examined

Holotype (Australian Museum P51372) male 'a' 6.5mm., other specimen in type series; male 'b' 5mm.

Diagnosis

As in the genus.

Description of holotype (male 'a')

Body: pleon with few dorsal arms, pleonites one to four with few setae, five and six with one dorsolateral robust seta each, length 6.5mm. *Head*: rostrum small, eyes absent, lateral cephalic lobes prominent, antennal sinus moderate. *First antenna*: length 0.8x body, 2.2x the second antenna, the peduncle shorter than the flagellum - 64:151 - with sparse setae; ratio of lengths of peduncular articles 10:9:6; flagellum of twenty five uniform (excepting article three which is short), sparsely setulate articles; calceoli present on peduncle article three and flagellum articles 1,2,6,8,10, aesthetascs present on most flagellar articles; accessory flagellum two articulate reaching slightly beyond the end of article one of the primary flagellum. *Second antenna*: length 0.36x body; peduncle 1.2x the flagellum, articles four and five subequal - 22:23 - and articles three to five with moderate ventral setation; flagellum of eight articles, weakly setose ventrally, calceoli present on articles one to five. *Left mandible*: palp relative lengths of articles 8:17:21; article three longer than two, weakly falcate, with 1B3C21D5E setae, the second article bearing three inner marginal setae; incisor with four teeth and fine facial setae; lacinia mobilis with 2 weak teeth and an area of fine baso-facial setae; accessory blades of three chisel robust setae and four plumose interraker setae; molar triturative with a long

posterior pappose seta. *Right mandible*: palp relative lengths of articles 8:23:27; third article longer than the second with 1B5C20D4E setae; incisor with four teeth; lacinia mobilis bifid, the anterior arm denticulate, the posterior with three teeth and an area of fine facial setules; two accessory blades (rakers), two plumose inter rakers, and three plumose and three hooked brushy setae onto the base of the molar; molar triturative without a posterior pappose seta. *Maxillae*. Left first maxilla: palp article two with four submarginal mediodistal slender robust setae - three terminally armed and one naked - two armed and one naked distofacial robust setae and one distolateral plumose seta; outer plate with nine denticulate terminal robust setae and two short, slender, naked setae at the medio distal corner; inner plate with two apical plumose setae and one small naked medio distal seta. Right first maxilla: palp article two with five thick medio-distal to apical robust setae articulated to the segment, one apico-lateral thin robust seta and one apico-lateral rastellate seta; inner plate with two plumose apical setae. Second maxilla: outer plate with a small disto-lateral spinule; inner plate with two medio-distal (almost medial) plumose setae. *Maxilliped*: palp article three with a row of thin setae on the inner margin, outer apex with three slender setae, apex face with two pairs of slender setae, dactyl with two medial and two sub terminal robust setae adjacent the nail, the apex strongly produced and rugose, as is the dactylar face; inner plate with two thick tooth like apical robust setae, several plumose and simple setae, and a row of medial sub-marginal plumose setae; outer plate with five baso-medial slender setae, a row of naked tooth like robust setae medial sub marginal to mid disto-facial, two distal plumose setae and a lateral sub marginal row of fine simple setae; peduncle bearing a pair of ventro-facial long setae basal to the inner plate. *First gnathopod*: coxal plate with a single post-ventral seta only; article three with a small posterior rugose hump; article four with a moderate rugose hump; carpus short, strongly lobate and rugose, the lobe rounded and without setae; propodus trapezoidal, slightly longer than wide, posterior angle rounded, anteriorly prominent and rugose, the palmar corner marked by one medial and a long and two short lateral robust setae without bifurcations or triggers, the palm slightly oblique and convex, dactylus reaching to the corner robust setae, robust setae along the palm simple, not crowded. *Second gnathopod*: slightly larger than the first, coxa bearing two apical setae, and a sac like gill; rugose carpal lobe larger than the first; rugose lobes of articles two to four smaller; posterior rugose lobe of the propodus more expanded than on the first

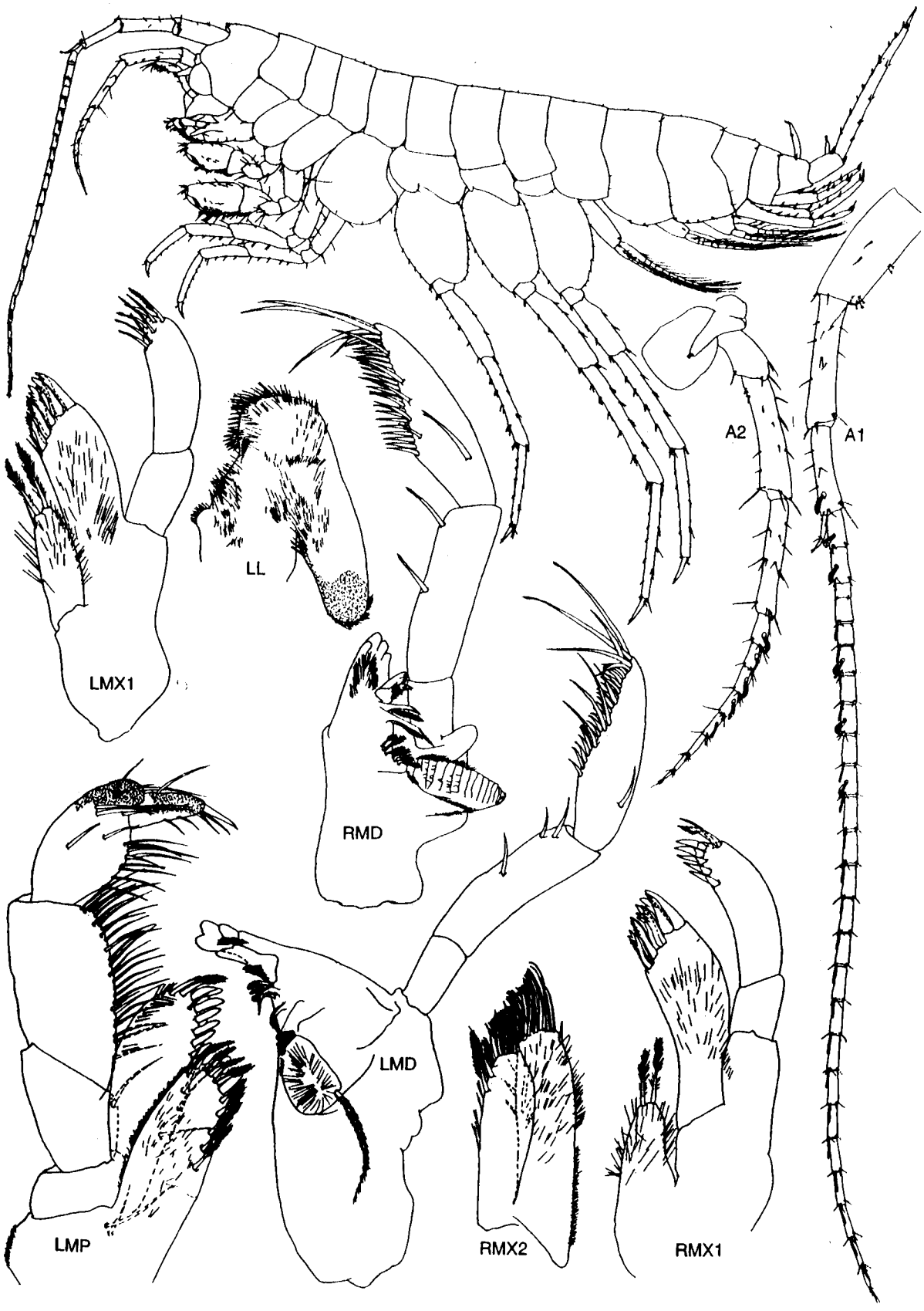

Fig. 3.117. *Jasptorus solepti* n. sp. holotype male 'a' 6.5mm; whole, antennae, mouthparts.

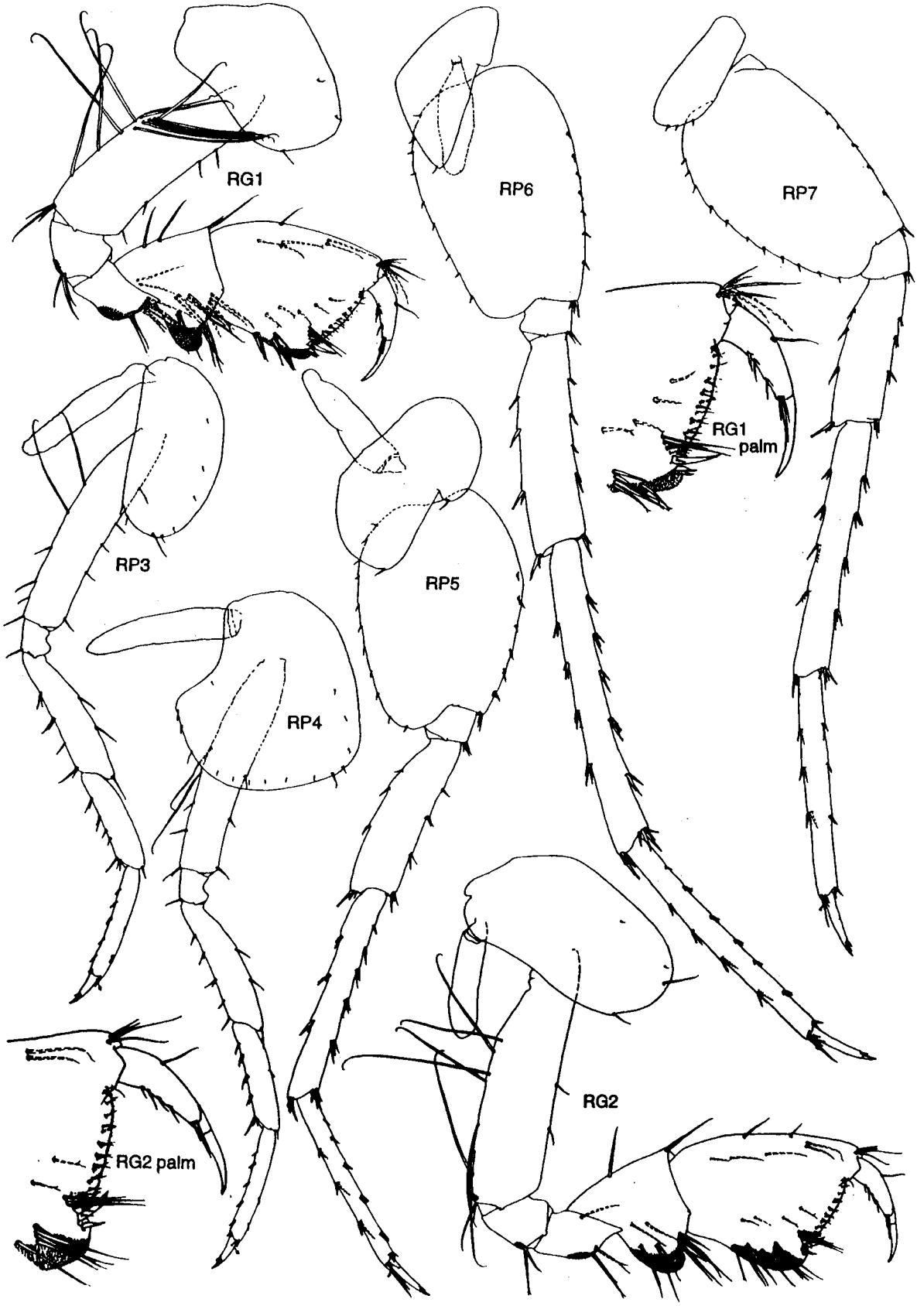

Fig. 3.118. *Jasptorus solepti* n. sp. holotype male 'a' 6.5mm; legs.

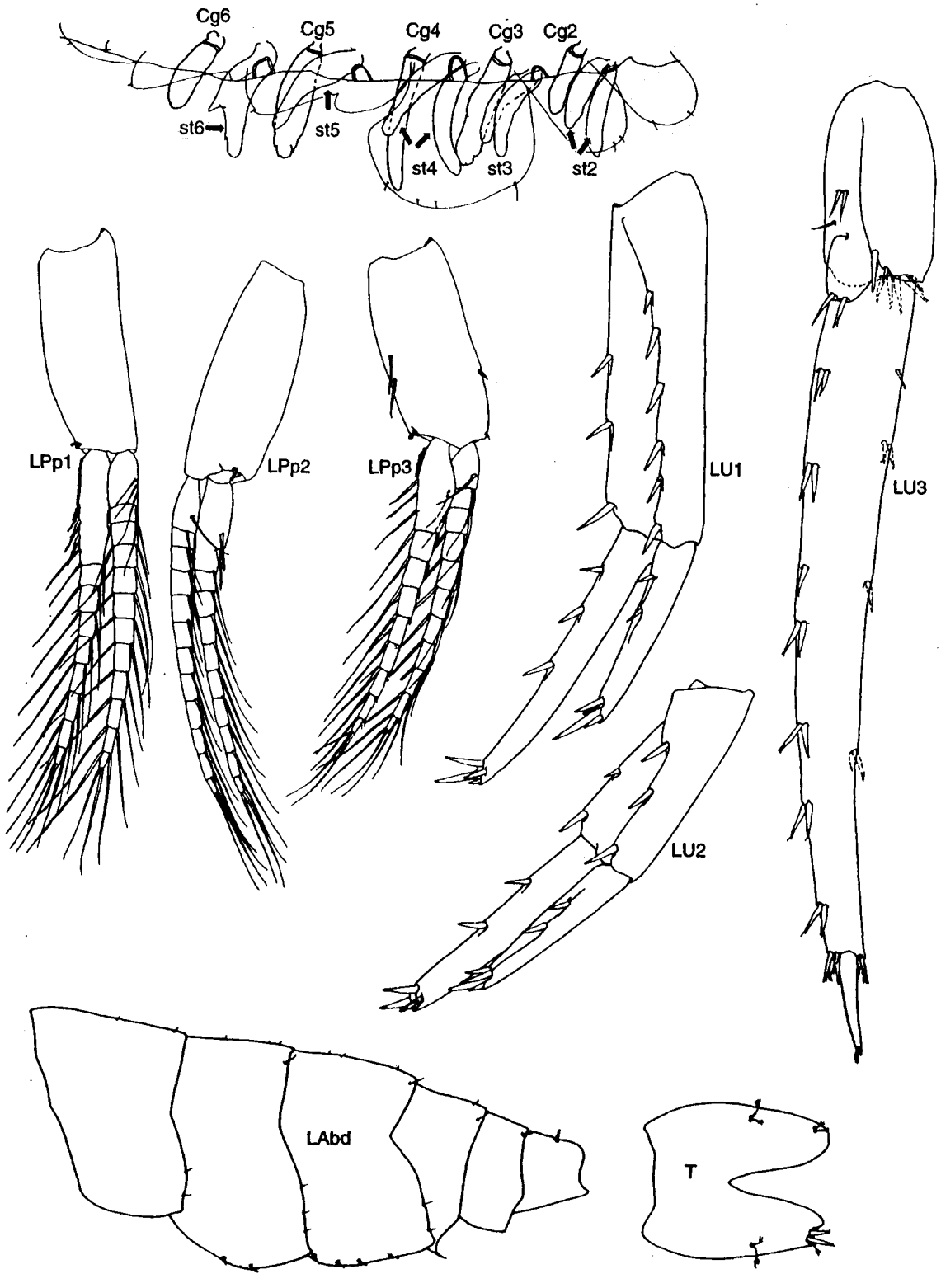

Fig. 3.119. *Jasptorus solepti* n. sp. holotype male 'a' 6.5mm; abdomen, gills, pleopods, uropods, telson.

gnathopod, the palmar corner marked by long and short lateral and medial robust setae, dactylus not reaching the palmar corner; the palm lined with simple setae. *Pereopods*: coxa three with few short and long apical setae; coxa four deeply emarginate with three anteroventral setae, one ventro-facial posterior seta, and several facial setules; pereopods three and four subequal, longer than the second gnathopod, articles four and five posteriorly spinose, articles six with 2-2-2-2-2 and 1-2-2-2-2 robust setae respectively; pereopods five to seven similar, coxae with 1-1-3 robust setae on the ventral margins of the posterior lobes, the second article of each moderately expanded posteriorly (P5>P6>P7), with short sparse marginal setae and a moderate postero ventral lobe, posterior margins of propodi lacking long setae except for baso-dactylar setae, dactyls without accessory setules apart from the usual one medial and facial setules. *Gills*: coxae two to six bearing simple sac like gills, coxa seven without gill; sternal plates two to six each with a pair of lumpy, incipiently dendritic gills attached to the anterior lateral edge of each segment. *Epimera*: without post ventral teeth, although each slightly acuminate; posterior margins moderately convex, with 2-3-2 setae; with 0-2-4 ventro-facial robust setae. *Urosomite one*: with a short robust seta at the base of uropod one. *Pleon*: pleonites one to four with few dorsal armaments; pleonite five with a single post lateral robust seta, pleonite six with one mid dorsal robust seta. *Pleopods*: similar, each with two retinaculae and no accessory retinaculae; peduncle of pleopod three only with two medial and two facial setae; rami with 12-9, 12-10, 11-9 lateral and medial articles. *Uropods*: third uropod extending well beyond uropods one and two in the intact specimen; lengths relative to uropod one - uropod two 0.64x, uropod three 1.54x: first uropod peduncle approximately equal to the third urosomite, length 1.9x lateral ramus, 1.2x medial ramus, the outer margin with a single sub-apical robust seta and a row of five short robust setae, the inner margin with a row of two short robust setae and a single distal robust seta; rami of unequal lengths, medial 1.3x lateral, both with a single row of dorsal robust setae - the lateral ramus with two lateral setae, the medial ramus with 3 medial setae- and each with four apical robust setae; second uropod peduncle 0.9x inner ramus, 1.2x outer ramus, with three short dorso-lateral and two short dorso-medial robust setae, the outer ramus shorter than the inner - 27:36 - both with only one row of short robust setae - lateral ramus with two lateral robust setae and medial ramus with two medial robust setae, each with four apical robust setae; peduncle of the third uropod 0.26x

length of outer ramus, as long as urosomite three, with three medio-facial setae, two medio-distal robust setae basal to the inner ramus, and a distal transverse lateral row of five robust setae; proximal article of the outer ramus with four transverse lateral robust seta rows of 1-2-1-1 robust setae, seven transverse medial rows of 2-2-1-2-2-2-2 robust setae and terminal lateral and medial rows of three and four robust setae basal to the distal article; distal article with three small terminal setules; inner ramus length 0.09x outer, with two apical setae only. *Telson*: moderate length, equal to urosomite three, the length 1.1x width; cleft 56%; apices with two short setae set in a notch on the left side, no robust setae or notch on the right, but a pair of sub terminal penicillate setules; lobes moderately tumid, with paired dorsolateral penicillate setules at M0.6 on either lobe.

Description of male 'b'

Body: length 5mm. Similar to male 'a', except in the following - *First antenna*: left peduncle third article with mediodistal calceolus; accessory flagellum of two articles, extending to M0.8 of the second article of the primary flagellum; primary flagellum of twenty one articles, with aesthetascs on articles five to twenty one; right primary flagellum of nineteen articles. *Second antenna*: left flagellum of seven articles with calceoli present on articles one to four; right flagellum of seven articles, with calceoli on articles three to five. *Mandibles*: both mandibular palp articles three with setae 1B3C11D3E. *Pleopods*: left first pleopod rami with four medial and five lateral articles; right first pleopod with seven and eight articles respectively; second pleopod with 7-8 and 9-7 articles respectively; third pleopod with 6-8 and 6-8 articles respectively. *Uropods*: peduncle of first uropod with three dorsolateral and one apicolateral and two dorsomedial and one apicomedial robust setae; outer ramus with one medial and one lateral robust setae; inner ramus with two medial and one lateral robust setae, both rami with four apical robust setae; peduncle of second uropod bearing one dorsolateral and one apicodorsal, tow dorsomedial and one apicomedial robust setae; outer ramus with one each medial and lateral robust setae, inner ramus with two each medial and lateral robust setae. *Epimera*: second epimeron with one rather than two facial robust setae near the ventral margin.

Distribution

Cave WJ10, Wee Jasper, New South Wales, 35°07'S, 148°41' E.

3.3.6 *Neoniphargus* Stebbing

Neoniphargus Stebbing, 1899: 424.

Unimelita Sayce, 1901: 237-238.

Type species

Neoniphargus thomsoni Stebbing, 1899 (= *Niphargus montanus* Thomson, 1893, a homonym).

Relationship

For generic diagnosis, additional description, keys and discussion of relationships see Williams and Barnard (1988: 123-125).

Composition

This genus contains seven species. We here describe a further three species.

3.3.6.1 *Neoniphargus coolemanensis* n.sp. Figs. 3.120 - 3.122

Etymology

Named for the type locality.

Type locality

First water trap, Murray Cave (cave CP3), Cooleman Plain, Kosciusko National Park, New South Wales, 35°22'S, 149°03'E.

Material examined

Holotype (Australian Museum P51373) female, 6mm. Collected by S. Eberhard, 20 January, 1994.

Diagnosis

Female only: first peduncular article of the first antenna longer than the second; second antenna without calceoli; second article of the mandibular palp longer than the third, and moderately sotose, setae of the third article BCDE; palmar corners of gnathopods without special medial robust setae; fourth coxa deeply emarginate, dactyls of pereopods three to seven multi spinous medially, articles four to six of pereopods three to seven moderately setose, with elongate basodactylar setae on legs five to seven, anterior margins of sixth article with 1-4-4 transverse robust seta sets (as well as locking robust setae); coxae five to seven with 1-1-3 weak robust

setae on the posterior lobe. Coxae two to seven bearing gills, the seventh reduced; lumpy to barely dendritic gills present on sternal plates two to six. Epimera without facial armaments, or post ventral teeth; third uropod extends slightly beyond uropods one and two in the whole animal; robust setae of uropods one and two all short; peduncle of uropod three 0.6x the length of the outer ramus; robust setae of outer ramus arranged in sets of 2-3-3 lateral, 1-2 medial, with no plumose setae; inner ramus bearing one apical robust seta, and no facial setae. Telson cleft about 60%, each lobe bearing three apical robust setae and a dorsal pair of robust setae.

Description of holotype (female)

Body: pleon with few setal dorsal armaments, the urosomite three bearing two pairs of dorsal robust setae, pleonites with few dorsal setae, length 6mm. *Head*: small, eyes small. *First antenna*: length 0.5x body, 1.4x the second antenna, peduncle less than the length of the flagellum, ratio of lengths of articles 50:33:23, setae sparse, calceoli and aesthetascs absent; accessory flagellum two articulate, extending to M0.2 of the second article of the primary flagellum; primary flagellum of nineteen uniform articles with very sparse setation. *Second antenna*: length 0.3x body, peduncle longer than the flagellum - 1.5x, articles four and five subequal, articles three to five with moderate ventral setation, flagellum with nine articles, weakly setose ventrally, calceoli absent. *Left mandible*: palp of three articles, ratio of lengths of articles 10:32:24, article two with ten inner marginal setae, article three weakly falcate, with 1B3C11D5E setae; incisor with five teeth; lacinia mobilis with three teeth; accessory blades of three chisel robust setae, three plumose robust setae; molar triturative, bearing a single brushy anterior seta and short posterior pappose seta. *Right mandible*: palp article two with twelve medial setae, article three with 2B2C10D5E setae; incisor with five teeth; lacinia mobilis bifid and denticulate; two accessory blades and two inter-raker plumose setae; molar bearing long posterior pappose seta. *Maxillae*. First maxillae: second article of the palp of the left first maxilla with six thin apical robust setae and two sub terminal facial setae; outer plate with nine robust setae, most denticulate; inner plate with two plumose apical setae; right first maxilla palp article two with four thick apico-medial robust setae articulated to the segment, one apicolateral thin robust seta and three thin ventro facial robust setae; outer plate with ten apical denticulate robust setae; inner plate with two plumose apical setae. Second maxilla: both plates with curved apical setae; inner plate with two medial sub apical plumose setae; outer plate with two

Fig. 3.120. *Neoniphargus coolemanensis* n. sp. holotype female 6mm; whole, antenna, mouthparts.

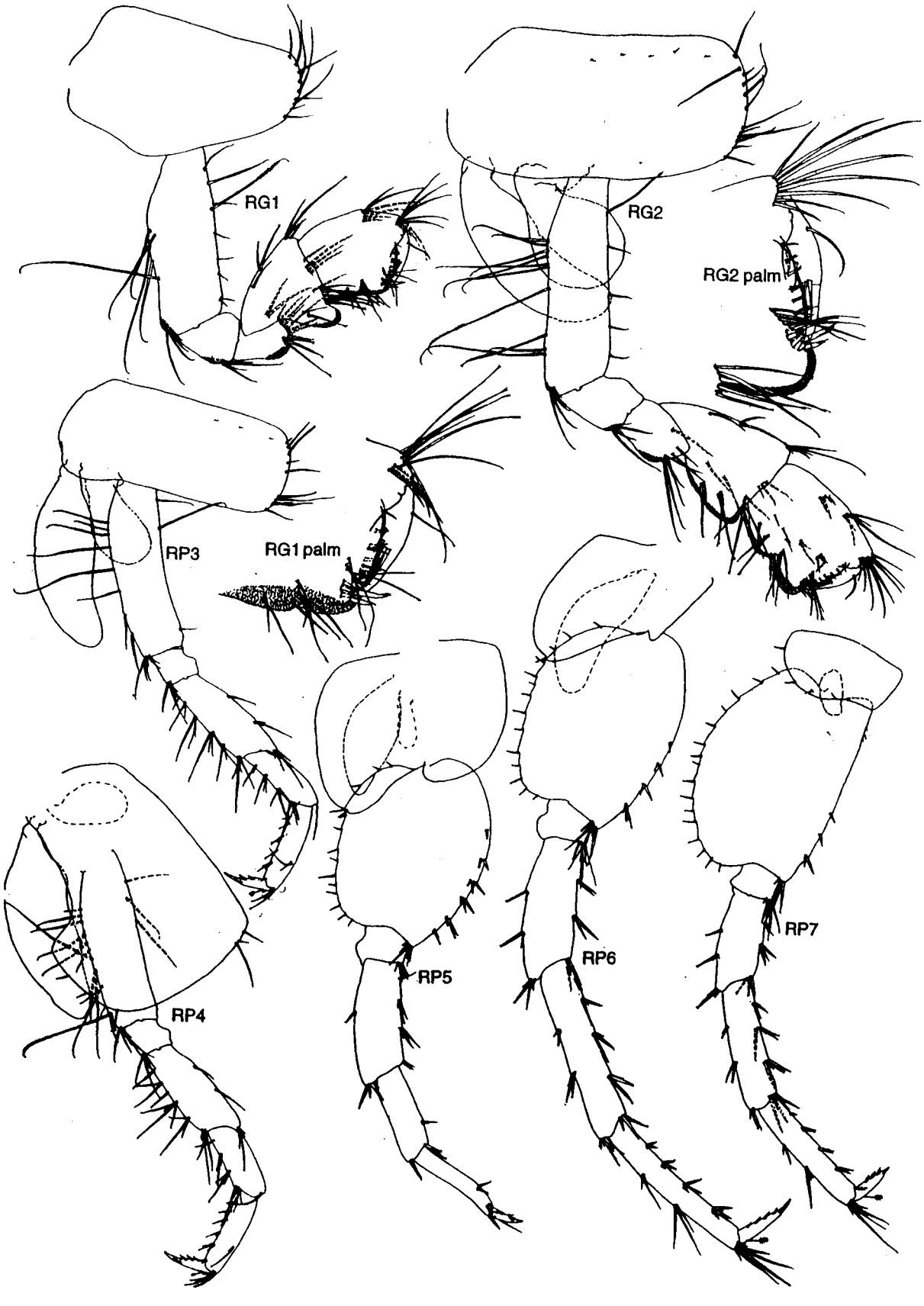

Fig. 3.121. *Neoniphargus coolemanensis* n. sp. holotype female 6mm; legs.

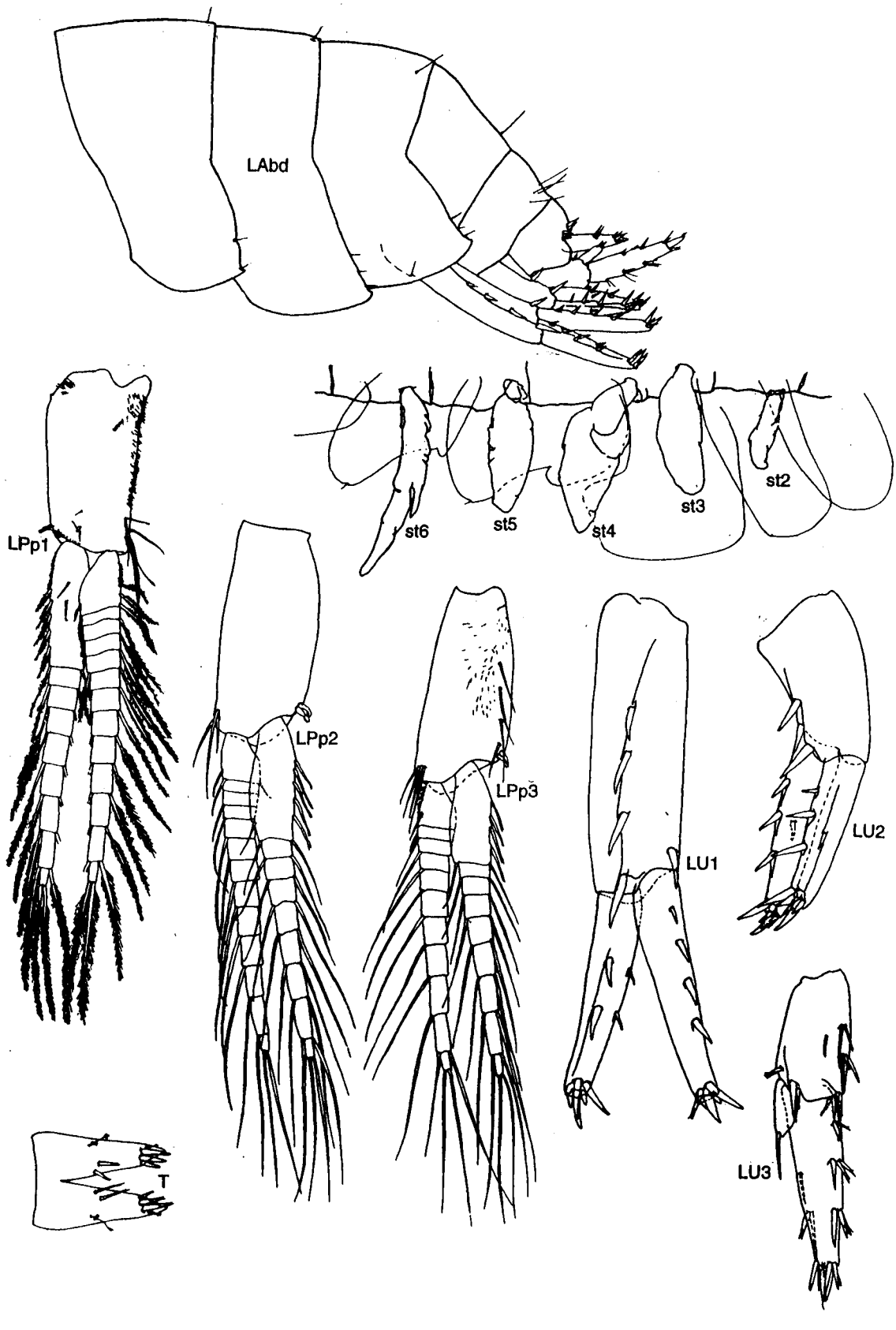

Fig. 3.122. *Neoniphargus coolemanensis* n. sp. holotype female 6mm; abdomen, gills, pleopods, uropods, telson.

subdistal naked lateral setae. *Maxilliped*: palp articles two and three with ranks of setae on the inner margin and sub marginal face, and a few distolateral setae, apex of article three strongly produced and bearing rugosities, dactyl with four accessory spinules on the inner margin, and disto-facially rugose; inner plate apex with three thick tooth like robust setae, two plumose setae and a naked seta, a submarginal medial row of five plumose setae, but no ventrofacial robust seta; outer plate with a medial oblique row of moderate to long naked robust setae disto-facially, a row of six facio-medial to disto-medial naked tooth like robust setae, apically a naked tooth like robust seta and armed tooth like robust seta, two raker setae and one plumose seta, and three slender disto lateral setae. *First gnathopod*: coxal plate tapering apically, with an apical rows of moderate length setae; articles two and three each bearing a small rugose posterior lobe; articles four to six with strong rugose lobes; carpus shorter than propodus, posterior lobe well developed, rugose, rounded and not setose apically; propodus trapezoidal, slightly longer than wide, bearing paired posterior rugose lobes, corner of the palm with three short medial robust setae and two strong, armed lateral robust setae; palm transverse, slightly convex, with moderate numbers of non-bifid robust setae, dactylus reaching the palmar corner robust setae. *Second gnathopod*: larger than the first; coxa sparsely setose apically bearing a sack like gill and a broad, naked oostegite; carpal lobe longer and more keel like than the first; propodus with a distinct pair of rugose lobes larger than in the first, palmar corner with three short medial and two long lateral robust setae, dactylus reaching the palmar corner robust setae, palm transverse, slightly convex, bearing moderate numbers of simple robust setae. *Pereopods*: coxa three with an apical sparse row of moderate length setae; coxa four deeply emarginate with three anteroventral setae and four posterior setae; pereopods three and four longer than the second gnathopod, subequal in length, articles four and five spinose posteriorly, articles six with robust seta formula 1-1-2-2-3 and 1-1-3-2-3, respectively; pereopods five to seven similar, coxae bearing 1-1-3 weak robust setae on the posterior lobe, articles two expanded posteriorly (P5<P6<P7), and slightly to moderately lobate post ventrally, with short and moderately slender posterior setae, propodus of leg five naked posteriorly, of six and seven with sparse short and long setae, long setae present at the bases of the dactyls of pereopods six and seven; dactyls three to seven each with several accessory setules (2-3-1-4-3) on the inner margin; coxae two to five each bearing an oostegite. *Gills*: coxae two to seven each

with a simple sac like gill, that of coxa seven reduced; sternal plates two to six bearing budded or partially dendritic gills attached on the anterior lateral edge of each. *Epimera*: without post ventral teeth, the posterior margins slightly convex on E1, straight on E2 and concave on E3; all without ventral robust setae; posterior setae sparse - 2,3,3. *Pleon*: pleonites one to five with few dorsal setae or robust setae; pleonite six bearing a pair of dorsal and a pair of dorso-lateral robust setae basal to the telson. *Pleopods*: with two retinacula each, no accessory retinacula, the peduncles each with several setae; rami of nine medial articles each and 13-13-11 lateral articles respectively. *Uropods*: third uropod extending slightly beyond the first and second in the whole animal, uropod lengths relative to the first - uropod two 0.7x, uropod three 0.6x. First uropod: peduncle length 1.2x the medial ramus, 1.5x lateral ramus, outer margin with one apico-distal robust seta and a row of short dorsal robust setae, medial margin with a single apicodistal robust seta; rami of unequal lengths, lateral ramus shorter and bearing two reduced rows of marginal robust setae the inner row short; and five apical robust setae; medial ramus with only a medial row of four robust setae, and four apical robust setae. Second uropod: peduncle approximately the same length as the rami, with three moderate length to long dorso-lateral robust setae (including one apical robust seta); outer ramus slightly shorter than the inner, each with two rows of short marginal robust setae, apices with four and five robust setae respectively. Third uropod: parviramous, peduncle length approximately 0.5x outer ramus, as long as urosomite three, bearing two pairs of medial and two groups of dorsal robust setae, as well as a distal row of five robust setae basal to the outer article; outer ramus proximal article with three lateral transverse robust seta rows of 2-3-3 robust setae and an apical group of three robust setae, as well as two medial rows of 1-2 robust setae and a terminal group of three robust setae; distal article with a single small terminal setule; inner ramus short, 0.27x length of outer ramus, with a single moderately long terminal robust seta. *Telson*: short, approximately the same length as urosomite three, length 1.4x width; cleft 77%; apices of each lobe with three sub distal robust setae and a single lateral penicillate setule, two dorsal robust setae medially at M0.4 to M0.5, and a submarginal lateral pair of penicillate setae at M0.4; lobes not tumid.

Relationship

This species differs from others of the genus in: ratio of lengths of peduncular articles of the first antenna 10:6.5:5.4, cf. 10:8:5 to 10:11:6, the second article being reduced; length of the first article of mandibular palp reduced, relative lengths being 8:39:30 cf. 8:25:23 to 8:20:24; robust setae at the palmar corner 5 or 6, rather than 6+; robust setae along the palm are not dense; dactyls of pereopods are multi-spinous, but differ from *N. spenceri;* robust setae of the inner rami of first and second uropods are reduced to one row; telson cleft 80% rather than 60%; lateral penicillate setules of the telson are at about M0.5 rather than M0.6; plumose setae are absent between rakers and base of the molar. This species keys to *N. spenceri* in Williams and Barnard (1988), but differs in: the small size of eyes; shorter first antenna; longer accessory flagellum; longer second antenna; mandibular palp second article more setose medially, third article with fewer BC setae and more E setae; second article of first maxilla with nine or ten robust setae, rather than seven; inner plate of maxilliped with three rather than two apical robust setae, but fewer plumose setae; first gnathopod coxa moderately setose apically, the fourth article with a moderate posterior rugose hump, articles two and three also with posterior rugosities and small hump, carpus moderately long, almost as long as propodus, propodus with fewer lateral corner robust setae, the palm slightly convex; pereopods generally less spinous, dactyls bearing 2, 3, 1, 4, 3 accessory spinules; sternal gills are not fully dendritic; epimera without post ventral teeth; uropod three not as strongly extended; telson longer than wide, cleft 77% rather than 56%, fewer dorsal robust setae, lateral penicillate setules more basal. This species differs from *N. secus* in: possessing eyes; the body more robust, and coxal plates longer; accessory flagellum is longer than the first article of the primary flagellum; flagellum of the second antenna is of nine rather than seven articles; the second article of the mandibular palp is more setose medially; coxae one to three are moderately setose distally; carpus of the second gnathopod relatively long; dactyls of pereopods multi spinous; coxa seven bears a small gill; sternal gills are less dendritic; third uropod is only slightly extended beyond uropods one and two; telson is more slender and more deeply cleft and bearing additional dorsal robust setae, the penicillate setules more basal. *N. coolemanensis* differs from *N. richardi* in: possessing eyes; the body is less slender; coxal plates larger; flagellum of second antenna longer; second article of mandibular palp bearing more setae; mandibular

palp more spinous, the inner plate less pubescent; carpus of second gnathopod relatively longer; dactyls of pereopods multi spinous; coxa seven with a small gill; sternal gills less dendritic; third uropod shorter; telson slender and not tumid, with dorsal robust setae as well as more apical robust setae.

Distribution

Murray Cave (cave CP3), Cooleman Plain, Kosciusko National Park, New South Wales, 35°22'S, 149°03'E.

3.3.6.2 *Neoniphargus secus* n.sp. Figs. 3.123 - 3.125

Etymology

From *secus* L.; otherwise or different.

Type locality

Gurangah Cave (Cave 321), Wombeyan Cave system, New South Wales, 34°19'S, 149°59'E.

Material examined

Holotype (Australian Museum P51374) female 'a' 8mm, Paratype (Australian Museum P51375) female 'b' 5mm, three other small females in the type series. Collected by S.Eberhard, 17 March, 1993.

Diagnosis

Article one of the peduncle of first antenna slightly longer than article two, calceoli absent from both antennae, mandibular palp article two longer than article three with very few setae (3R2L ventral, 1L1R dorsal), BCDE setae present on article three. The fourth coxa moderately emarginate, dactyls of legs three to seven with only one medial and one facial spinules, legs five to seven , articles four to six without slender setae except for a few short basodactylar setae, and articles six anterior margins with one, five and four robust seta sets respectively, coxae five to seven with 3,1,2 weak robust setae on the posterior lobe. Gills present on coxae two to six, and dendritic sternal gills present on sternites two to six. Epimeron three only bearing ventrofacial robust setae. Uropod three extends well beyond uropods one and two in the intact specimen, all robust setae of uropods one and two short, the peduncle of uropod three 0.3x the length of the outer ramus, which bears robust setae arranged in rows both laterally (1-2-2-3) and medially (2-3-2-2), without

plumose setae; the inner ramus with a single apical robust seta, lacking other arms. The telson cleft 40%, each lobe bearing three sub apical robust setae only.

Description

Body: pleon not armed dorsally, with few setae, pleonites five and six bearing no dorsal robust setae, length 8mm. *Head*: rostrum small, eyes absent. *First antenna*: length 0.5x body, 2.3x the second, flagellum of nineteen articles, peduncle shorter than the flagellum, ratio of lengths 10:8:6, setae sparse, calceoli absent, aesthetascs present on flagellum articles two to eighteen, flagellar segments uniform, sparsely setulate; accessory flagellum two articulate, equal to article one of the primary flagellum. *Second antenna*: length 0.25x body, peduncle 1.7x the flagellum, articles four and five subequal, articles three to five moderately setate ventrally, flagellum seven articulate, weakly setulose, without calceoli, but bearing small aesthetascs on flagellar articles two to six. *Left mandible*: palp article three shorter than article two, weakly falcate, almost linear, bearing 2B3C9D4E setae, article two with two medial and one lateral setae; incisor with five teeth; lacinia mobilis with four teeth; accessory blades of three chisel robust setae with four interraker plumose setae plus five additional plumose setae beyond the rakers onto the base of the molar; molar bearing moderate posterior pappose seta without brushy basal setae. *Right mandible*: palp with 2B4C12D5E setae; incisor with five teeth; lacinia mobilis bifid and denticulate; accessory blades of two chisel robust setae and two plumose robust setae plus six additional plumose setae onto the base of the molar; molar bearing a long posterior pappose seta. *Maxillae*: article two of the palp of left first maxilla with four thin apico-medial robust setae, two sub-terminal facial setae and a stout setulate latero-distal robust seta; outer plate with nine mostly denticulate robust setae; inner plate with three apical plumose setae; palp article three of the right first maxilla with a medio-distal row of four stout robust setae, two armed slender facial robust setae and one disto-lateral stout setulate robust seta; the outer plate bearing nine denticulate robust setae, the inner plate two plumose apical setae; both plates of the second maxilla bearing long curved apical setae, outer plate with a single small disto lateral seta, inner plate with two medio distal plumose setae. *Maxilliped*: palp article three with moderate numbers of setae on the inner face, a row of six setae at the base of the dactyl, the apex strongly produced, the lateral face of the article, apex and inner distal face of the dactyl all rugose, dactyl with three accessory spinules on the inner edge, the nail naked; inner plate apex with two

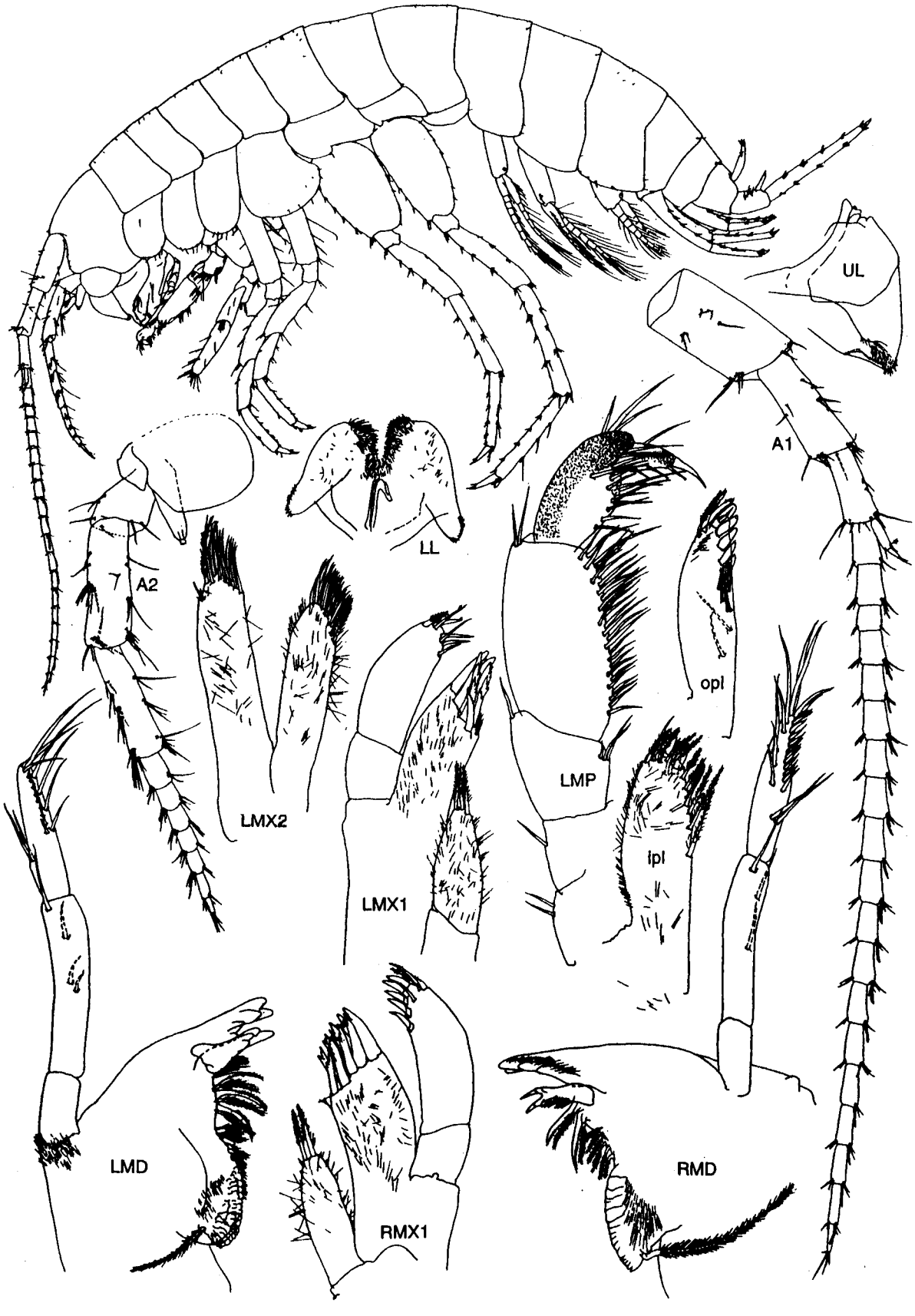

Fig. 3.123. *Neoniphargus secus* n. sp. holotype female 'a' 8mm; whole, antennae, mouthparts.

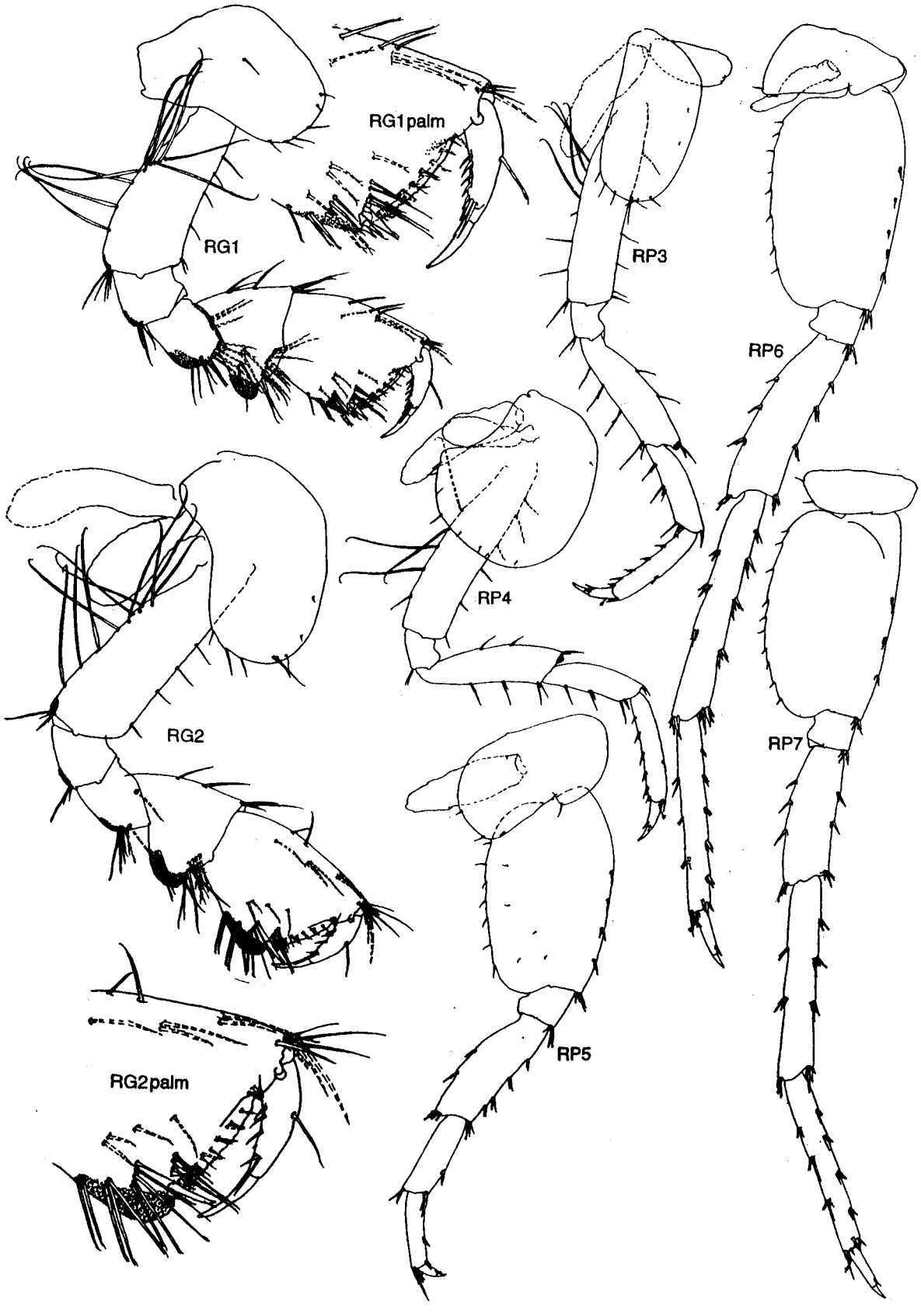

Fig. 3.124. *Neoniphargus secus* n. sp. holotype female 'a' 8mm; legs.

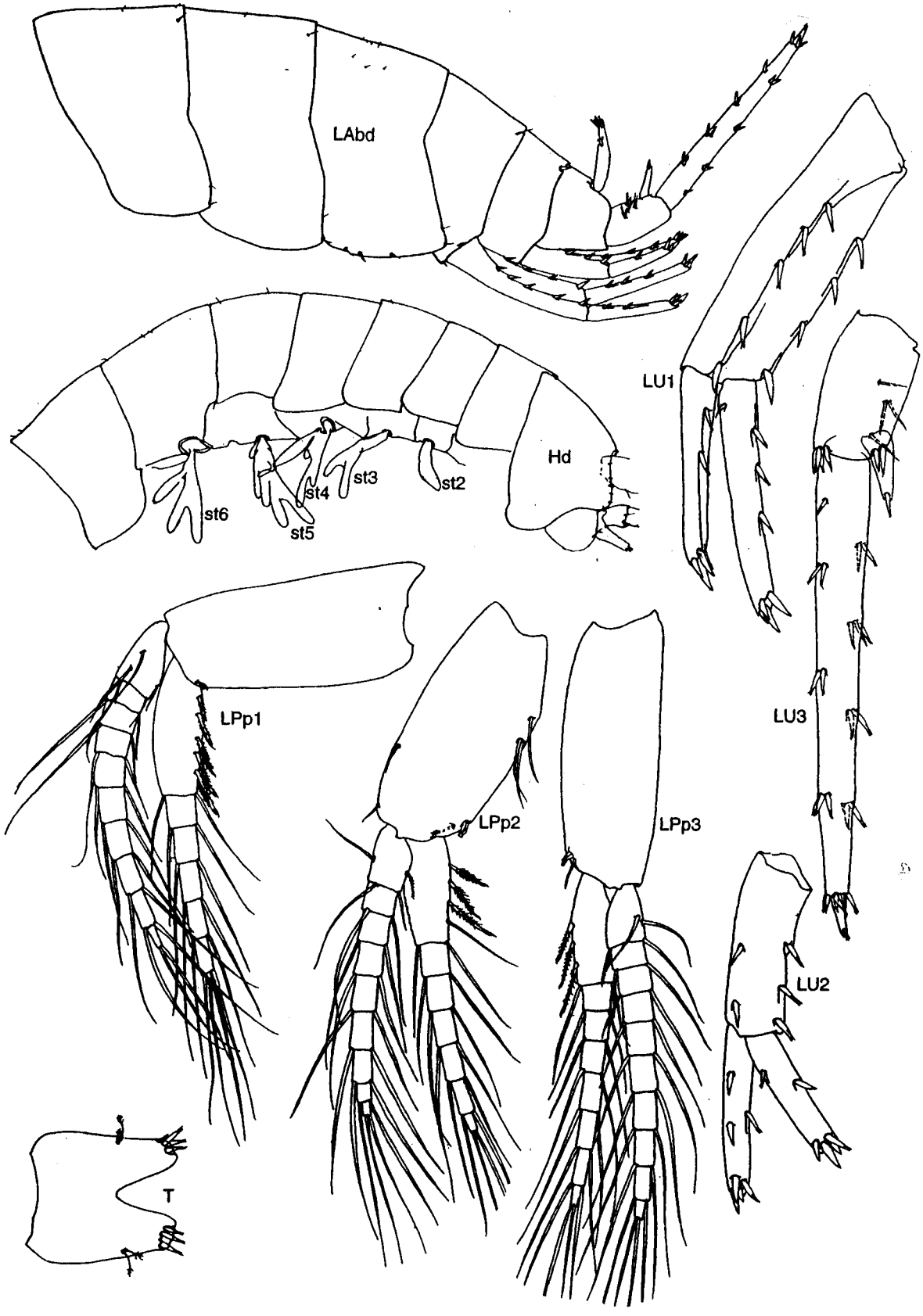

Fig. 3.125. *Neoniphargus secus* n. sp. holotype female 'a' 8mm; abdomen, gills, pleopods, uropods, telson.

facial and one ventral stout, naked tooth like robust setae, five facial and two ventral plumose setae and one naked seta, the inner margin with a row of seven plumose and one naked setae; outer plate with three mid-medial rows of 2, 1, 5 long setae, a disto-facial row of five stout naked tooth like robust setae, one plumose and two rastellate latero-distal robust setae in a row and a small naked apical seta. *First gnathopod*: coxal plate with a sparse apical row of short setae; articles two, three and four with small posterior rugose lobes; carpus short, with a large rugose posterior lobe rounded and not setose apically; propodus trapezoidal, longer than wide, with a distinct rugose palmar corner bearing three lateral and one medial robust seta, the palm transverse to slightly oblique, moderately convex, palmar robust setae simple and not crowded; dactylus reaching the end of the palm, with several accessory spinules along the inner margin, and stiff spinules near the inner nail articulation. *Second gnathopod*: larger than the first; coxa bearing few apical setae, a sac like gill and broad oostegite; articles two to four bearing small posterior rugose lobes; carpal lobe similar to the first gnathopod; palmar corner expanded by presence of a rugose lobe, corner robust setae being two short medial and four lateral, the dactyl reaching the inner edge of the lobe, bearing small recumbent inner tooth like robust seta at M0.6. *Pereopods*: coxa three with short sparse apical setae; coxa four moderately emarginate, with four anteroventral setae, without posterior setae; pereopod three subequal with four, longer than the second gnathopod, articles four and five spinose posteriorly, articles six with 2-2-2-2 and 1-2-2-2-2 robust setae respectively; pereopods five to seven similar - five shortest, six longest; coxae five to seven bearing 1,1,2 setae on the posterior lobe, the second article of each expanded posteriorly, slightly to moderately post-ventrally lobate with short posterior setules, posterior margins of the propodi lacking long setae except for long sub-dactylar setae; dactyls of legs three to seven with only a single facial spinule and small medial spinule. *Gills*: simple sac like gills present on coxae two to six; dendritic gills present on sternites two to six, attached to the anterior lateral edge of each. *Epimera*: one to three without post ventral teeth, posterior margins slightly convex to straight, each with two small setae, postero-ventral margin of the third epimeron with three small robust setae. *Pleon*: pleonites one to six with sparse dorsal setation; pleonite five with a single distal dorso-lateral robust seta. *Pleopods*: peduncles each with two retinacula, pleopod one with a single accessory robust seta; peduncles without setation except pleopod three which bears three baso-medial

and two disto-lateral setae; rami with 10-7, 9-7 and 10-8 lateral and medial articles respectively. *Uropods*: third uropod elongate, extending well beyond uropods one and two in the intact specimen, uropod lengths relative to uropod one - uropod two 0.64x, uropod three 1.16x; first uropod peduncle length 1.5x outer ramus, outer margin with one apico-distal robust seta and a row of four short dorsal robust setae, the inner margin with three short robust setae and a moderate length apical robust seta; rami unequal in length (inner ramus 1.2x outer), the inner ramus with two weakly represented rows of short setae, the outer ramus a lateral row only, both rami with four apical robust setae; second uropod peduncle approximately the same length as the inner ramus, longer than the outer ramus, with two medial and three latero-dorsal robust setae; rami each with two poorly represented rows of short marginal robust setae and four apical robust setae; peduncle of the third uropod as long as the third urosomite, 0.3x the length of the outer ramus, bearing four facial setae, two robust setae basal to the inner ramus and a transverse disto-lateral row of four robust setae; outer ramus proximal article with transverse lateral and transverse medial rows of 1-2-2-3 and 2-3-2-2 robust setae respectively, each side with distal clusters of three robust setae; distal article small, 0.1x proximal, with small apical setules; inner ramus small, 0.16x outer ramus, naked except for a single apical seta. *Urosomite one*: at the base of uropod one bearing a small articulated robust seta. *Telson*: short, 1.2x as long as broad; cleft 40%; sub-apices of each lobe bearing three short robust setae, the right lobe with a small additional seta disto-laterally; a pair of dorso-lateral penicillate setules at M0.6 on either lobe

Female 'b'

Length 5.5mm and two other small females. Essentially as for female 'a', with minor differences only.

Relationship

This species differs from others of the genus *Neoniphargus* in that eyes are totally absent; the first article of the mandibular palp is relatively longer; palmar corner robust setae are fewer and palmar robust setae less dense and without triggers; no accessory retinaculum is present but the third pleopod bears an accessory seta adjacent the retinacula; the telson is less cleft. *N. secus* differs from *N. richardi* in: lower lip without posterior rugosities; mandibular palp with more E setae; first maxilla palps with fewer apical teeth; second maxilla more slender; maxilliped palp article three more rugose, outer plate bearing medio-facial comb rows of robust

setae, inner plate with fewer naked apical tooth like robust setae and more medial plumose setae; dactyls of gnathopods bearing more inner accessory spinules, second gnathopod dactyl with small recumbent inner tooth like robust seta; pereopods three and four, article four bearing small antero-distal rugose lobe; pereopod five shorter and less spinose; peduncle of pleopod one without baso-lateral pubescence; urosomite one at the base of uropod one bearing a small rather than moderate to large articulated robust seta; telson cleft 40% rather than 50%, each lobe bearing three apical robust setae rather than one.

Distribution

Gurangah Cave, cave 321, Wombeyan cave system, New South Wales, 34°19'S, 149°59'E.

3.3.6.3 *Neoniphargus richardi* n.sp. Figs. 3.126 - 3.129

Etymology

Named for Richard Williams in recognition of his indirect contribution to amphipod studies.

Type locality

Among tree roots, River Cave Spring (Cave W47) Wombeyan Caves system New South Wales, 34°19'S, 149°59'E.

Material examined

Holotype (Australian Museum P51376) female 'a' 6.5mm, Allotype (Australian Museum P51377) male 'b' 5mm: in the type series; one other female 6.5mm, two juveniles 2.5mm. Collected by S.Eberhard 16 March, 1993.

Diagnosis

Article one of the peduncle of first antenna longer than article two; calceoli present on the second antenna of the male; mandibular palp article two longer than article three, sparsely setose, setae of article three BCDE. Palmar corners of both gnathopods without special medial robust setae. Coxa four deeply emarginate in both sexes. Dactyls of pereopods three to seven with only one facial and one medial setule, legs five to seven without fine setae except for an elongate basodactylar seta on each propodus, propodi bearing 4-4-1 posterior robust seta

sets. Coxae five to seven with only weak robust setae on the posterior lobe. Coxal gills present on legs two to six. Epimera two and three with two and three ventro facial robust setae. Uropods with only short robust setae, the third uropod strongly extended posteriorly beyond the first and second in the whole animal, the peduncle 0.5x the length of the outer ramus, the outer ramus bearing robust setae arranged in multiples in several medial and lateral rows, without plumose medial setae, the second article short; the inner ramus with a single apical robust seta and without facial setae. The telson cleft about 50%, each lobe with single sub apical robust setae and paired lateral penicillate setules at M0.57.

Description of holotype (female "a")

Body: weakly armed dorsally, pleonites one to four with few setae, pleonites five and six with two and three dorsal and dorso lateral strong robust setae, length 6.5mm. *Head*: rostrum small, eyes absent, lateral cephalic lobes strongly projecting, antennal sinus moderate. *First antenna*: long, 0.5x the length of the body, 1.4x the second antenna, peduncles shorter than the flagellum, article one longest, ratio of lengths 30:25:16, calceoli and aesthetascs absent from the female, the accessory flagellum two articulate, extending to M0.9 of article one of the primary flagellum, primary flagellum of seventeen sparsely setose articles- articles three, eight and nine being longer. *Second antenna*: approximately 0.25x body length, peduncle longer than the flagellum - about 1.5x - peduncular articles four and five subequal, articles three to five with moderate ventral setation, the flagellum of nine articles, weakly setose ventrally, calceoli and aesthetascs absent from the female. *Left mandible*: palp of three articles, the second longest, bearing eight inner marginal setae, the third weakly falcate, bearing 2B3C10D3E setae, rugose lobe on the mandible basal to the palp; incisor with five teeth, lacinia mobilis four teeth, accessory blades of three chisel robust setae and three plumose setae, molar bearing a moderate posterior pappose seta, with three brushy basal setae. *Right mandible*: palp article three setae 2B3C10D3E, basal to the palp a rugose lobe; the incisor with four teeth, the lacinia mobilis bifid, denticulate on one face, four teeth and a cluster of fine basal setules on the other; accessory blades of two chisel robust setae and two plumose setae, with three brushy setae leading to the molar, molar triturative, with a long posterior pappose seta. *Maxillae*: left first maxilla palp with four thin apical robust setae and two slender sub terminal facial setae, all armed with spinules or setules; outer plate with five denticulate terminal robust setae, and a small

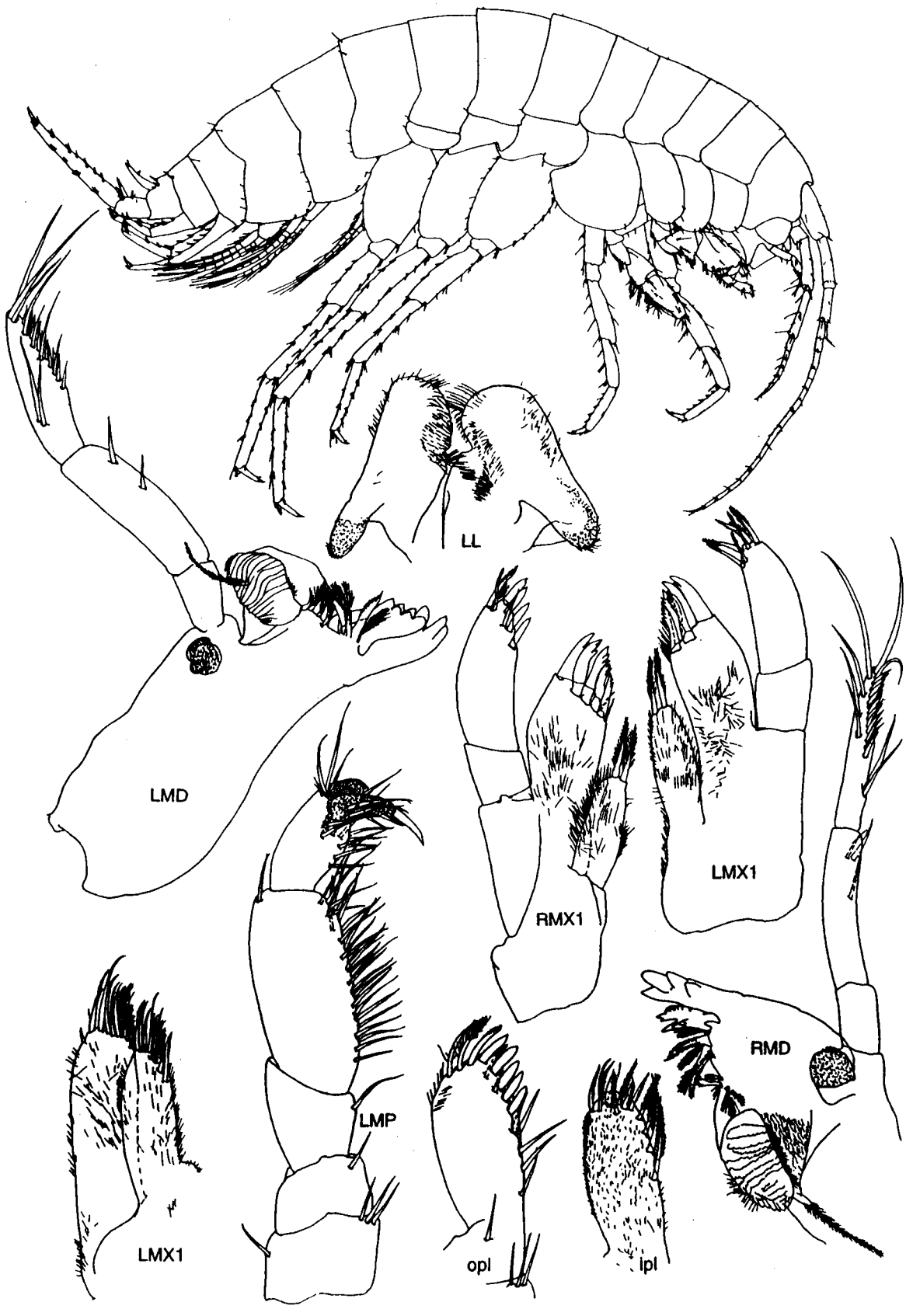

Fig. 3.126. *Neoniphargus richardi* n. sp. holotype female 'a' 6.5mm; whole, mouthparts.

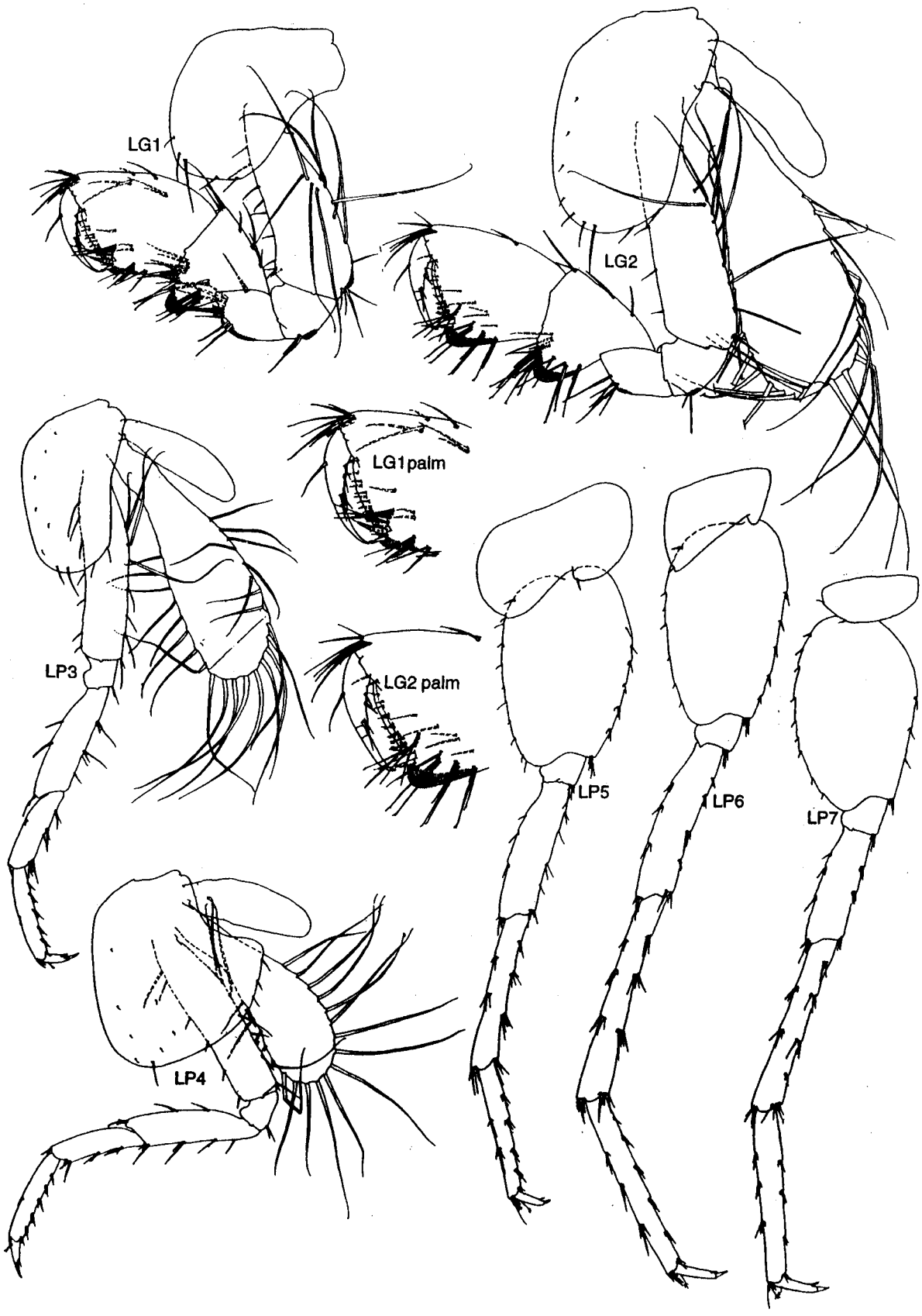

Fig. 3.127. *Neoniphargus richardi* n. sp. holotype female 'a' 6.5mm; legs.

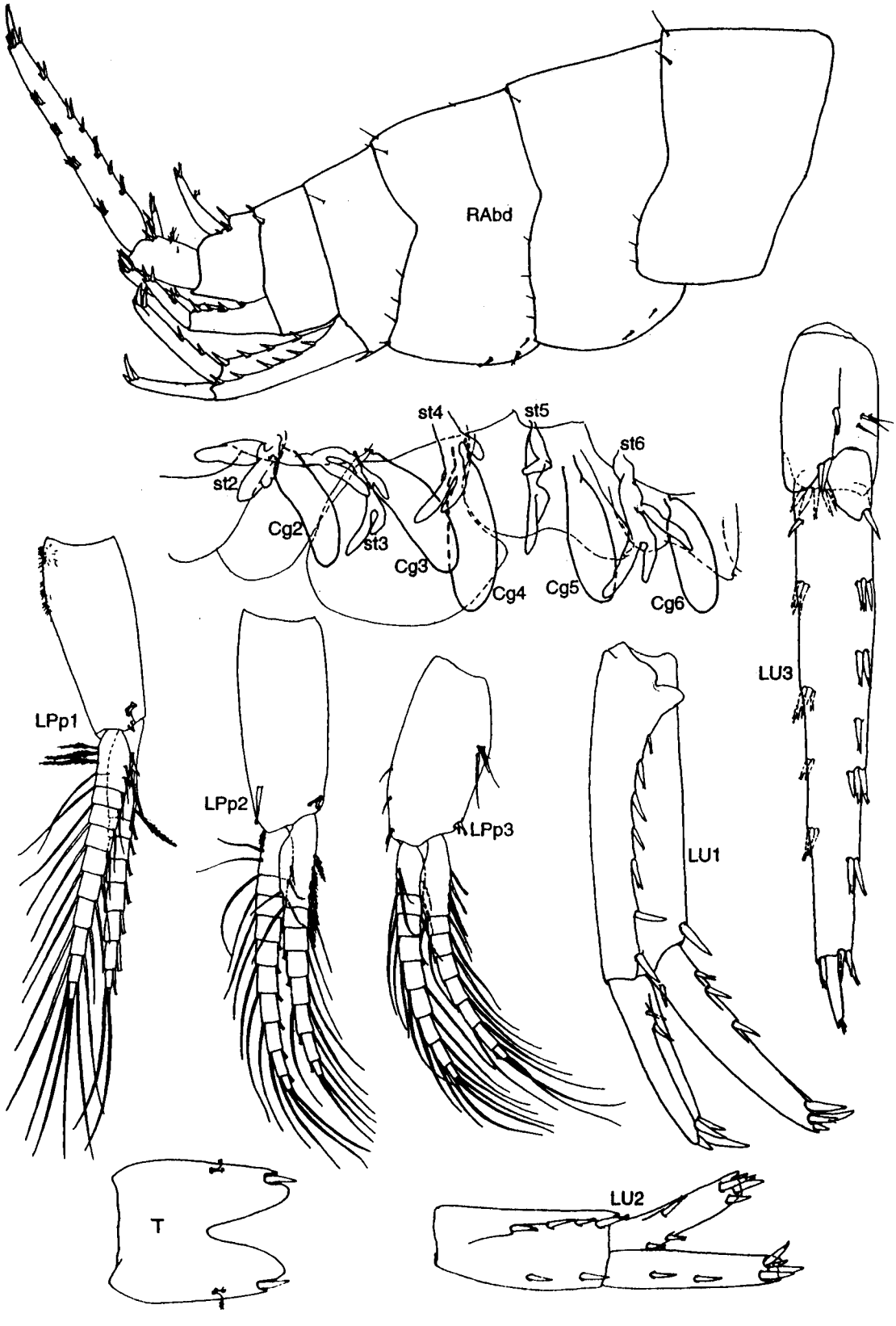

Fig. 3.128. *Neoniphargus richardi* n. sp. holotype female 'a' 6.5mm; abdomen, gills, pleopods, uropods, telson.

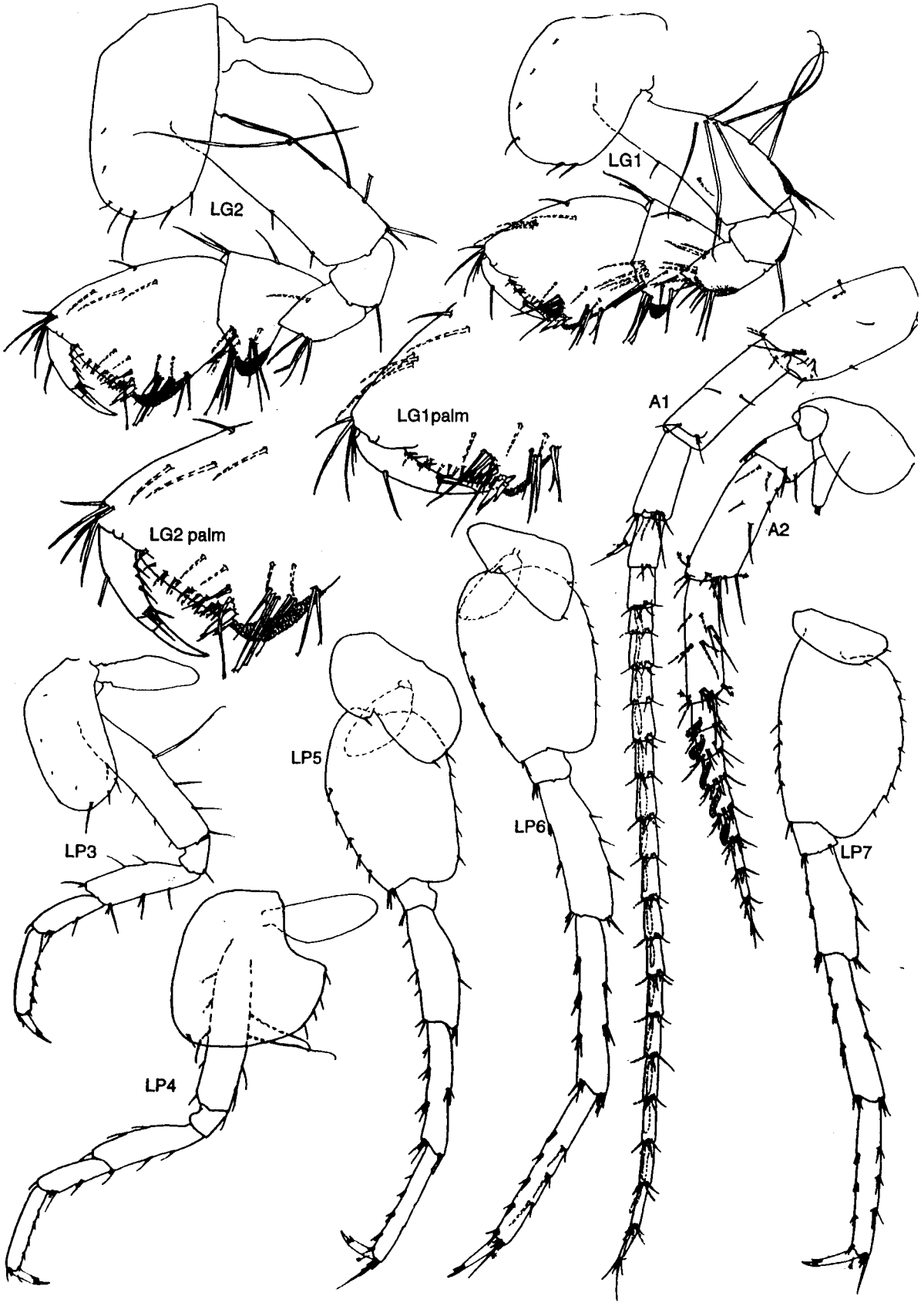

Fig. 3.129. *Neoniphargus richardi* n. sp. allotype male 'b' 5.0mm; antennae, legs.

distomedial area of setules; inner plate bearing two plumose apical setae; right first maxilla palp second article with a medio-distal row of four naked tooth like robust setae, one disto-lateral armed robust seta and two slender facial setae; outer plate with five denticulate robust setae and two disto-medial thin setae; inner plate bearing two plumose apical setae. Second maxilla: both plates with long curved distal setae; outer plate bearing a lateral sub apical short seta; inner plate with two distal medio-facial armed setae. *Maxilliped*: palp third article with stout medial and facial setae and a group of three short and two small apico-lateral setae, apex strongly produced and rugose, dactyl rugose and bearing three accessory spinules, the nail naked; inner plate with three apical naked tooth like robust setae, several plumose and naked setae and a medial marginal row of four plumose setae; outer plate bearing a disto-medial to apical row of five progressively facial robust naked robust setae, an apical group of three slender armed setae, two ventro-facial short setae and a baso-medial row of slender setae. *First gnathopod*: coxal plate with sparse apical setae; articles two to four with small posterior rugose lobes; carpus short, strongly lobate, the lobe rounded, rugose, without apical setae; propodus trapezoidal, longer than wide, the posterior angle rounded and rugose, palmar corner bearing two medial and two lateral robust setae, palm transverse, slightly convex, palmar robust setae simple, dactylus with accessory spinules, and reaching to the palmar corner robust setae. *Second gnathopod*: larger than the first; coxa sparsely setose apically, bearing simple sac like gill and broad long oostegite; articles two to four all bearing small posterior areas of rugosity; carpal lobe broader but not deeper than of the first gnathopod; propodus posterior corner lobate, larger than for the first gnathopod, rugose, the palmar corner with two lateral and one medial stout robust setae, dactylus reaching palmar corner robust setae. *Pereopods*: coxae three and four with few apical setae, coxa four moderately emarginate, both bearing simple sac like gill and broad, long oostegite; pereopods three and four subequal in length, longer than the second gnathopod, articles four and five posteriorly spinose, posterior robust seta formulae of article six are 1-2-2-2-2 and 1-2-2-3-2 respectively; pereopods five to seven similar, leg six longest, coxae with 1,1,2 posterior weak robust setae, coxa seven with no gill, articles two expanded posteriorly, weakly lobate post-ventrally, with small marginal setae, article two of pereopod six slightly narrower; propodi with moderately long baso-dactylar setae. *Gills*: coxae two to six bearing simple sac like gills; sternal plates two to six with

pairs of fleshy, dendritic sternal gills attached to the post lateral to mid lateral of each segment. *Epimera*: second epimeron with a small post-ventral tooth, posterior margins of each convex to slightly sinuous bearing few setae, anterior ventro face of epimera two and three bearing two and three small robust setae. *Pleon*: few dorsal armaments; pleonites five and six with dorsal and dorsolateral robust setae; pleonite six bearing an additional robust seta baso-lateral to the telson. *Pleopods*: similar, each with two retinacula; peduncle one with three small accessory setules, and short baso-lateral pubescence; peduncle two with a single distolateral strong seta; peduncle three with four lateral and four mid medial setae; rami of 10-8, 10-8, 9-8 articles respectively. *Uropods*. Third uropod extending well beyond uropods one and two in the intact specimen; uropod lengths relative to uropod one - uropod two 0.7x, uropod three 1.3x. First uropod: peduncle length 2.3x medial ramus, 2.9x lateral, lateral margin with a distal, sub-apical robust seta, and a dorso-marginal row of six short to moderate length robust setae, the medio-dorsal face with a single sub-apical robust seta; rami unequal, outer ramus with one medial and one lateral robust seta and four apical robust setae; inner ramus with one baso-lateral robust seta, three medial robust setae and four apical robust setae. Second uropod: shorter than the first, peduncle bearing three dorso-lateral and one sub-distal short robust setae, and two medial robust setae; inner ramus longer than outer, with two medial robust setae and four apical robust setae; outer ramus with two medial, one lateral, and four apical robust setae. Third uropod: parviramous, peduncle length 0.3x length of the outer ramus, as long as urosomite three, bearing three dorso-facial robust setae, one mid medial and two medial robust setae basal to the inner ramus, and a disto-lateral row of five robust setae; outer ramus proximal article with four trans-lateral robust seta rows of 3-4-2-3 robust setae and five trans medial robust seta rows of 3-2-1-3-2 robust setae, two medial and three lateral distal robust setae basal to the second article; distal article bearing three small apical setules; inner ramus short, 0.13x outer ramus, with a single apical seta. Urosomite one at the base of uropod one bearing a moderate to large articulated robust seta. *Telson*: short, about the same length as urosomite three, slightly longer than broad; cleft 50%; with a single sub-apical lateral robust seta on either lobe and paired dorso-lateral penicillate setules on either lobe at M0.57.

Description of male 'b'

Body: length 5mm. *First antenna*: peduncle with sparse setae, relative lengths of articles 10:8:5, 0.5x flagellum length; accessory flagellum of two articles, small, reaching to M0.9 of first article of primary flagellum; primary flagellum long, of nineteen articles with sparse setae, aesthetascs present on articles two to nineteen. *Second antenna*: short, 0.5x antenna one; peduncle 1.7x flagellum, articles four and five subequal, with sparse setation; flagellum of eight articles, moderately setate, calceoli present on articles one to five. *Mandibular palp*: left palp article three setae 1B3C11D3E; right palp article three setae 2B4C12D3E. *First gnathopod*: coxal plate with few apical setae and several small anterofacial setae; articles two, three and four with small rugose posterior keels; carpus short, bearing a strong posterior rugose lobe; propodus with small rugose posterior keel; robust setae of palmar corner two medial, two lateral, palm slightly oblique and convex, palmar robust setae moderately crowded and simple; dactyl bearing three inner margin accessory robust setae, nail reaching to palmar corner robust setae. *Second gnathopod*: coxa bearing sac like gill, with few apical or facial setae; articles two to four with tiny post distal rugose keel; carpus with prominent posterior rugose lobe; propodus with moderate to strong rugose posterior lobe, palmar corner with one medial and two lateral robust setae, palm slightly oblique, almost straight, palmar robust setae simple; dactyl with three inner margin accessory robust setae, nail reaching slightly beyond palmar corner robust setae. *Pereopods*: similar to female, except propodi of legs five to seven with long basodactylar setae extending almost to or beyond the dactyl. *Epimera*: without post ventral teeth; with 0, 2, 3 ventrofacial robust setae; posterior margins convex, sinuous, and straight, all weakly setulate. *Pleon*: pleonite five bearing a single dorsolateral robust seta; pleonite six with a dorsal robust seta basal to the telson. *Pleopods*: peduncles each with two retinacula; third peduncle with a small distolateral slender seta and four setae on the mid posterior margin; rami with 5-9, 7-9, 5-8 medial and lateral articles respectively. *Uropods*. First uropod: peduncle with four dorso-lateral and one apico-lateral robust seta, and three dorso-medial and one apico-medial robust seta; medial ramus with two lateral and four apical robust setae; lateral ramus with one lateral and four apical robust setae. Second uropod: peduncle with two latero-dorsal and two apico-lateral robust setae, and one apico-medial robust seta; medial ramus with one lateral, two medial and four apical robust setae; lateral ramus with one

lateral and four apical robust setae. Third uropod: peduncle longer than urosomite three, bearing no marginal robust setae, and two apicolateral robust setae; inner ramus length 0.5x peduncle, 0.15x outer ramus, bearing one apical robust seta; outer ramus of two articles; proximal article length 5x distal, with transverse lateral robust seta rows of 2-2-2 and four distal robust setae, and transverse medial robust seta rows of 1-3-2-2 and one distal robust seta; distal article with one small apical setule. *Telson*: longer than urosomite three; one apical robust seta on either lobe; lateral penicillate setules at M0.6 on either side.

Description of female 'c' (6.5mm), juveniles (2.5mm.)

As for female 'a', without developed oostegites.

Relationship

This species differs from others of the genus in the following ways: eyes absent; outer plate of first maxillae with five denticulate robust setae, rugosities absent from the posterior angle of article four of the second gnathopod of the male; palmar corner of first gnathopod with two or three robust setae rather than six or more; palmar robust setae not dense, or with triggers; the second article of pereopods five to seven least expanded on leg six rather than five; accessory seta present adjacent retinaculum of the first pleopod; one robust seta row on the inner ramus of uropod two; setae absent from the inner margin of the ramus of uropod three; telson cleft 50% rather than 60%.

Differences between *N. richardi*, and *N. coolemanensis* and *N. secus* are set out within discussion of those species.

Distribution

River Cave Spring, cave W47, Wombeyan cave system, New South Wales, 34°19'S, 149°59'E.

3.3.7 *Wesniphargus* Williams and Barnard, 1988

Type species

Neoniphargus nichollsi Straškraba, 1964.

Composition

This genus was monotypic, but a further species, *W. yanchepensis*, from a cave in Western Australia is described here.

Diagnosis

Williams and Barnard (1988) re-examined the incomplete holotype of *W. nichollsi* and provided both a generic diagnosis of *Wesniphargus* and a partial redescription of the type species, *W. nichollsi*, based on this examination and the original description and drawings of Straškraba (1964). Even so, the generic diagnosis was incomplete. The discovery of a further species that can be assigned unequivocally to the genus, and an examination of fresh material that can be assigned to *N. nichollsi*, permits completion of the generic diagnosis with some minor changes.

Pleonites with weak dorsal arms, rostrum small or obsolescent, lateral cephalic lobes weakly to moderately projecting, antennal sinus weak to moderate. Eyes present or absent. First antenna elongate, longer than second, ratio of peduncular articles 10:7:5 to 10:9:5, accessory flagellum two articulate. Second antenna flagellum length equal to or less than length of peduncle, with very large calceoli in male. Ratio of articles of mandibular palp 8:22:22 to 8:28:26, second article moderately setose, article three moderately to barely falcate, setae BCDE. Labium without inner lobes. Maxillae not medially setose on inner plates except in some one or two marginal plumose setae on the second; maxilla one inner plate sub rectangular with two apical plumose setae, the outer plate with seven robust setae, palps weakly asymmetric. Second maxilla inner plate lacking oblique row of facial setae, the apicomedial edge with one plumose medial seta. Maxillipedal palp article three with or without rugose apical lobe, marginally pubescent or bearing fine setae. Coxae one to four elongate, sparsely setose ventrally, coxae one to three lacking a row of posterior robust setae, coxa one subquadrate or tapering below, coxa four emarginate. coxa five much shorter than four. Gnathopods small; carpi shorter in male, lobate; articles four and five with or without rugosities; propodi not expanded apically, palms weakly oblique, lacking rugosities in some, robust setae symmetrically bifid or not, bearing short terminal triggers; robust setae at corner of palm four, with small sub apical triggers; robust setae along palm moderately dense,

with or without triggers. Pereopods three and four, article six, posterior robust seta sets evenly spaced, legs five to seven moderately elongate, articles two of legs five to seven broadly expanded, ovate, post ventrally lobate. Dactyls of legs three to seven with one facial and one marginal setule. Gills borne on coxae two to six, simple sac like, those of five and six slightly reduced in some. Thoracic segments two to six with lateral sternal gills of incipient dendritic form but fingers only small lumps. Pleopods; basomedial setae of inner rami bifid, branches dissimilar, of different length and shape, occasionally one branch of diamond head shape or both simple; two to four retinaculae each peduncle, with or without accessory retinaculae or robust setae. Epimera with small, blunt post ventral extensions, but not forming teeth, some with facial robust setae, with or without setae near the ventral margin, posterior margins weakly setulate. Uropods: apicolateral corner of the peduncle of uropods one and two with one robust seta; outer rami of both uropods one and two shorter than the inner, the margins spinous; uropod one lacking basofacial arms. Uropod three extended, parviramous or magniramous and dispariramous, the peduncle short; outer ramus two articulate, medial setae moderately dense and plumose, article two short to very short; inner ramus short to aequiramous, sparsely setulate or with moderately dense plumose setae. Telson length moderate to elongate, cleft 75 to 85%, the lobes laterally tumid in some, with apical spination or both apical and dorsal robust setae, no major setation, no baso-lateral arms except for a pair of lateral penicillate setules at M0.6 to M0.7 on either side.

Additional Description

Upper lip uniform, rounded below. Accessory blades of mandibles with few interraker plumose setae, several to many additional setae beyond rakers onto the base of the molar, pappose posterior seta on either or both molars. Inner plates of maxillae weakly to moderately pubescent on inner margins. Maxilliped inner plate with distolateral row of one to three plumose setae, with additional robust setae and plumose setae; outer plate with a distal row of few plumose setae, with a medial submarginal row of blunt naked tooth like robust setae and facial robust setae; palp articles two and three poorly setose laterally, article two moderately to strongly setose medially, article three of some with a row of non comb robust setae near the base of the dactyl, the apex slightly produced, rugose in some, marginally pubescent or with fine setae. Gnathopod one without one seta of article four enlarged and robust seta like; dactyls without recumbent inner tooth like robust seta, with stiff

spinules at the inner nail articulation, without additional spinules along the inner dactylar margin. Pleopods similar, peduncles naked, rami extending equally or sub equally. Urosomite one with or without a robust seta of moderate length at the base of uropod one.

3.3.7.1 *Wesniphargus yanchepensis* n.sp. Figs. 3.130 - 3.132

Etymology

Named for the type locality.

Type locality

Yanchep Cave, Western Australia, 31°33'S, 115°41'E.

Material examined

Holotype (WAM 520-97) female 'a', 8mm., Allotype (WAM 521-97) male 'b', 7mm. Also in the type series: juvenile 'c' 4mm.(WAM 522-97), Western Australian Museum, collected by W. F. Humphreys, M. S. Harvey,, C. Rippon, from freshwater pool in limestone cave, with hand net, 19 April,1991, Yanchep Caves, Western Australia, 31°33'S, 115°41'E.

Diagnosis

Pleonites with weak dorsal arms. Head; rostrum obsolescent, lateral cephalic lobes moderately projecting, moderate antennal sinus. Antenna one elongate longer than second antenna, ratio of peduncular articles 4:3:2; accessory flagellum two articulate; second antenna flagellum length less than peduncle. Mandibular palp ratio of articles 7:25:23; article two moderately setose, article three barely falcate, setae BCDE. Labium with no inner lobes. Maxillae not medially setose on inner plates except for two marginal plumose setae on second maxilla at M0.8; first maxilla inner plate sub rectangular, with two apical plumose setae; outer plate with seven denticulate robust setae, palps almost symmetric - left side with thin apical robust setae, right palp with mix of stout and slender robust setae. Second maxilla: inner plate lacking an oblique row of setae on the face, apico-medial margin with two plumose medial setae. Maxilliped: palp article three with a slight apical lobe bearing fine marginal setules. Coxae one to four elongate, sparsely setose ventrally; coxae one to three lacking a row of posterior robust setae; coxa one tapering below; coxa four emarginate; coxa five shorter than coxa four. Gnathopods small, not

sexually dimorphic in the palmar spination, carpi longer in female (0.7-0.8x propodi), lobate; articles four to six of gnathopods bearing post-marginal rugosities; article four of gnathopod one bearing a rugose margin; propodi not expanded apically; palms weakly oblique and convex; robust setae symmetrically bifid, also bearing short terminal triggers; robust setae at corner of palm two long and two short, bifid and with small triggers; robust setae along palm moderately dense with triggers on most. Gnathopod one: propodus posterior margin arms of a single robust seta in tandem, with an additional submarginal transverse row of three robust setae at M0.5. Pereopods three and four article six with posterior robust seta sets evenly spaced; pereopods five to seven moderately elongate; article two broadly expanded, ovate, post ventrally lobate; pereopods three to seven dactyls with one marginal and one facial setule. Oostegites present on female coxae two to four. Coxae two to six with sac like gills; gills five and six not reduced. Thoracic segments two to six with lateral sternal gills; small, lumpy, but not dendritic. Pleopods one to three with baso-medial setae, bifid, branches dissimilar, of differing length and shape, some with one branch of diamond head, this organ borne at about M0.5 of the branch; retinaculae 4-3-3 respectively, accessory retinaculae 0-1-1. Epimera: post-ventrally bearing very small rounded extensions: blunt, without a tooth; none with facial robust setae, without setae near the ventral margin; posterior margins weakly setulate. Uropods; apicolateral corner of peduncle of uropods one and two with one robust seta, with a pair of medio-marginal robust setae at M0.7, and at M0.9; outer rami shorter than inner, margins spinose; uropod one lacking baso-facial arms; all rami with 2 robust seta rows; uropod three extended, magniramous, dispariramous, peduncle short, outer ramus lanceolate, two articulate, medial setae moderately dense and plumose; article two very short, inner ramus dispariramous, lanceolate, with moderately dense plumose medial setae. Telson of moderate length; cleft 75%; lobes moderately tumid laterally, with apical and dorsal spination; no major setation; no baso-lateral arms, except for a pair of lateral penicillate setules at M0.6 on the dorso-lateral face.

Additional characters

Upper lip uniformly rounded below; accessory blades (rakers) usually with few interraker plumose setae; many additional(penicillate) setae beyond rakers onto base of molar; large basal ragged molarial seta on R mandible; no other apical molarial seta. Lower lip uniform, inner lobes absent; medial margins of inner plates

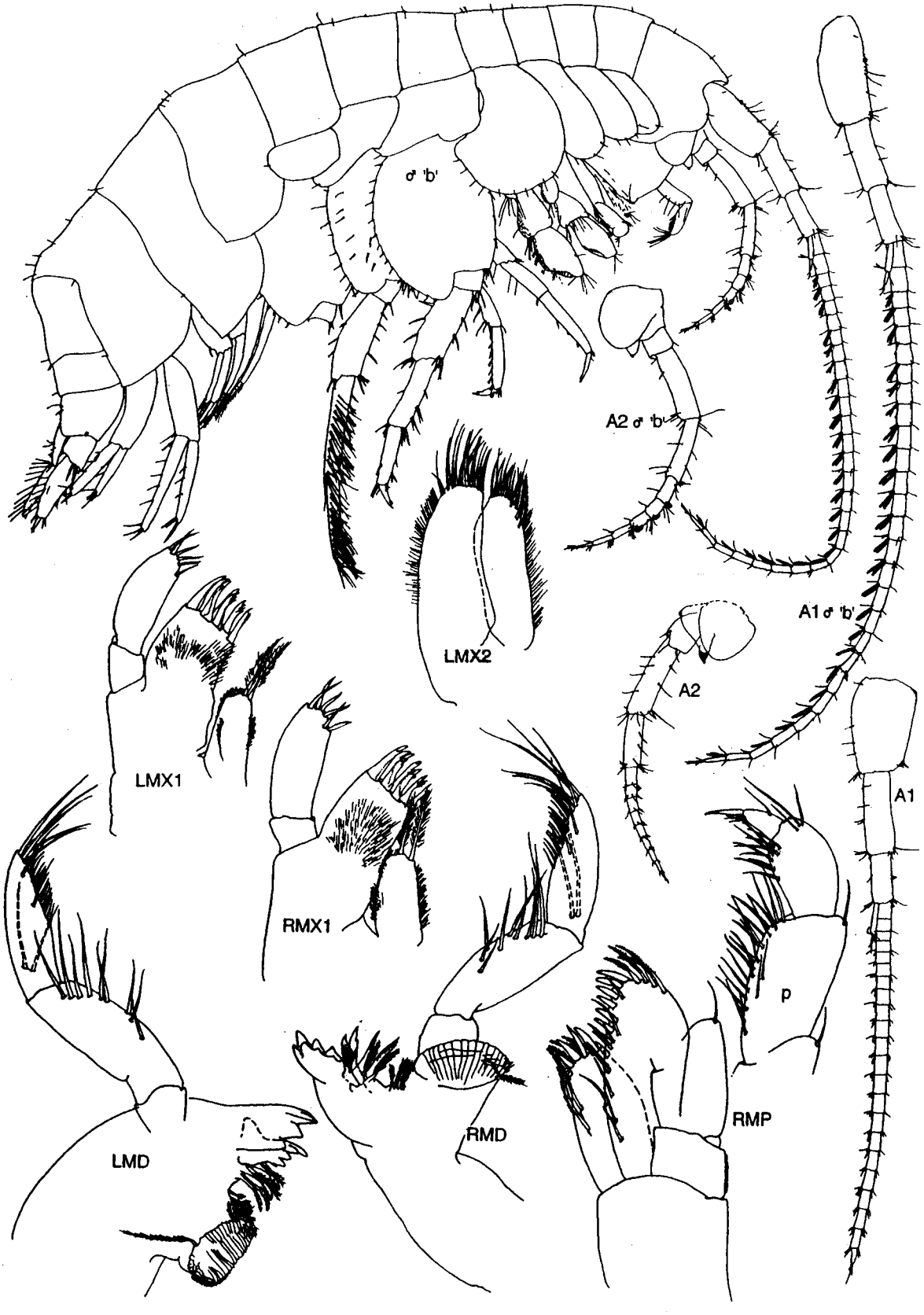

Fig. 3.130. *Wesniphargus yanchepensis* n. sp. holotype female 'a' 8mm; whole, antennae, mouthparts (all drawings except those indicated). Allotype male 'b' 7mm whole specimen, antennae.

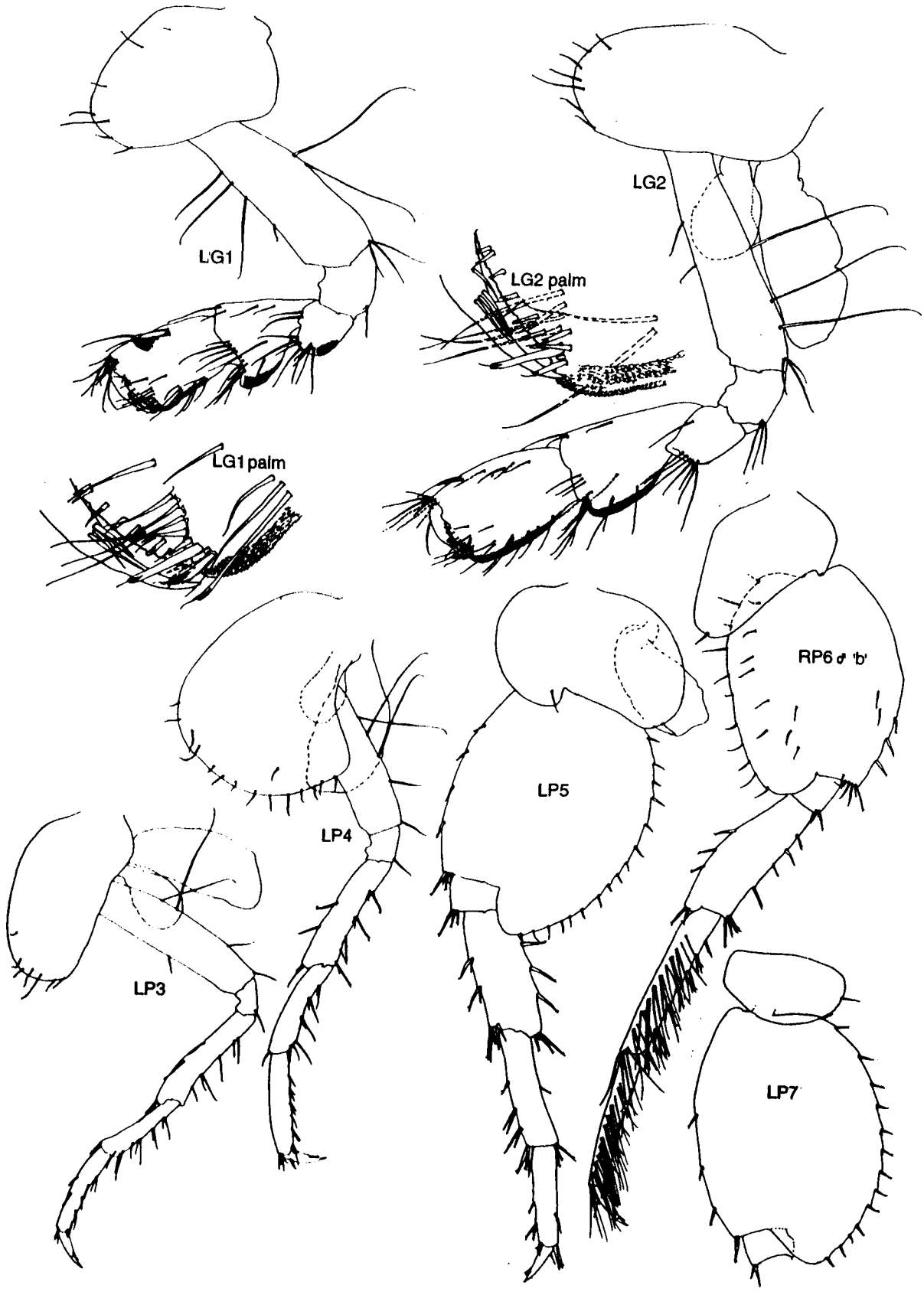

Fig. 3.131. *Wesniphargus yanchepensis* n. sp. holotype female 'a' 8mm; legs (all drawings except those indicated). Allotype male 'b' 7mm R peraeopod six.

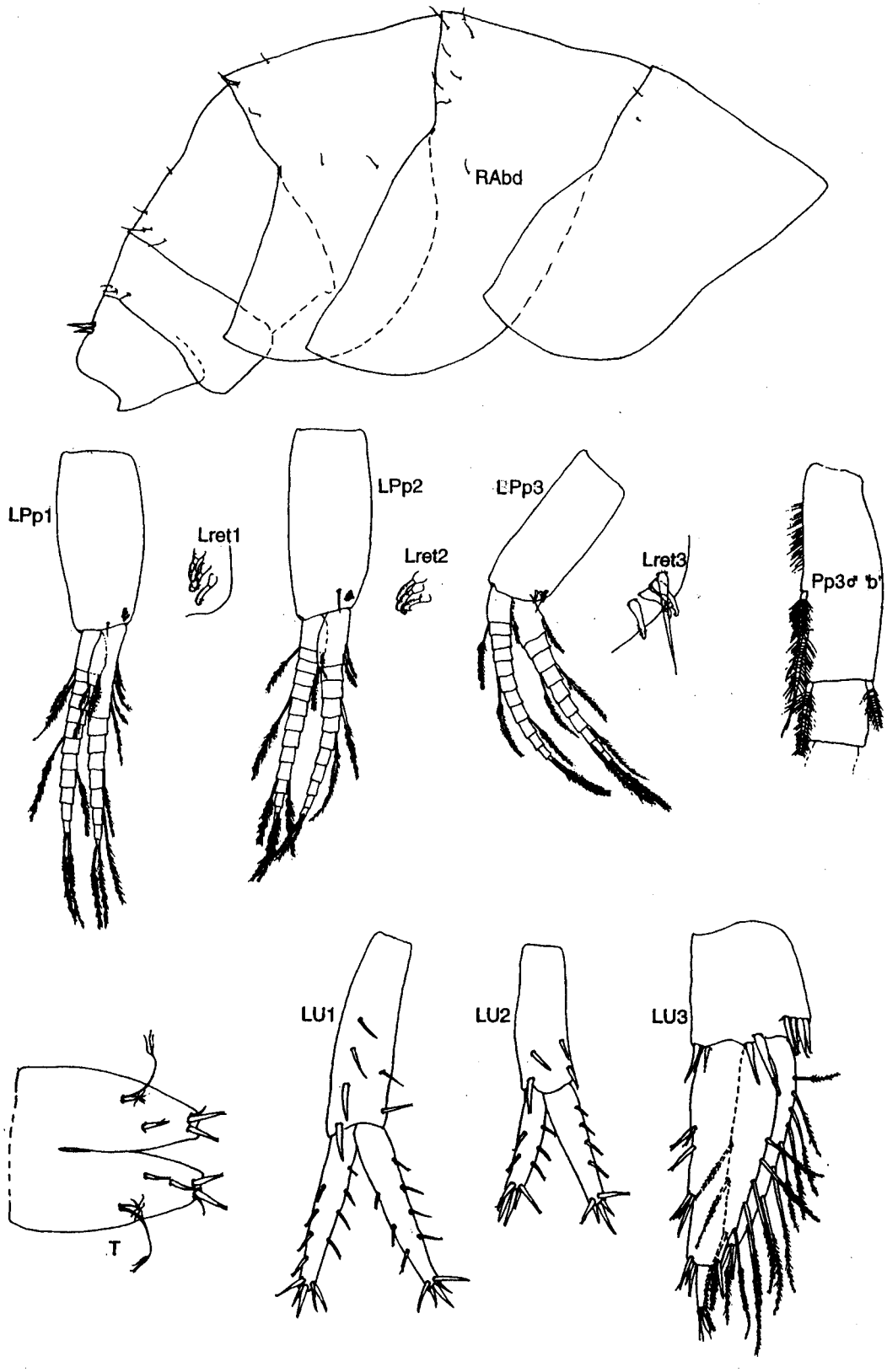

Fig. 3.132. *Wesniphargus yanchepensis* n. sp. holotype female 'a' 8mm; abdomen, gills, pleopods, uropods, telson (all drawings except those indicated). Allotype male 'b' 7mm articles one and two inner ramus, pleopod three.

of maxillae moderately pubescent, both plates with long apical setae; inner plate with three distal plumose setae, apical robust setae and mid-facial plumose setae; outer plate with a distal row of plumose setae, medial sub-marginal teeth and facial robust setae; palp articles two and three poorly setose laterally, basally naked; article two strongly setose medially, article three without a row of non comb robust setae near the dactylar base, apex only slightly produced, not rugose, marginally pubescent or with fine setae. Dactyls without small recumbent inner tooth like robust seta on either gnathopod, with stiff spinules or setules at inner nail artic line, without additional spinules along inner dactylar margin. First gnathopod without seta of the fourth article enlarged and scythe like. Pleopods similar, peduncles naked, rami extending equally. Urosomite one, at the base of uropod one without a robust seta.

Description of holotype (female 'a')

Body: pleon sparsely armed dorsally, few setae on pleonites one to five; moderately setose disto-laterally, pleonite five without robust setae on each side, pleon six with a pair of dorso-lateral robust setae each side, length 8mm. *Head*: rostrum absent, eyes absent. *First antenna* (: length 0.46x body, 1.8x second antenna; peduncle much shorter than flagellum, ratio of lengths of articles 21:18:11 (= 3.8:3.2:2), flagellum of twenty two articles, without aesthetascs or calceoli; articles not uniform, proximal articles three to six shorter than distal articles, article three shortest; sparsely setulate; accessory flagellum two articulate, extending to M0.6 of article three of the primary flagellum. *Second antenna*: length 0.25x body, flagellum of nine articles, the peduncle longer than the flagellum; article four longer than five, articles three to five with sparse ventral setation, without calceoli or aesthetascs. *Upper lip*: apical margin evenly rounded. *Left mandible*: ratio of lengths of palp articles 8:28:26, article two with nine long naked medial to disto-facial setae, article three without pubescence, setae 2B2C14D5E; incisor with four teeth; lacinia four large and one small teeth; three setose accessory blades and three plumose interraker setae, a row of plumose setules leading to base of the molar; molar bearing posterior pappose seta, without other penicillate basal setae. *Right mandible*: incisor with two rows of cusps of four large and three small teeth; lacinia mobilis bifid, both blades acuminate, the medial blade with a medial marginal pair of small teeth at M0.75, the lateral blade bearing weak facial cusps and a row of setae; accessory blades of two rakers and two plumose robust setae; palp article two

bearing nine facial setae; setae of palp article three 2B2C13D6E; molar bearing large posterior pappose seta. *Lower lip*: without inner lobes; bearing slender robust setae apically on outer lobes; facially and marginally pubescent; posterior protuberances also marginally pubescent. *Maxillae*. Left first maxilla: palp article two with five thin apical robust setae and one medio-distal robust seta, without other setae; outer plate with seven robust setae, most denticulate, facially pubescent; inner plate with two apical plumose setae borne on the disto-medial margin, outer distal and inner margins pubescent, with a mid-facial row of pubescence. Right first maxilla: palp article two bearing four slender terminal robust setae and two medio-distal robust setae, one armed on the medial margin with short setules, the other naked, slender; outer plate bearing seven denticulate terminal robust setae, facially pubescent; inner plate with two apical plumose setae, borne on the medial margin; medial and lateral margins as well as a small latero-facial area pubescent. Second maxillae: similar; most robust setae of both plates long, curved; outer plate apex bearing many long, curved robust setae, lateral margins pubescent; inner plate sub-apical medial corner bearing a short row of plumose setae, apex bearing many long, curved setae; medial margin pubescent. *Maxilliped*: palp laterally pubescent basally, articles two and three poorly setose laterally, article two strongly setose medially, article three without comb robust setae basal to the dactyl, the apex slightly produced bearing a few short marginal setules, and a transverse sub-apical facial row of three long setae; inner plate bearing three distal plumose setae, four apical stout naked robust setae, two medial sub-apical robust setae and two facial plumose setae at M0.4 and M0.6; outer plate bearing a disto-lateral row of four plumose setae, a sub-marginal medial row of eight naked tooth like robust setae extending from M0.6 to the mid apex, the medial margin thus robust setae absent beyond M0.6, a discontiguous medio-facial row of eight slender robust setae extending from M0.2 to M0.9 and two slender medial robust setae at M0.4 and M0.55. *First gnathopod*: coxal plate with four slender apical and three facial anterior setae; articles two and three without rugosities; article four with small posterior rugose hump; carpus short, lobate - lobe tilted apically - and rugose; propodus sub rectangular, slightly expanded apically, longer than wide, length to width ratio; 48:33, bearing an anterior facial area of rugosities, palmar corner rounded, with a narrow rugose posterior keel, the corner marked by two medial and two lateral bifid robust setae which also bear short triggers; one lateral robust seta

slightly elongate; palm weakly oblique, slightly convex, dactylus without recumbent inner tooth like robust seta, reaching end of palm. *Second gnathopod*: coxa moderately setose apically, bearing sac like gill and long naked oostegite; articles two and three without posterior rugosities, article four with a small rugose keel; carpus longer than gnathopod one, with a long rugose posterior lobe; propodus longer and narrower than on gnathopod one, length to width ratio; 80:130; posterior margin a long rugose keel; palmar corner rounded, marked by four lateral robust setae; dactyl bearing three stiff setules at inner nail articulation line and a single, more proximal robust seta, reaching slightly beyond the robust setae of the palmar corner. *Pereopods*: coxa three with six apical setae as well as a single anterior seta; coxa four emarginate, ventrally and post-ventrally bearing fourteen setae and one ventro-facial seta; pereopods three and four weakly setose posteriorly, three less setate than four; articles six and seven post-marginal robust seta formulae 3-2-2-2-1 plus 2 locking robust setae and 1-2-2-1-2 plus 3 locking robust setae, respectively; pereopod five article six with few posterior robust setae; pereopod six articles five and six with many robust setae and setae; pereopods three to seven dactyls with one medial and one facial setules; coxa five only with a single ventro-marginal robust seta; coxae six and seven naked ventrally with a single post-ventral robust seta at the posterior corner, coxa seven also with a single posterior robust seta; article two broadly expanded, ovate, lobate post ventrally, with short to moderate posterior setules. *Gills*: coxae two to six with sac like gills, five and six not reduced; sternal plates two to six with pairs of fleshy sternal gills bearing small lumps, of incipient dendritic form, attached between centre and lateral edge of each segment. *Oostegites*: present on female coxae two to five, broadly ovate on coxae two to four, more slender on coxa five; margins without elongate setae. *Epimera*: one to three without post ventral teeth; each with a small blunt protrusion, not acuminate, smallest on epimera three; posterior margins almost straight, without ventral robust setae, adjacent each post-ventral margin a single seta dorsal to the margin. *Pleon*: with few dorsal setae or robust setae; dorso-lateral posterior margin of pleonites one to six with setae: 6-11-9-6-4-0, and robust setae: 0-0-0-0-0-2. *Pleopods*: similar, without peduncular arms, with 4,3,3 retinacula and an associated or accessory robust seta; basal setae of inner ramus bifid with similar and dissimilar branches, rami of 12-9, 13-11, 12-11 articles respectively. *Uropods*. Uropod three extending beyond uropods one and two in entire animal. Uropod lengths relative to uropod

one; uropod two = 0.65, uropod three = 1.1; most robust setae of uropods bearing short sub-distal triggers. First uropod: peduncle length 1.1x inner ramus, 1.1 x outer ramus; outer margin without apical robust seta, and with weak row of four dorso-lateral robust setae, the most distal being medio-sub apical; medially 2 weak robust setae; the lateral ramus slightly shorter than medial (35:37); both with two rows of marginal robust setae, both apices with 5 terminal robust setae. Second uropod: peduncle about 1.2x length of inner ramus, with two medial and two lateral dorsal robust setae; outer ramus shorter than inner (22:26), with two rows marginal robust setae; inner ramus without a lateral row of robust setae; apices of both rami with 5 terminal robust setae. Third uropod: peduncle length 0.5x length of first article of outer ramus, 0.75x urosomite three, with a subdistal medial transverse row of four trigger robust setae, a pair of apico-dorsal robust setae, two dorsal and one ventral apico-lateral robust setae; outer ramus proximal article with four lateral trigger robust seta clusters: discontiguous; lateral robust setae proximal to distal 0-2-1-0-3-0-3; medial margin with six plumose setae and one distal robust seta; distal article small, much shorter than proximal (28:133); apex with four sub terminal dorsal short stiff setae; inner ramus length approximately 0.7x length of outer ramus, bearing on the inner margin a row of eight plumose setae; outer margin with three plumose setae; apex with one plumose seta and two trigger robust setae. *Telson*: moderately long, 1.2x length urosomite three; cleft 75% of length; lobes moderately tumid laterally; apex notched, both apices blunt, rounded; dorsal sub-apices each with two large robust setae and a small lateral penicillate setule; a single dorsal robust seta on the right lobe at M0.7, two dorsal robust setae on the left lobe at M0.7 and M0.8; each lobe with a pair of penicillate setules dorsolaterally at M0.6.

Description of allotype (male 'b')

Similar to female except in the following. *Body*: length 7mm. *First antenna*: length 0.67x body, 2.5x second antenna; ratio of lengths of peduncular articles 4:2.5:2; flagellum of twenty seven articles all except basal and ultimate article with aesthetascs; calceoli absent. *Second antenna*: 0.26x body length, flagellum of six articles, without aesthetascs, articles one to three bearing large type nine calceoli. *Mandibles*: left palp article two with five moderate mediodistal setae, article three with setae 1B2C9D4E; right palp article two with five moderate mediodistal setae, article three with setae 2B2C10D4E. *Gnathopods*: carpi short, about 0.5x propodi.

Pleon: pleonites five and six with two disto-lateral robust setae. *Pleopods*: peduncles each with two retinacula, one and three with a single small mediodistal robust seta; rami with 6-9, 8-9, 7-10 medial and lateral articles respectively, inner setae of first article of medial ramus apically bifid. *Uropods*: peduncle of uropod one with three dorso-lateral and two dorso-medial robust setae, margins each with one apical robust seta, outer ramus with three medial, two lateral and five apical robust setae, inner ramus with two medial one lateral and five apical robust setae; peduncle of second uropod with one dorso-medial and one apical robust seta one each side, outer ramus with one lateral, two medial and five apical robust setae, inner ramus with two lateral, two medial and five apical robust setae. *Telson*: slightly longer than urosomite six; two apical robust setae on either lobe plus a dorsal robust seta on each at M0.75, and a pair of lateral penicillate setules at M0.6.

Description of juvenile 'c'

Body: length 4mm. Similar to female 'a'.

Relationship

Wesniphargus yanchepensis differs from *Wesniphargus nichollsi* in: eyes absent; flagellum of first and second antennae with more articles; flagellum of first antenna with paired aesthetascs on several articles; second article of mandibular palp relatively shorter; third article of mandibular palp without pubescence, bearing more E setae; lower lip posteriorly pubescent; palps of first maxilla with fewer setae, and outer plate facially pubescent; third article of maxillipedal palp without rugosities, outer and inner plates bearing more setae; propodi of both gnathopods bearing rugosities; carpus of second gnathopod long; coxae of pereopods five to seven each bearing a post-ventral robust seta; pereopod six, articles five and six bearing many setae; coxal gills five and six not reduced; epimera without post-ventral teeth; pleopods bearing 4,3,3 retinacula (cf. two each); third uropod aequiramous, and bearing medial setae; telson broader and bearing dorsal robust setae additional to paired apical robust setae.

Distribution

Yanchep Cave, Western Australia, 31°33'S, 115°41'E.

3.3.7.2 *Wesniphargus nichollsi* (Straškraba). Figs. 3.133 - 3.137

Diagnosis

As set out by Williams and Barnard, 1988.

Description

As described by Williams and Barnard, 1988.

Material Examined

Western Australian Museum: Female 'a', 5mm. (WAM 523-97) and male 'b', 2.8mm. (WAM 524-97), outflow of Mammoth Cave, Western Australia, 34°03'S, 115°01'E; male 'd', 2.8mm. (WAM 525-97), from a pool of black water beside the Yellingup to Augusta Road near Margaret River, Western Australia, 33°54'S, 115°20'E; all collected by K.Davies, C.M.Austin, B.Knott on 29 August, 1991. This material can be assigned without equivocation to the taxon *W. nichollsi*: it conforms in all essential features to the redescription of this taxon provided by Williams and Barnard (1988). Given the incomplete nature of that redescription (see above), and the provenance of some of the fresh material, the opportunity is taken to fully describe this fresh material.

Description of male 'b'

Body: pleon sparsely armed dorsally; pleonites one to four moderately setose disto-laterally; pleonite five with four lateral robust setae; pleonite six with two lateral robust setae; length 2.8mm. *Head*: rostrum absent; eyes large, dark, reniform. *First antenna*: length 0.45x body, 1.8x antenna two, peduncle much shorter than flagellum, ratio of lengths of articles 10:7:5, flagellum of fifteen articles, without calceoli, articles 3-11 and 14-15 each with one aesthetasc, articles not uniform, proximal articles shorter than distal, article three shortest; accessory flagellum two articulate, extending to M0.5 of the second article of the primary flagellum. *Second antenna*: length 0.25x body; peduncle longer than flagellum, article four longer than five, articles three to five with sparse ventral setation; left flagellum six articulate, right five, weakly setose ventrally, bearing giant calceoli on articles one to four of the left flagellum, articles one to three of the right, and distal aesthetascs on antepenultimate and ultimate articles of each. *Upper lip:* apical margin rounded evenly. *Left mandible*: palp article three shorter than two, ratio of lengths 8:35:20, article two with long ventrofacial setae and mid-marginal pubescence; article three short, falcate, ventro-basally pubescent, setae 0C6D6E; incisor six toothed; lacinia

mobilis with five teeth; three setose accessory blades and two plumose interraker setae, several brushy setae onto the base of the molar. *Right mandible*: ratio of palp article lengths 8:25:20, article two ventromedially and facially pubescent, bearing two medial marginal and five submarginal to facial long setae; incisor with four teeth, lacinia mobilis bifid, the anterior branch with eleven peg like , terminally rounded denticles and terminating in a tooth, the posterior branch with seven peg like denticles; accessory blades of two rakers and plumose setae; molar strongly triturative with posterior pappose seta. *Lower lip*: without inner lobes, bearing elongate blunt robust setae apically on the outer lobes, facially and marginally pubescent; posterior protuberances marginally pubescent. *Maxillae*. Left first maxilla: palp article two narrow, with five thin apical robust setae and two sub apical facial setae; outer plate with seven strong denticulate robust setae; inner plate with two plumose apical setae. Right first maxilla: palp article two broad with one apicolateral long stout robust seta disto-marginally setulose, two subterminal facial setae, one armed, two stout naked distal robust setae and one small disto-medial robust seta; outer plate bearing seven denticulate terminal robust setae; inner plate with two apical plumose setae. Second maxilla: with long distally curved, blunt and flattened apical setae; outer plate medio-lateral submarginal face with a short row of two or three long robust setae; inner plate disto-medial corner with a slightly submarginal thick plumose seta. *Maxilliped*. Palp: article three with several thick setae on the inner edge, two ventral submarginal setae, a row of four robust setae basal to the dactyl and the adjacent margin pubescent, three strong disto-lateral robust setae, the apex weakly produced and rugose; dactyl unguiform with a nail, and two accessory marginal spinules; article two well setose medially. Inner plate: bearing three stout naked apical robust setae, a short discontinuous row of three plumose submarginal facial setae extending apically from M0.6, and facially disto-laterally a single plumose seta and a naked robust seta. Outer plate: with three slightly submarginal medio-distal naked tooth like robust setae, one apical naked tooth like robust seta and three distolateral pappose robust setae. *First gnathopod*: coxal plate with few apical setae; articles three to five with posterior rugose lobes, small on article three, moderate on articles four and five; carpus short; propodus sub rectangular - length to width ratio 92:65 - not expanded apically, palmar corner sub rectangular, not rugose, with two medial and two lateral naked blunt robust setae, palm very weakly oblique, slightly convex, dactylus without accessory marginal

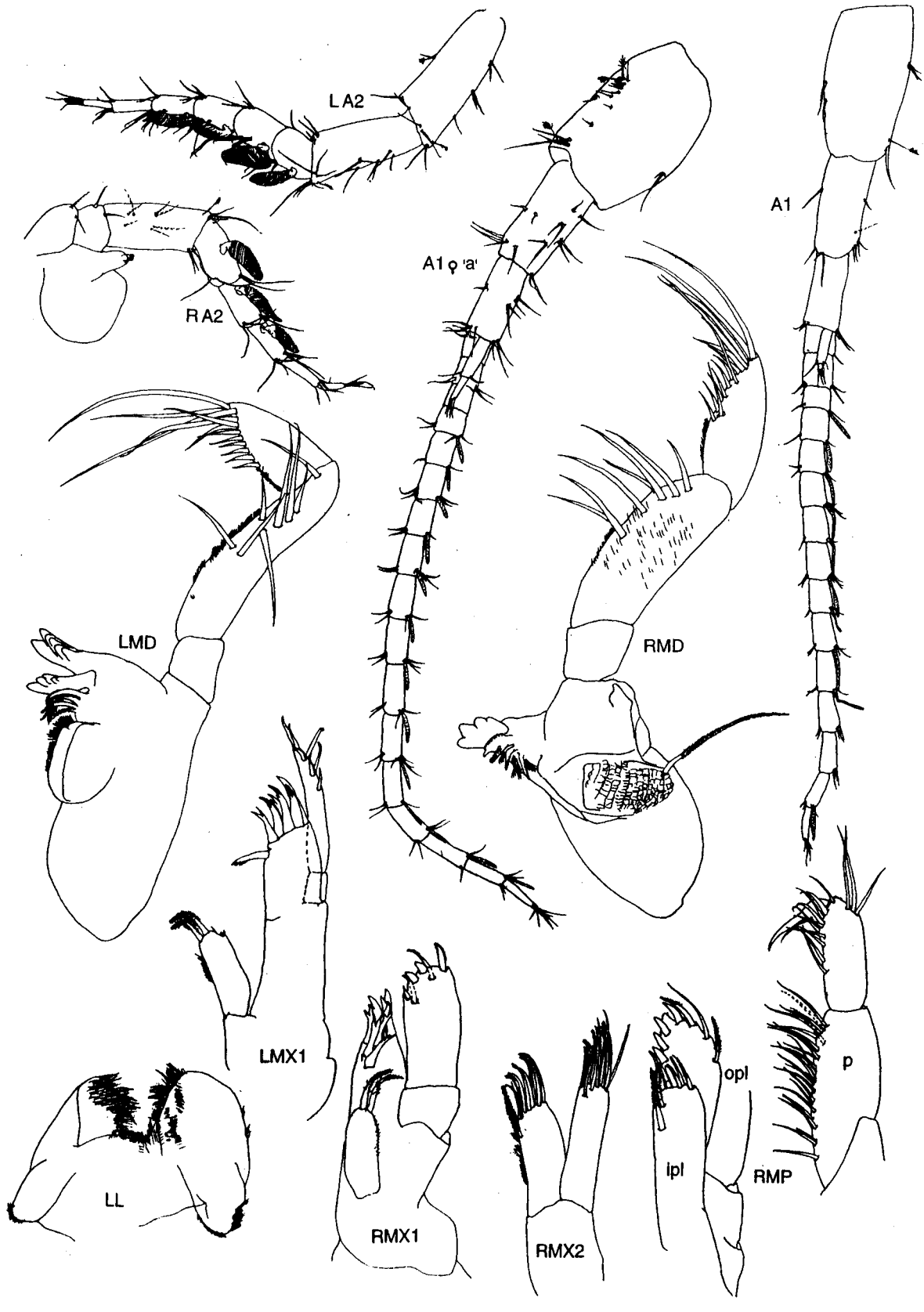

Fig. 3.133. *Wesniphargus nichollsi* (Straškraba) male 'b' 2.8mm; antennae, mouthparts (all drawings except those indicated). Female 'a' 5.0mm first antenna.

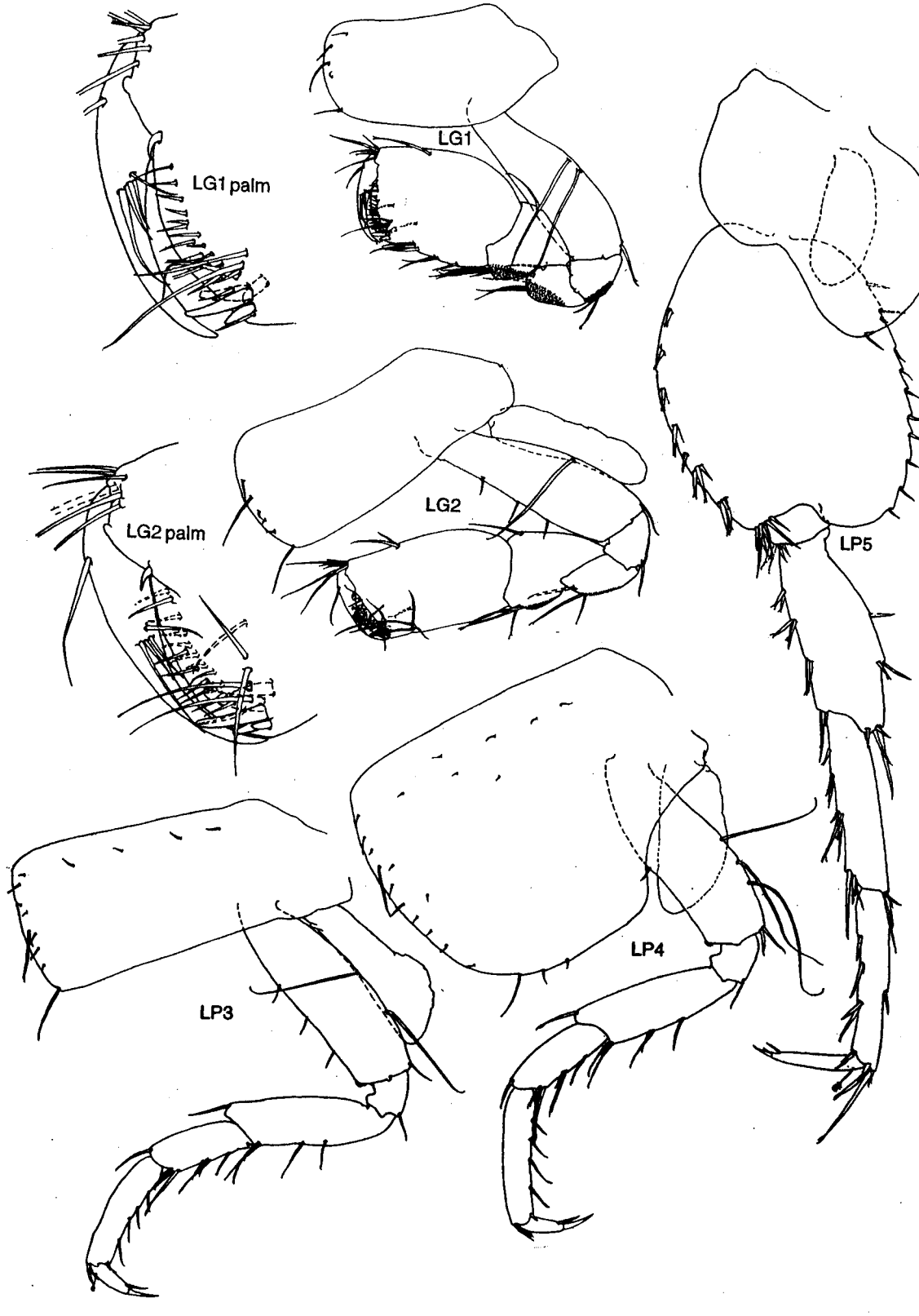

Fig. 3.134. *Wesniphargus nichollsi* (Straškraba) male 'b' 2.8mm; gnathopods.

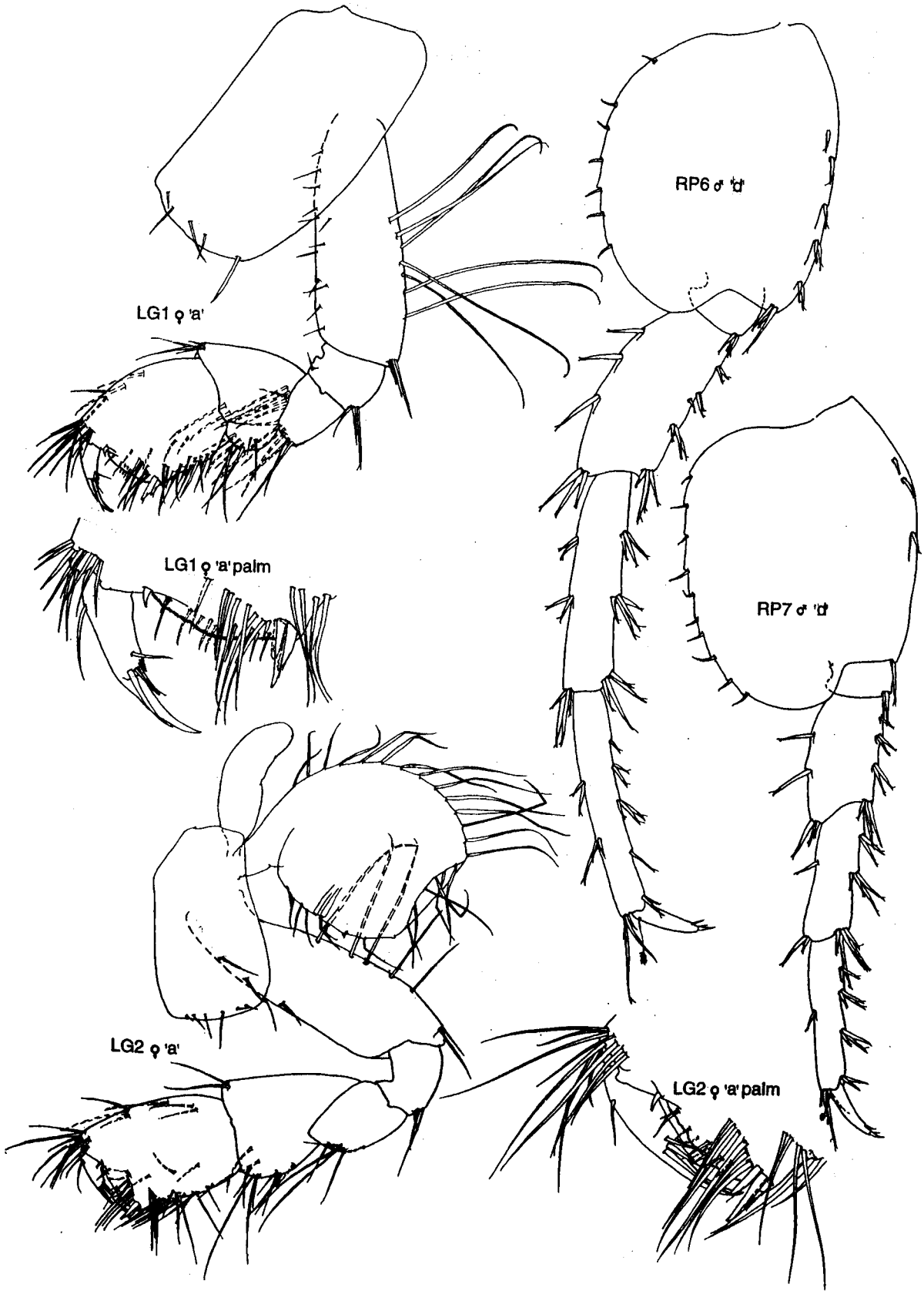

Fig. 3.135. *Wesniphargus nichollsi* (Straškraba) female 'a' 5.0mm gnathopods one and two, male 'd' right pereopods six and seven.

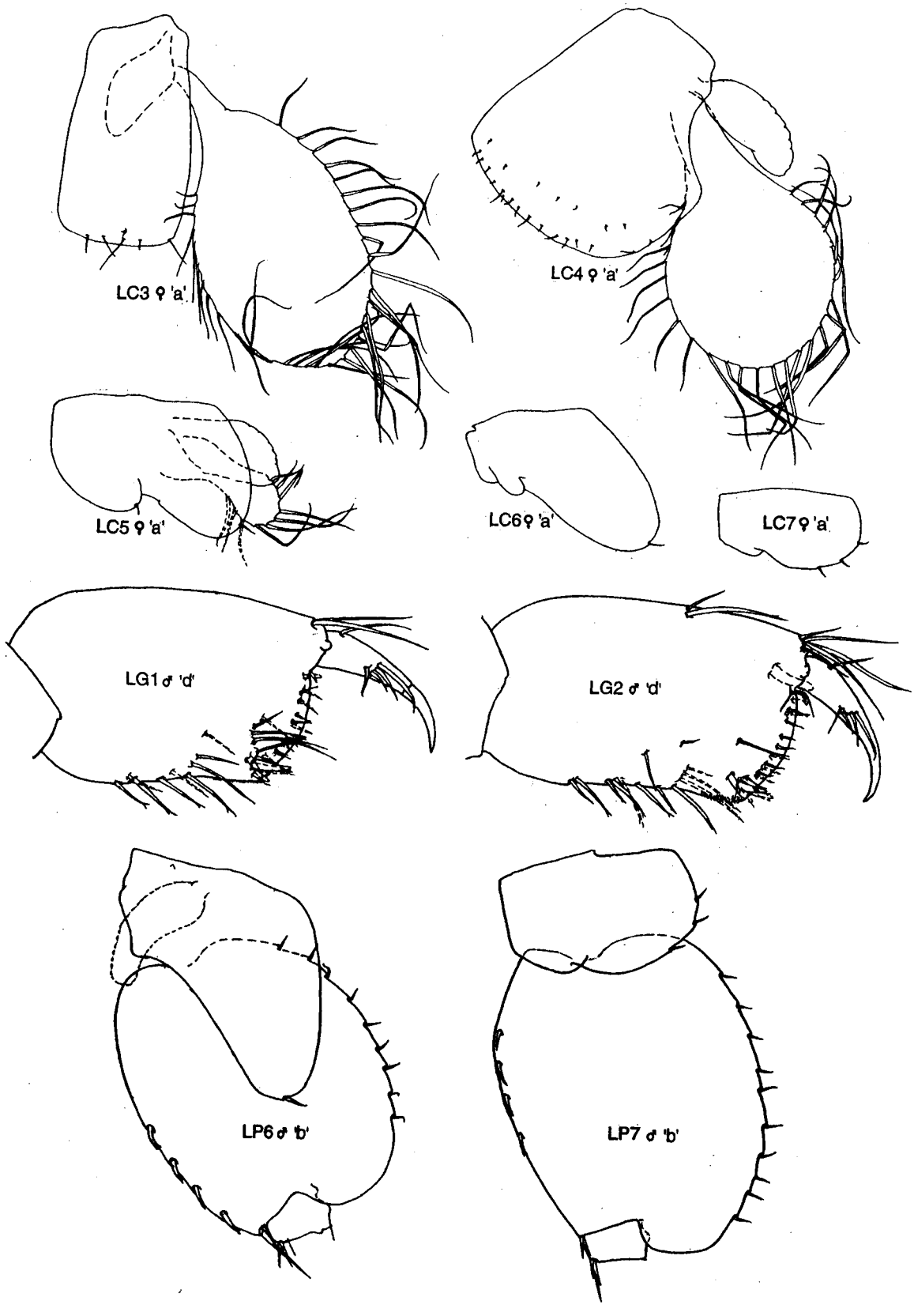

Fig. 3.136. *Wesniphargus nichollsi* (Straškraba) male 'b' 2.8mm pereopods six and seven (part), male 'd' 2.8mm dactyls of gnathopods one and two, female 'a' 5.0mm coxae three to seven.

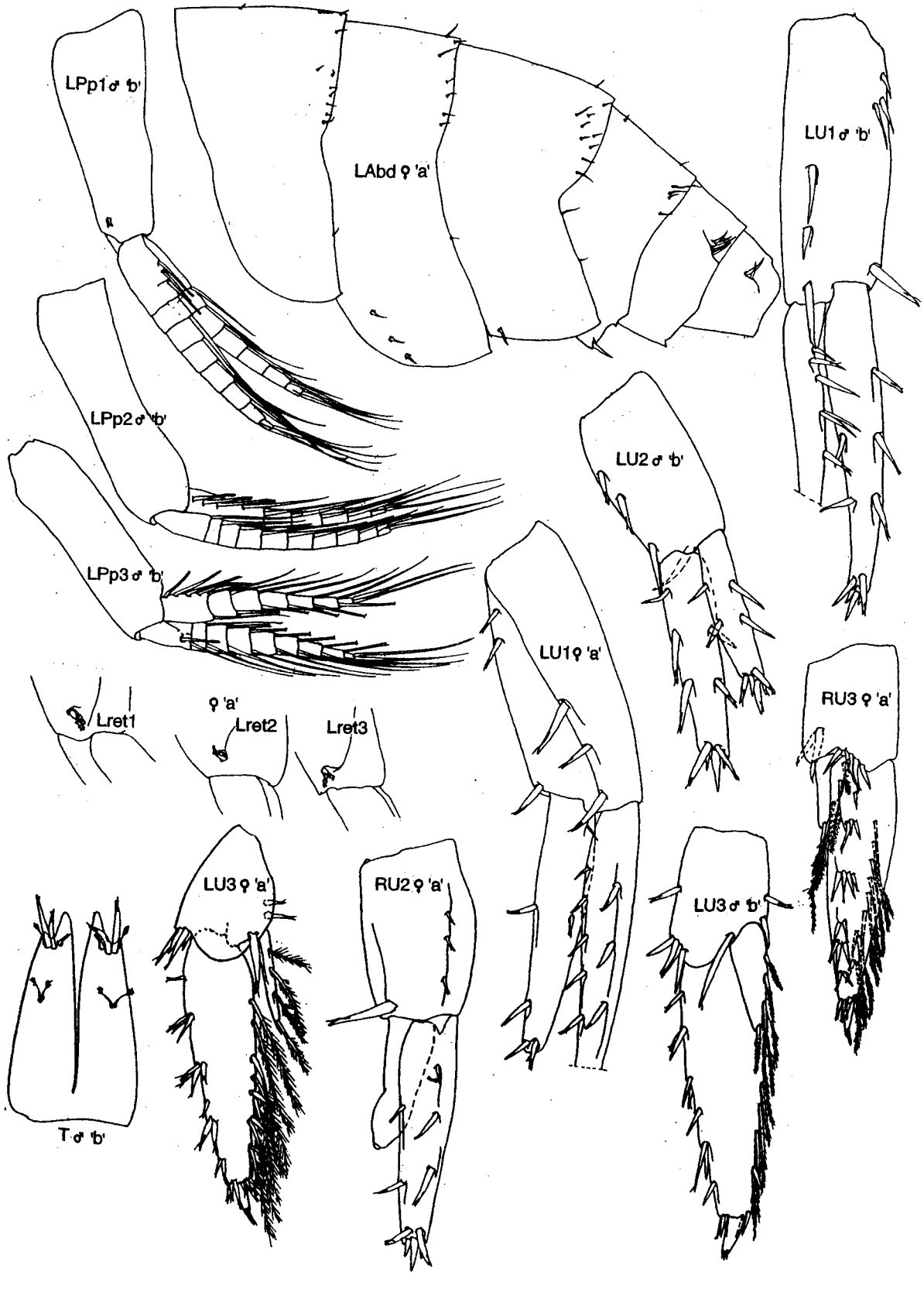

Fig. 3.137. *Wesniphargus nichollsi* (Straškraba) male 'b' 2.8mm pleopods, left uropods and telson; female 'a' 5.0mm abdomen, retinacula, uropods.

spinules, nail long, reaching to palmar corner. *Second gnathopod*: coxal plate poorly setose apically with three long and three short setae, bearing a long simple sac like gill; articles two to four with small posterior rugose margins, carpus longer than the first gnathopod, the lobe much reduced; propodus longer and narrower than the first - length to width ratio 92:50 - palmar corner three lateral and one medial stout robust setae, palm with moderately dense simple robust setae. *Pereopods*: coxa three with three long and six short apical setae and a facio-anterior row of four moderate setae; coxa four emarginate, moderately setose apically and facially; pereopods three and four weakly spinose posteriorly, articles six with posterior robust setae 1-1-1-1 and 1-1-2-2 plus two locking robust setae, respectively; posterior lobes of coxae of pereopods five to seven dominant, with few ventro-marginal robust setae (1-1-2) , articles two strongly expanded, very broadly lobate post ventrally, with short posterior setules. *Gills*: coxae two to six with sac like gills, those of five and six reduced slightly; sternal plates two to six with pairs of fleshy lumped gills attached to the lateral edge of each segment. *Epimera*: post ventral teeth small blunt protrusions, not acuminate, smallest on the third; posterior margins almost straight; second epimeron with three antero-ventral submarginal robust setae, the third with two. *Pleon*: with few dorsal setae and robust setae; pleonites one to six with setae 9,6,9,4,0,0 , pleonites five and six with 4,2 disto-lateral robust setae. *Pleopods*: similar; peduncles naked except for a pair of retinaculae; rami moderately long of 8-7, 10-7, 9-7 lateral and medial articles respectively; basal article of the inner rami armed with several terminally bifid setae with asymmetrical apices, some with 'diamond' heads, some symmetrical. *Uropods*. Third uropod: extending beyond first and second in the intact specimen; uropod lengths relative to uropod one uropod two 0.7, uropod three 0.75. First uropod: peduncle length 1.1x outer ramus, 0.85x inner; outer margin with one apical robust seta and two dorsal robust setae, medial margin with three small basal robust setae and one apical robust seta; lateral ramus shorter than medial, both with two rows of marginal robust setae, the lateral apex with four robust setae, the medial with five. Second uropod: peduncle 0.8x length of the inner ramus with one apicodorsal robust seta and three medial robust setae; outer ramus shorter than the inner -70:100 - both rami with two strong rows of marginal robust setae, apices with five robust setae. Third uropod: peduncle length 0.4x outer ramus, much longer than urosomite three -2.9x - with an apicolateral cluster of four facio-

subdistal robust setae and a long dorsal robust seta, single mid-medial and mid-lateral robust setae; outer ramus proximal article with six lateral robust seta clusters of 1-2-2-1-2-1 robust setae, the medial margin with a row of seven setae and one distal robust seta; distal article small, 0.14x proximal, with three dorsal sub apical short setae; inner ramus length 0.3x outer, with three medial plumose setae and one apical plumose seta. *Telson*: elongate, longer than urosomite three; cleft 85%; apices extended medio-distally as short lobes, sub-apices each with three robust setae in a transverse row, plus a single penicillate setule arising at the base of the largest, most lateral, robust seta; each lobe with a pair of penicillate setules dorsolaterally at M0.6.

Description of female 'a'

As for male 'b' except in the following: *Body*: 5mm. *First antenna*: flagellum with seventeen articles, aesthetascs present on articles four to seventeen; accessory flagellum extending to M0.6 of third article of primary flagellum. *Second antenna*: flagellum without calceoli. *Gnathopods*: coxal plate of second gnathopod with four long and three short apical setae; carpi longer than male - 0.7 to 0.8x propodus; robust setae at corner of palm three (rather than four); posterior margin of propodus with an additional submarginal robust seta; dactyls with two recumbent robust setae on the inner margins *Pereopods*: coxa three with three long and two short apical setae, no row of facial setae; coxa four emarginate with twelve short and two long ventral setae and two posterior setae on the anterior face; coxa five anterior lobe strongly reduced with one posterior seta on the anterior lobe and one posterior seta on the posterior lobe; coxa six with one posterior seta only, coxa seven with two post ventral setae and one posterior seta. *Oostegites*: present on coxae two to five; oostegites two to four broadly ovate with long, strong regularly spaced marginal setae; oostegite five more slender, otherwise similar. *Epimera*: with sparse posterior setation, ventral face of epimeron two with three robust setae, of epimeron three with one robust seta. *Pleonites*: one to four with small posterior robust setae, five and six bearing strong lateral spination. *Urosomite one*: with strong articulate ventro-distal robust seta at the base of uropod one. *Pleopods*: each bearing pair of retinacula, without accessory retinacula or robust setae. *Uropods*: rami of first uropod both with four apical robust setae; peduncle of third uropod with five (rather than four) apico-lateral robust setae; outer ramus proximal article with 1-3-4-2-3-2 lateral robust setae, distal article with two sub terminal setae.

Description of male 'd'

Body: length 2.8mm. *Gnathopods*: sub-rectangular, similar size, less spinous than female 'a'. *Pereopods*: pereopod six much longer than seven - 1.3x - both with long baso-dactylar setae as long or longer than dactyl; pereopods without other setae; article two of pereopod six with moderate single posterior robust setae, anterior robust setae stronger, several paired; article two of pereopod seven with small to moderate posterior robust setae, few anterior robust setae, none paired; anterior robust setae of both pereopods six and seven dominant to posterior.

Distribution

Mammoth Cave, and near Margaret River, Western Australia, 34°03'S, 115°01' E.

3.3.8 Discussion

The discovery among NSW cave specimens of species apparently belonging to the Neoniphargidae, but which displayed characters other than those defined by Williams and Barnard (1988) stimulated examination of family characters, and led to redefinition of the family. Description of previously undescribed male *W. nichollsi*, enabled comprehensive redefinition of the genus *Wesniphargus*.

No previously described neoniphargids are confirmed stygobionts, although *Wesniphargus nichollsi* has been collected from stygal locations and is regarded as a troglophile (Williams 1986). Differences observed among the new species reported here, including morphological modifications such as loss of eyes and pigmentation, and attenuation of bodies and appendages, are characteristic of stygobionts (Culver *et al* 1995; Holsinger 1994 a, b): exclusion from the family definition of characters such as body form and possession of eyes (Williams and Barnard 1988), previously included by Bousfield (1977, 1982a), is therefore supported. Bousfield (1982a) defined the third uropod as short: the third uropod is long in several new species and is considered an adaptation to troglobitic habit (Holsinger 1994a) in those taxa. However, it is noted an inner ramus was always present on the third uropod as indicated by Williams and Barnard (1988), the outer ramus always bore a second, albeit small article, and that among stygobiont taxa the first, never the second article of the third uropod was elongate. Simplification of

sternal gills has not been attributed to troglobitic adaptation, yet reduction of dendritic to 'incipiently dendritic' gills has been observed in the troglophilic *W. nichollsi* (Williams and Barnard 1988); the wholly troglobitic *W. yanchepensis* n. sp. and *Jasptorus solepti* n. sp. both bearing lumpy or 'incipiently dendritic' sternal gills, are reported here. Furthermore, the sternal gills of described *Neoniphargus* sp. are not universally dendritic, and anterior gills are simple or marginally dendritic in some species in which fully dendritic sternal gills occur only on the more posterior sternites. Also, Bousfield (1982a) considered dendritic gills frequent rather than obligatory characters among Neoniphargidae. Thus the removal of the condition fully dendritic sternal gills as an essential family character of the Williams and Barnard diagnosis (1988, p. 114) corresponds to observed conditions of the gills in a wider spectrum of samples. The telson of some new species described here is cleft less (14 - 20%) than among previously known Neoniphargidae (50-75%), which Bousfield (1982a) considered significant. However, the telson of these new species is otherwise similar, with truncate, notched lobes, few apical robust setae, and a pair of dorsal setae in most cases.

3.3.9 Distribution of the Neoniphargidae. Fig. 3.138

Neoniphargidae, excepting *Wesniphargus*, are essentially taxa of cold waters of the south east of the continent and Tasmania (Williams and Barnard 1988). Tasmanian species occur widely in post glacial regions above 1000m altitude, and Victorian species occur in streams of the Great Dividing Range above 600m altitude: all are epigean. In such high altitude habitat freezing, and thus dry, winter conditions would be experienced, suggesting these species have developed some mechanism for maintaining an aquatic habitat at such times, such as burrowing into crevices or mud. Stewart (1992) notes in South Africa young of species of *Paramelita* may be hypogean, and survive dry summers in phreatic intersices. In New South Wales a number of new, stygobiont taxa are recorded from cave locations, where water temperatures are consistently low but do not approach freezing (Eberhard and Spate

1995). Neoniphargids are not recorded from epigean habitats in the region, where surface waters are less permanent, and temperatures less stable.

Wesniphargus nichollsi, in contrast, occurs in Western Australian in habitats which are neither hypogean, nor cold water, although it is regarded as a troglophile, and does occur in the efflux stream of Mammoth Cave, Margaret River region. The wholly stygobiont species *W. yanchepensis* inhabits cave sites at Yanchep, the most northern occurrence of a neoniphargid, approximately 31°30" S. Consistent temperatures may, however, be the significant characteristic of such habitat - within the cave system water temperatures remain a constant 19.0-19.3°C year round (Jasinska *et al* 1996).

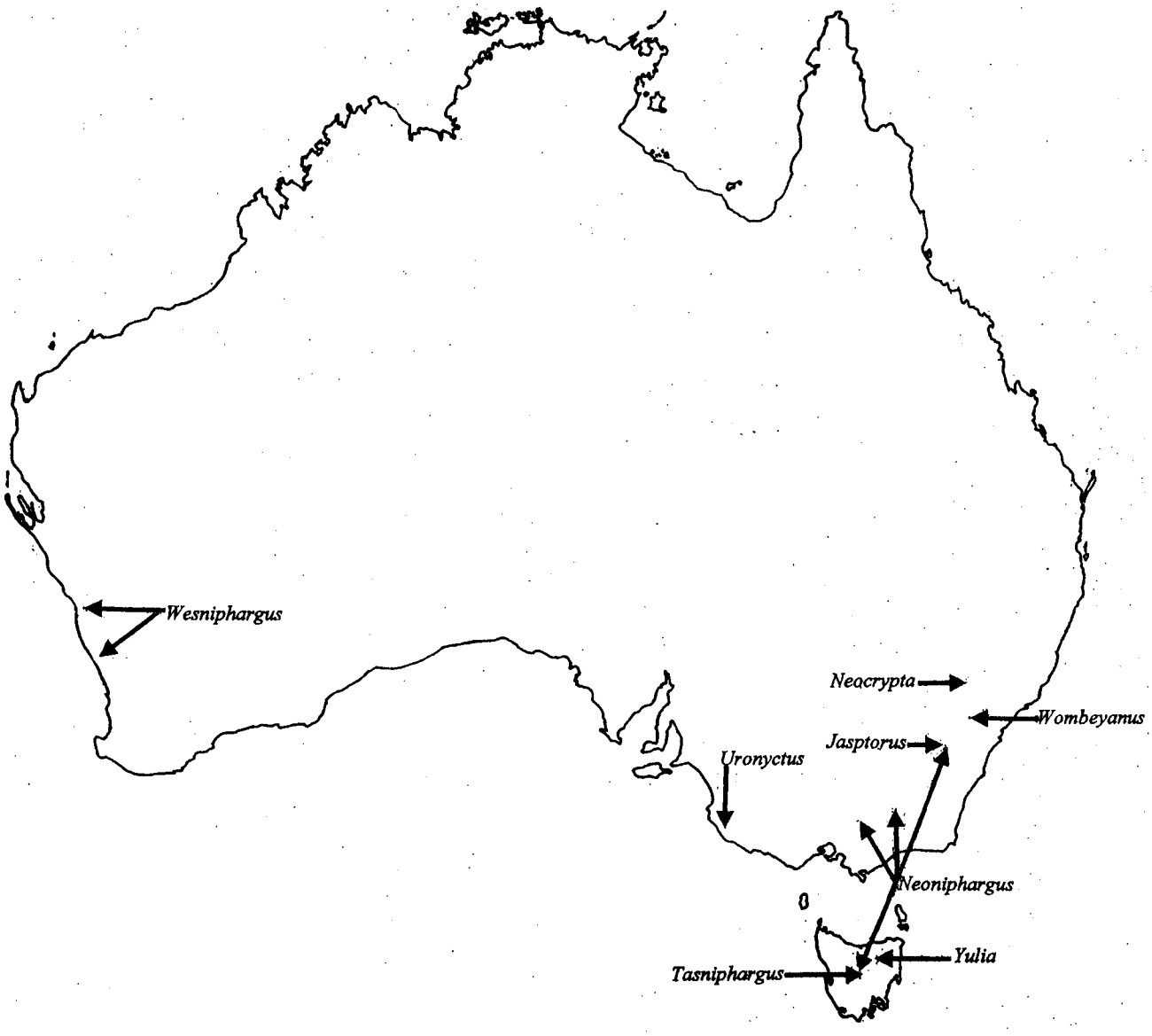

Fig. 3.138. Distribution of genera of the family Neoniphargidae.

3.3.10 Composition of the Family Neoniphargidae

With this review of the family and establishment of new taxa the Neoniphargidae includes seven genera and twenty two species.

Jasptorus solepti Bradbury and Williams, 1997b - Wee Jasper Cv. system, N.S.W.

Neocrypta primaris Bradbury and Williams, 1997b - Limekiln Cv. Wellington, N.S.W.

Neocrypta robinae Bradbury and Williams, 1997b - Diprotodon Cv. Canomodine, N.S.W.

Neocrypta moniae Bradbury and Williams, 1997b - Bowan Park Cv system, N.S.W.

Neocrypta georginae Bradbury and Williams, 1997b - Apple Tree Cv. Copperhania, N.S.W.

Neocrypta annae Bradbury and Williams, 1997b - Bowan Park Cv. system, N.S.W.

Neocrypta simoni Bradbury and Williams, 1997b - Paradox Cv. Jenolan, N.S.W.

Neoniphargus thomsoni Stebbing, 1899 - Mt. Wellington, Tas.

Neoniphargus alpinus G.W.Smith, 1909 - Mt. Read, Tas.

Neoniphargus exiguus G.W.Smith, 1909 - Coffee Ck., Huntingfields, Tas.

Neoniphargus tasmanicus G.W.Smith, 1909 - Great Lake, Tas.

Neoniphargus spenceri (Sayce, 1901) - Plenty Range, Vic.

Neoniphargus fultoni Sayce, 1902 - Warburton, Vic.

Neoniphargus obrieni Nicholls, 1926b - Mt. Buffalo, Vic.

Neoniphargus coolemanensis Bradbury and Williams, 1997b - Murray Cv. Cooleman Plain, N.S.W.

Neoniphargus secus Bradbury and Williams, 1997b - Gurungah Cv. Wombeyan system, N.S.W.

Neoniphargus richardi Bradbury and Williams, 1997b - River Cv. Wombeyan system, N.S.W.

Tasniphargus tyleri Williams and Barnard 1988 - Great Lake, Tas.

Wesniphargus nichollsi (Straskraba, 1964) - Cannington, W.A.

Wesniphargus yanchepensis Bradbury and Williams, 1997b - Yanchep Cv. W.A.

Wombeyanus botulosus Bradbury and Williams, 1997b - Bullio Cv. Wombeyan system, N.S.W.

Yulia yuli (G.W.Smith, 1909) - Yules Lake, Tas.

Chapter 4

Family Melitidae Bousfield

Introduction

The family Melitidae is represented among described Australian freshwater Amphipoda by two monospecific genera: *Brachina* (*B. invasa*), Barnard and Williams 1995, and *Nedsia* (*N. douglasi*), Barnard and Williams 1995. The family was established by Bousfield in 1973.

Barnard and Barnard (1983) regard the melitids as one of the more primitive marine groups with a dispariramous uropod three, that may be ancestors of several groups, including the eriopisellids, nuuanuids, ceradocopsids and possibly the hadziids ('a cul-de-sac of evolution' among marine gammarids'). Whilst Barnard and Williams (1995) assigned *Nedsia* and *Brachina* to the family Melitidae, within the hadzioid superfamily, the hadziid/melitid group is complex and not clearly defined. Holsinger (1994a) groups Melitidae within the Hadziidae, pointing to 'considerable taxonomic instability within this group, much of which has apparently resulted from rampant parallelism and excessive homoplasy'. The hadzioid/melitoid complex, comprising the major marine gammarids, includes many species which have invaded anchialine and freshwater habitats. They are divided into two main groups, the hadziid (melitid) subgroup which is characterised by dispariramous third uropod, and the ceradocids which bear aequiramous third uropods. In the plesiomorphic condition, the hadziid/melitid inner ramus takes the form of a simple elongate triangle bearing few medial and apical setae, whereas the outer ramus carries a second article and bears lateral robust setae (Barnard and Barnard 1983).

In describing *Brachina invasa* and *Nedsia douglasi* Barnard and Williams (1995) regarded both as part of the melitoid/hadzioid complex, being taxa of 'essentially marine derivation'. *Brachina invasa*, a medium size amphipod (6mm) from

Parachilna Creek in the Flinders Ranges of South Australia, was considered most similar to the *Abludomelita-Melita*, complex, a pan-tropical marine supergenus. *Brachina* differs from the *Abludomelita-Melita* complex in the absence of inner lobes of the lower lip and in reduction of the mandibular palp, indicating the genus probably belongs rather with the hadziids, with closest affinities to *Psammoniphargus*, notwithstanding the significant differences of symmetrical palps of the first maxilla and a somewhat more developed mandibular palp. *Brachina* and *Psammoniphargus* Barnard and Williams (1995) therefore regarded as convergent Indo-Pacific genera derived 'from the melitoid facies by loss of inner lobes of the lower lip'. The 'lack of sternal gills and presence of a basofacial spine (robust seta) on the peduncle of the first uropod indicate a marine origin of the two derivatives'. *Nedsia douglasi*, a small to medium sized (~5mm) amphipod from a well on North West Cape, Western Australia, is also regarded as being of marine derivation. The genus displays similarities to eriopisids (Karaman 1984), particularly in the presence of an elongate second article of the outer ramus of the third uropod, which is uncommon but does occur elsewhere, for example in *Pseudoniphargus adriaticus*,Karaman 1955 and *Niphargus longicaudatus*, Costa 1851. Unlike *Eriopisa* or *Psammogammarus,* however, the anterior coxae of *Nedsia* are not significantly reduced, nor is the female second gnathopod hadziid, or the first gnathopod ceradocid as in *Psammogammarus*. Moreover, the mandibular palp is reduced to two articles, although the terminal article is linear as in eriopisids, rather than falcate with distinct D and E setae as in *Hadzia*. *Nedsia* is characterised by the presence of a basofacial spine (robust seta) on the peduncle of the first uropod; shortened apical article two of the accessory flagellum, as well as presence of a mediodistal spine (robust seta) on the first peduncular article of the first antenna; the lower lip bears inner lobes; the mandibular palp is reduced; the inner plate of the maxilliped bears only two apical spines (robust setae), the outer plate medial spines (robust setae) are replaced by wavy cusps; sternal gills are absent.

Because of the complexity of the hadzioid/melitoid group it is apposite to continue to regard these marine derived genera as of the family Melitidae, following Barnard and Williams (1995). Characteristically, they bear a basofacial robust seta on the peduncle of the first uropod, dispariramous third uropods, and lack sternal gills and calceoli.

Descriptions of new genera and species

Barnard and Williams (1995) described *Nedsia douglasi* from North West Cape, Western Australia. Additional melitid material collected by the Western Australian Museum from North West Cape, and from Barrow Island is described. Furthermore, an apparently 'new species of *Melita*' from a cave on the Nullarbor Plain (Knott 1983, 1985) was collected and described.

New taxa assigned to the family Melitidae include ten new species of the genus *Nedsia* from Barrow Island, Western Australia, as well as a new genus, *Norcapensis* and the species *N. mandibulis*, from North West Cape, Western Australia, and the new Nullarbor Plain genus *Nurina* and the species *N. poulteri*. The male *Nedsia douglasi* Barnard and Williams, previously unrecorded, is also described from new material from North West Cape, and the genus rediagnosed and the species redescribed.

4.1 Nullarbor Plain, Western Australia

The presence of melitid like amphipods in Nurina Cave, Nullarbor Plain (127°01'E, 32°01'S) were reported by Knott (1983, 1985). Specimens of these amphipods were collected by a colleague (S.Eberhard) in 1998 and the new genus *Nurina* and species *N. poulteri* described.

4.1.1 *Nurina* n. gen.

Etymology

Named for the type location, Nurina Cave, Western Australia..

Type Species

Nurina poulteri n. sp.

Diagnosis

Pleonite six dorsolaterally naked, pleonite 5 with robust dorsolateral seta; rostrum obsolescent; lateral cephalic lobes strongly projecting, large, plate like, with distinct ventral notch formed by the blunt extension of the anteroventral margin. Eyes absent. First antenna longer than the second, ratio of peduncular articles 1:1.3:0.5. Accessory flagellum four articulate, the fourth article tiny. Second antenna long, flagellum much shorter than peduncle, calceoli absent. Upper lip asymmetrical, ovate and apically piliose. Mandible: palp three articulate, article one short, naked; third article with CDE setae; accessory blades numerous, with interraker plumose setae and brushy basal setae onto the molar. Lower lip: bearing broad inner lobes. Maxillae: moderately setose medially, ovato-triangular, facially setose (pubescent), with medial and apical plumose setae; outer plate with nine denticulate robust setae, palps asymmetric the left with thin apical and subapical setae, the right with apical broad spine fused to the article as well as apical and subapical setae. Inner plate of second maxilla without plumose medial setae, but some naked paired medial setae extending to the apex, some facial. Both plates of second maxilla with naked apical and subapical setae of medium to moderate length and both with few marginal setules (pubescence). Maxilliped: inner plate long, extending to M0.7 of outer plate, with a medial submarginal disto-facial row of plumose setae extending more facial apically, blunt, naked tooth like robust setae subterminally and an apical row of plumose setae; outer plate large, with long, curved, robust apical plumose setae continuous with a distal row of submarginal to apical, short to long naked tooth setae, and medial to sub marginal to facial paired rows of long naked setae; medial margin straight, without marginal robust setae, the distomedial corner quadrate; palp article two short, article three elongate, with no lateral setae; article three moderately to densely setose medially, with a row of long setae at the base of the dactyl distolaterally and facially; apex produced slightly, bearing marginal setules, dactyl unguiform, multispinous, without facial setules (not pubescent), bearing a long naked nail with basal setae. Coxae: one to four normal, longer than broad,

lacking posterior robust setae; coxae one to three subquadrate, not apically expanded; coxa four moderately excavate posteriorly; coxa five shorter than four; female coxa six anterior lobe ventrally extended, coxa seven small, unlobed anteriorly. Gnathopods: diverse, gnathopod one much smaller than gnathopod two, dactyl of gnathopod one without recumbent inner tooth spine, both dactyls with distinct nail. First gnathopod small, merus lacking hyaline lobe, without rastellate seta, carpus longer than propodus, not lobate, palm of propodus transverse, short, deeply notched in males, distal row of long robust setae borne on palmar submargin each with a small subapical trigger; gnathopod two enlarged, 1.5-2.x gnathopod one, carpus short, triangular and lobate, dactyl enlarged and ovate, palm strongly oblique, setose, defining corner absent, but indicated by limit of robust setae; dactyl shorter than extent of robust setae. Pereopods: three and four shorter than pereopods five to seven, posterior setae on article six of pereopods three and four evenly spaced, weak; pereopods five to seven moderately long, six longest, the others subequal in length, the basis (article 2) moderately expanded, ovato-rectangular, posteriorly extended and slightly lobate; dactyls of pereopods lacking accessory spinules other than the usual single posterior and anterior setules. Coxae two to six each bearing a single flask shaped gill, that of coxa six sub equal in size to the gill of coxa five. Without sternal gills. Oostegites: present on coxae two to five of mature females; narrow, marginally poorly setose. Epimera: posteroventral corner of epimera one to three acuminate, but without spine or seta, posterior margins straight to slightly convex, with moderate numbers of setae; epimera two and three with facial robust setae near the ventral margin. Pleopods: peduncles with few setae, rami extending equally, basomedial setae of inner rami bifid; retinaculae two per pleopod, plus two accessory retinaculae. Uropods: apico-lateral corner of peduncles of uropods one and two with one and two robust setae; lateral- and medial- dorsal margins of peduncle of first uropod spinose, of second naked; first uropod with basofacial robust seta; rami of uropod one subequal, the lateral ramus of uropod two shorter than the medial; rami of both uropods with two robust seta rows; third uropod strongly extended, peduncle of moderate length, outer ramus large of one article only, inner ramus short and scale-like; lateral and medial setae of outer ramus dense; peduncle with apical, medial and distal robust setae. Urosome: ventrodistal robust seta on urosomite one at base of uropod one absent. Telson: shorter than broad, cleft 95%, laterally convex, medially sinuous, bearing

long, medial, lateral and sub-apical robust setae, with one or two apical or sub-apical penicillate setae and paired lateral penicillate setules.

Relationships

The family Melitidae is characterised (Barnard and Barnard 1983) by:

the lower lips usually bearing inner lobes weak to fleshy; maxillae fully to not setose medially; the first gnathopod and also the female second gnathopod "melitid" in form; with a distinct palm; the male second gnathopod enlarged, the palm without robust setae or scattered robust setae; the third uropod is parviramous; the telson cleft; coxal gill seven absent; the first antenna accessory flagellum is of two or more articles; peraeopods 3-4 are ordinary, 5-7 basis variably enlarged, the dactyls simple; pleonites and urosomites only occasionally dentate; the oostegites narrow. *Nurina* **n. gen.** bears these characteristics. *Nurina* is similar to *Melita* in that the peduncle of the third uropod is not elongate, inner lobes are present on the lower lip, the telson tapers distally, uropod three extends beyond uropod one in the whole specimen, anterior coxae are significantly longer than posterior coxae, the maxillae are weakly setose medially, the second gnathopod not bilaterally diverse, nor chelate, and the mandibular palp three articulate. However, *Nurina* differs from *Melita* in that: the eyes are lost; the second peduncular article of the first antenna is relatively longer, the third shorter; the primary flagellum of the first antenna is relatively much shorter, $\sim$2x vs 5x the length of the peduncle; the accessory flagellum is of four articles, rather than 2+; the third article of the mandibular palp bears C as well as D and E setae; the inner lobes of the lower lip are broad, but thin and poorly developed rather than well developed and fleshy; the inner plate of the first maxilliped is triangular rather than 'falcatotriangular' being straight not curved, and the outer plate bears nine robust denticulate setae as opposed to 7+; the dactyl of the maxillipedal palp is barely curved, not unguiform. *Nurina* differs from *Psammogammarus* Karaman in that the third uropod is distinctly parviramous and anterior coxae are distinctly longer than posterior coxae; from *Galapsiellus* J. L. Barnard and *Anchialella* J. L. Barnard in that the peduncle of the third uropod is not elongate, the second gnathopod strong and the carpus not elongate; from *Psammoniphargus* in that the lower lip bears inner lobes and the mandibular palp is not reduced to a single article; from *Nainaloa* Karaman and Barnard and *Rotomelita* J. L. Barnard in that the telson is not rectangular, but tapering and without excavate apices; from *Melitoides* Gurjanova in that the third uropod exceeds the length of the

first in the undissected specimen; from *Victoriopisa* Karaman and Barnard and *Eriopisa* Stebbing in that anterior coxae are significantly longer than posterior and that the third uropod is without a second article on the outer ramus; from *Maleriopa* Barnard and Karaman and *Paraniphargus* Tattersall in that maxillae bear medial setae; from *Dulichiella* Stout in that the male second gnathopods are not asymmetrical, the body is smooth, without transdorsal serrations, and the inner plate of the first maxilla bears many setae and is not sickle like; from *Tegano* Karaman and Barnard in that the mandibular palp is not reduced to two articles.

4.1.1.1 *Nurina poulteri* n. sp. Figs. 4.1-4.5

Etymology

Named for Mr Norm Poulter who was involved in the collection of specimens from both Nurina Cave and cave N1327, and without whose participation this new species would not have been described.

Type locality

Underground water, Nurina Cave, Roe Plains, Western Australia, 127°01'E, 32°01'S, underground water, cave N1327, Roe Plains, Western Australia, 127°01'E, 32°00'S.

Material examined

Holotype male 'a' 9 mm (Western Australian Museum C24436), Allotype female 'b' 7.5 mm (Western Australian Museum C24437), male 8.9 mm (Western Australian Museum C24438), and 15 other specimens in the type series collected on 31 December, 1998 by Stefan Eberhard from Nurina Cave N46, Roe Plains, Western Australia, 127°01'E, 32°01'S; two females collected by N. Poulter and D. Hall (Western Australian Museum BES4648, BES 4651) on 10 April, 1997 and eight other females collected on 31 December, 1998 by Stefan Eberhard, all from cave N1327, Roe Plains, Western Australia, 127°01'E, 32°01'S.

Diagnosis

As for the genus.

Description of holotype (male 'a')

Body: Length 9 mm. Urosome with few, scattered weak setules, urosomite five with one distolateral robust seta. *Head*: rostrum obsolescent, eyes absent. *First antenna*: Length 0.6 x body, 1.4 x second antenna; flagellum longer than peduncle,

of twenty articles, the ultimate article tiny; peduncle article one 0.7 x the second which is longest, the third shortest, ratio of articles 1: 1.3: 0.5, article one with few setae, bearing a ventrodistal group of simple and penicillate setae and one robust seta; sparse short and long setae present on articles two and three; calceoli and aesthetascs absent; accessory flagellum four articulate, the ultimate article tiny, extending to M0.3 of the fifth article of the primary flagellum; primary flagellum sparsely setulate, articles 3-4 short. *Second antenna*: length 0.4x body, peduncle much longer than flagellum, articles four and five equally long, sparsely setulate, other articles with few setae, length ratio of articles 1:3.3:3.1; flagellum short, eight articulate, moderately setose, lacking calceoli. *Upper lip*: asymmetrical, offset to the right, ovate, apically piliose. *Lower lip*: bilobed, the inner lobes broad, weak, extending to M0.7 of the outer lobes; outer lobes with strong denticulate distal setae, medial and distomedial pilia. *Left mandible*: palp three articulate, ratio of articles 1:3.5:3, the first article short and naked, the second linear, longer than article one with few medial and no lateral setae; article three sublinear, lacking A or B setae, with 1C, 3D, 4E setae; incisor bearing five teeth, lacinia mobilis four, accessory setal row of eight rakers and four interrakers; molar with distal plumose seta and peripheral posterior pubescence. *Right mandible*: palp similar, article two bearing few setae, article three with 1C, 3D, 4E setae, mandible with five teeth, lacinia mobilis bifid and strongly denticulate. *First maxilla*: left and right sides asymmetrical; inner plate ovatotriangular bearing eight left and seven right plumose distomedial and apical setae covered in short setules (pubescence); outer plate bearing nine denticulate terminal robust setae on both sides, facially setulate (pubescent); left palp, second article with a sub apical row of eight slender setae and six apical slender to strong naked setae; right palp article two with a sub apical row of seven naked and one distally plumose setae, two mediodistal naked setae and three broad tooth spines fused to the apex. *Second maxilla*: apicolateral margin of both plates setulate (pubescent), terminating in long naked , curved setae in apical and sub apical rows; medial setae of inner plate not plumose although some terminally rastellate. *Maxilliped*: peduncle bearing few setae; inner plate subrectangular, facially and distolaterally setulate (pubescent); the outer plate bearing a medial submarginal row of fourteen naked tooth setae continuous with a medial subapical row of four tooth setae, all increasing in length distally forming a submedial pallisade row of teeth, distomedial to apicofacial paired rows of naked

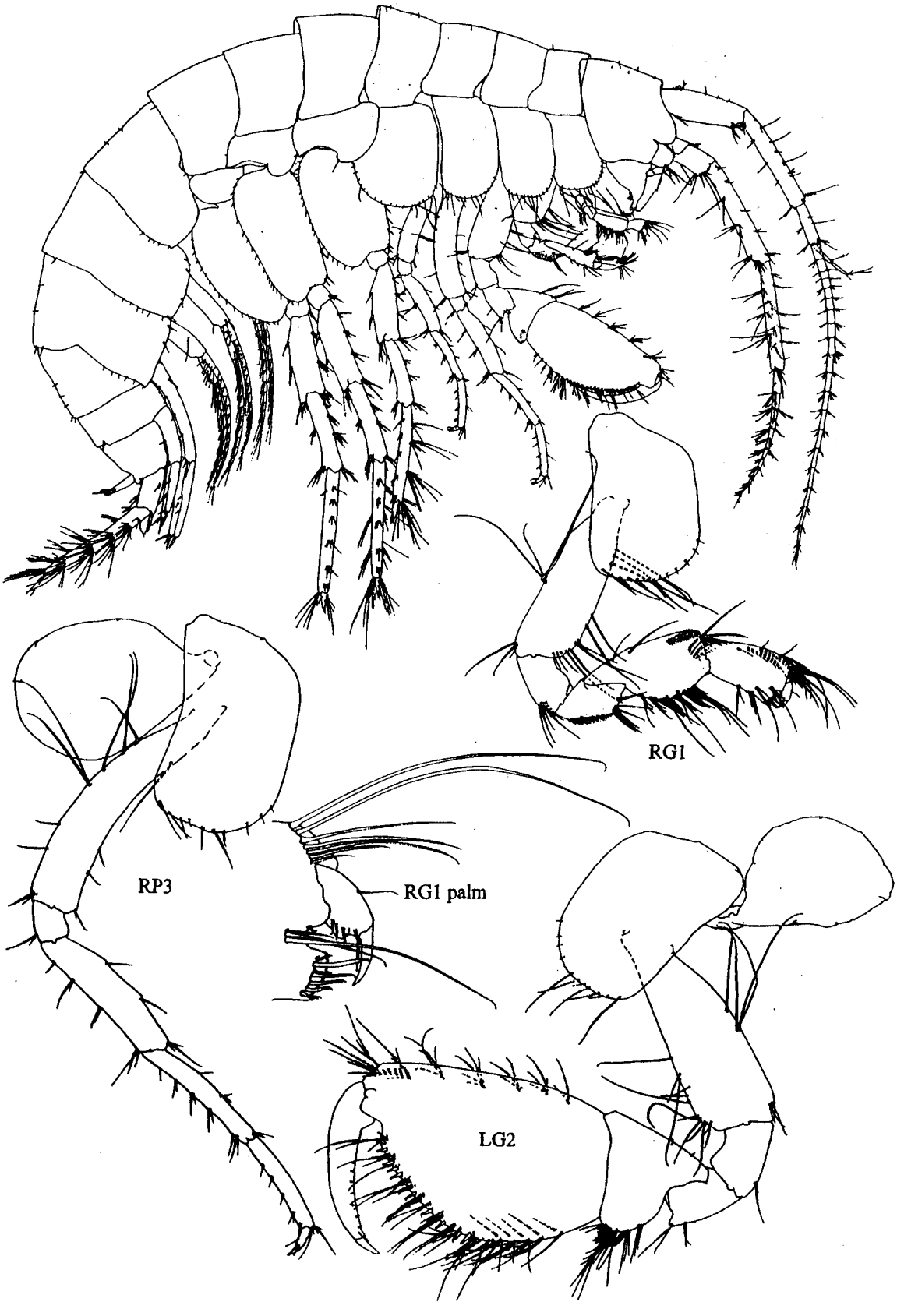

Fig. 4.1. *Nurina poulteri* male 8.9 mm: whole; holotype, male 'a': right gnathopod 1 and palm, left gnathopod 2, right pereopod 3.

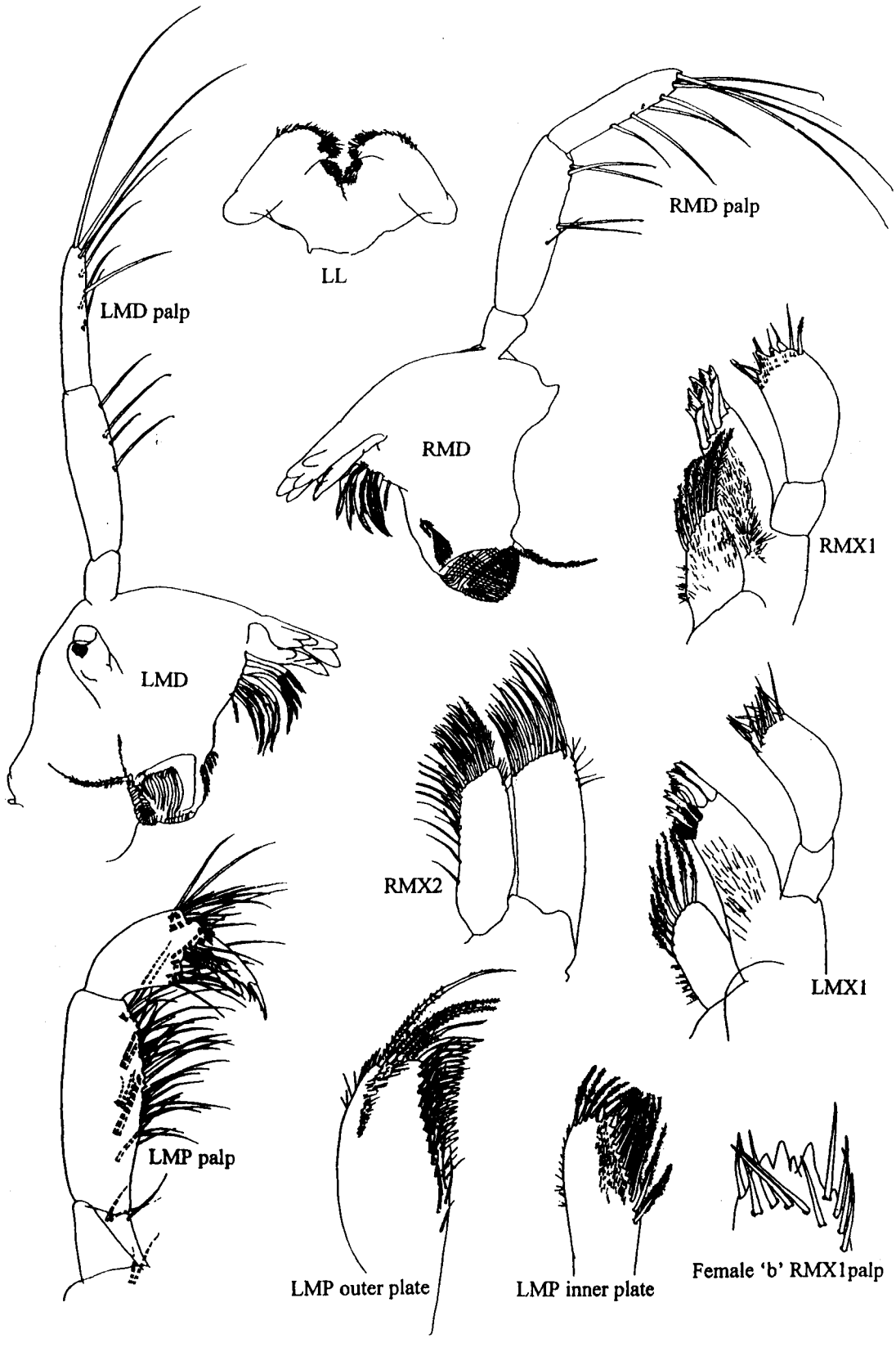

Fig. 4.2. *Nurina poulteri* holotype, male'a': mouthparts (all illustrations except where indicated); allotype, female'b': apex of right first maxilla palp.

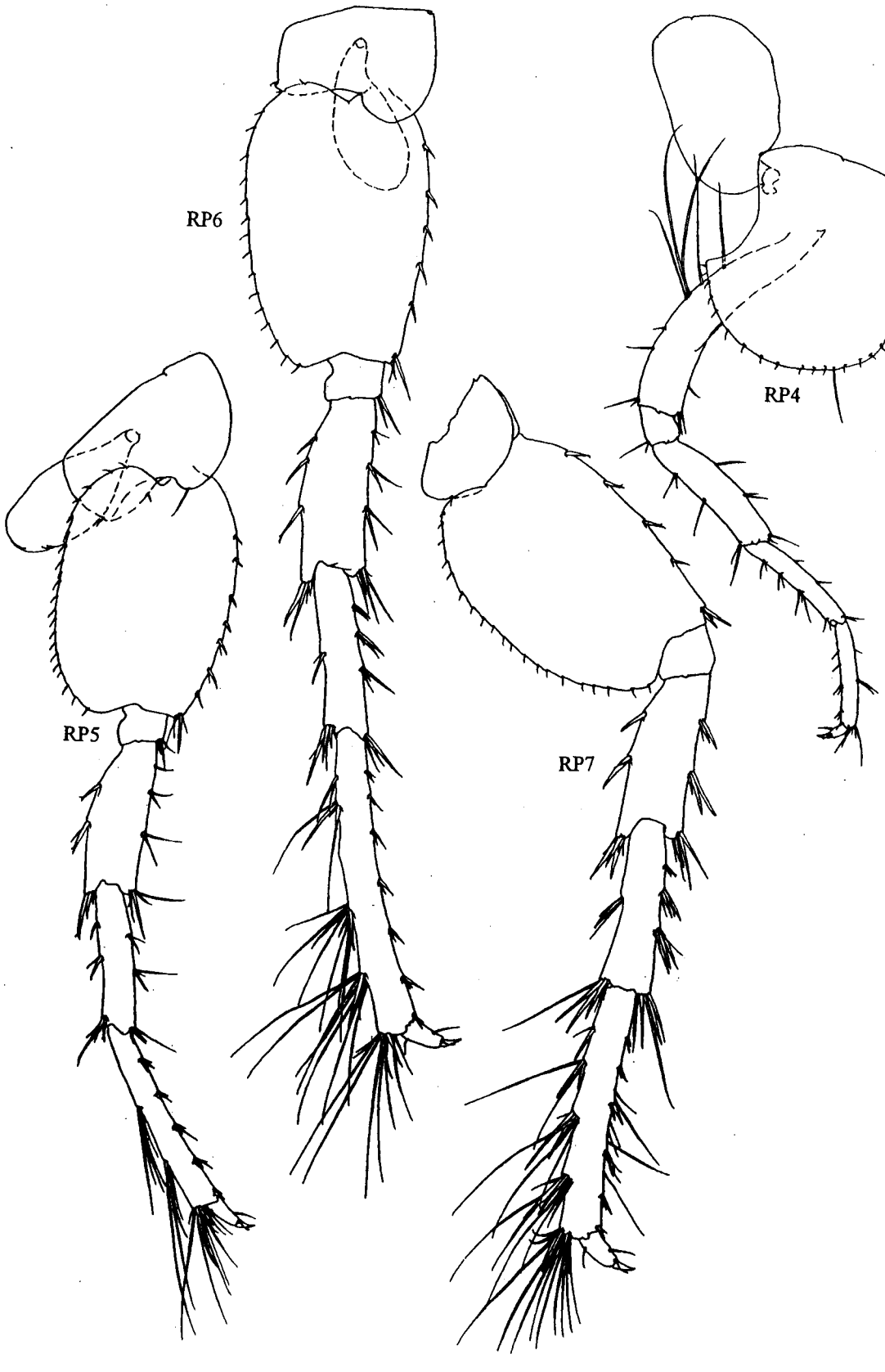

Fig. 4.3. *Nurina poulteri* holotype, male 'a': pereopods 4-7.

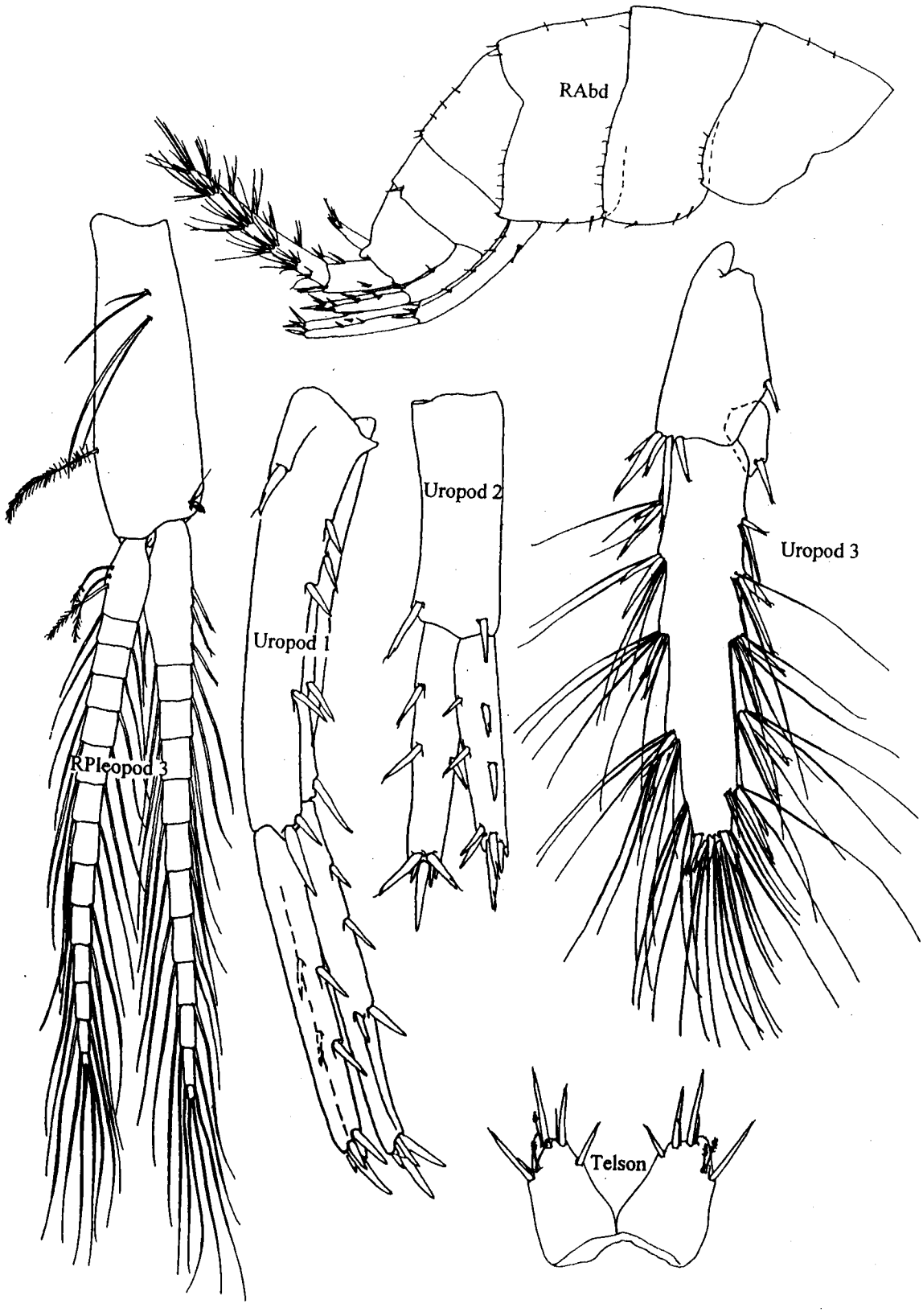

Fig. 4.4. *Nurina poulteri* holotype, male 'a': abdomen, third pleopod, uropods 1-3, telson.

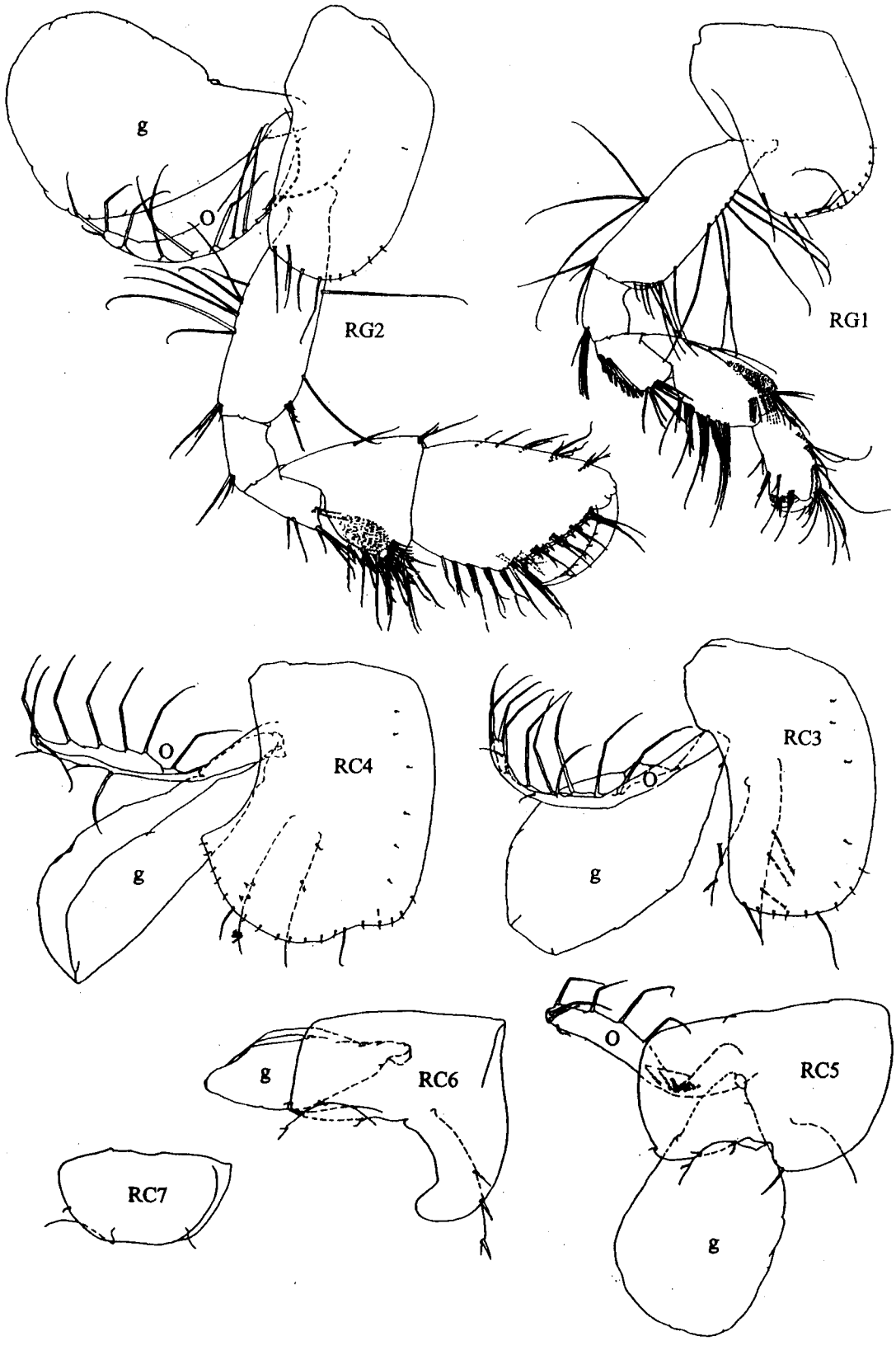

Fig. 4.5. *Nurina poulteri* allotype, female 'b': gnathopods 1-2, coxae 3-7 indicating coxal gills and oostegites.

setae, an apicolateral to apical row of four long plumose setae, apicofacially and apicolaterally pubescent; the inner plate with a medio- to apico-facial row of eleven plumose setae, seven apicolateral plumose setae and three sub apical strong naked tooth spines; medial margin straight, naked, the apicomedial corner subquadrate; palp article three with a medial to distolateral row of long setae, and a row of long setae basal to the dactyl, the apex marginally setulate with a group of slender setae facial at the hinge of the dactyl, the dactyl itself bearing three accessory posterior setules and two setules basal to the nail. *First gnathopod*: small; coxal plate subrectangular, apically rounded with an apico-marginal row of eight long, slender setae and five anteroventral short slender setae; merus posteriorly bulbous and setate with a distal row of long, strong setae; carpus subtriangular, short about 0.5x propodus, not lobate, bearing post-transverse rows of strong rastellate and a few elongate simple slender setae; propodus trapezoidal, apically expanded, longer than wide with few anterior, posterior and facial setal rows, seven clusters of elongate facial setae at the dactyl base; palmar corner subquadrate, the palm short, marginally finely denticulate, strongly notched, with a sub palmar row of seven strong setae between the corner and notch, the palmar angle transverse to slightly oblique; the dactyl short, with three medial setae and a long slender seta basal to the nail, reaching almost to the palmar corner. *Second gnathopod*: much larger then the first; coxal plate subrectangular, broadly rounded apically with four short anteroventral and seven longer apical setae; merus postdistally extended, subquadrate; carpus subtriangular, moderately lobate, bearing transverse posterior rows of long setae; propodus much enlarged, three times the first gnathopod, ovate, longer than wide (1.5x) with seven transverse dorsal (anterior) rows and six ventral (posterior) rows of setae; palm strongly oblique, rounded without a clearly defined palmar corner, the palm delineated by a marginal row of robust trigger setae and long slender simple setae; the dactyl short of the palmar corner bearing a row of small hooked setae sub marginal to the proximal edge, a small recumbent inner tooth spine and single seta basal to the nail. *Pereopods*: pereopods three and four equal in length, longer than the gnathopods; coxa three subrectangular, apically rounded, broader than long, with only a few marginal setae ventrally; coxa four ovatorectangular, moderately excavate posteriorly, with small marginal ventral setae; coxae five and six bilobed; coxa five with a single slender seta ventral on the anterior lobe and small ventral and postventral setules; coxa six with two very small

posterior setules; coxa seven lacking an anterior lobe, bearing one small posterior setule. Pereopods three and four second article bearing long, straight, distally curved posterior setae, articles three and four with few short to medium length setae, articles five and six with mixed slender and robust setae. Pereopods five to seven; basis moderately expanded, with small posteroventral lobes, short to medium length anterior robust setae and short, weak posterior setae; merus to propodus well armed with long robust and slender setae, extremely long posteriorly on the carpus of each, dactyls without accessory setae except the normal single posterior and outer penicillate setules. *Gills*: coxae two to six bearing flask shaped gills, decreasing in size posteriorly, although gill six not significantly smaller than gill five. *Pleopods* peduncles each bearing two retinaculae and two accessory retinaculae distomedially, and few short setae, some plumose; rami subequal in length, basal articles each with several setae, the medial setae of medial rami diamond headed, all rami of fourteen articles, except the medial third being of twelve articles. *Epimera*: epimera one with one anterior and one mid submarginal robust seta, the postventral corner acuminate but not spinous, the posterior margin slightly convex, almost straight, with six small setules; epimeron two with two anteroventral submarginal robust setae, the postventral corner acuminate, not spinous, the posterior margin slightly sinuous with five small setae; epimeron three with three anteroventral facial robust setae, the postventral corner acuminate but not spinous, the posterior margin slightly sinuous with six small setae. *Pleon*: pleonites one to three and urosomite one bearing few weak dorsal and dorsolateral setae; urosomite two with a single postlateral robust seta, urosomite three naked. *Uropods: First uropod*: longest; peduncle length 1.3x the length of the inner ramus, bearing a robust seta basofacially, a dorsolateral row of three robust setae and two apicodorsal robust setae, and a dorsomedial row of two robust setae and one apicomedial robust seta; rami subequal in length, the inner ramus being slightly longer, the outer ramus bearing two lateral and two medial robust setae, the inner ramus with one lateral and three medial robust setae, and each with five apical robust setae. *Second uropod*: smaller than the first, 0.6x the length; the peduncle length equal to the inner ramus, slightly longer than the outer (1.1x), peduncle bearing single apicolateral and apicomedial robust setae; outer ramus with two dorsolateral and one dorsomedial robust setae and five apical robust setae, the inner ramus with two dorsolateral, two dorsomedial and five apical robust setae. *Third*

uropod: strongly extended, length 0.8x uropod one; peduncle short, less than 0.5x the length of the outer ramus, with five apicolateral robust setae and one apicomedial robust seta basal to the inner ramus; inner ramus small, scale like, 0.4x peduncle length, bearing a single distal robust seta; outer ramus elongate, one articulate, linear, sub rectangular with a width to length ratio of 0.2, bearing five lateral and five medial transverse ranks of mixed long robust setae and very long slender simple setae, an apical cluster of six short robust setae and twelve very long slender simple setae. *Telson*: length less than width, shorter than urosomite three (0.75x), cleft 95% of length, lobes sub triangular, lateral margin almost straight, medially concave, narrowing distally to a mid distal peak bearing three small apical acuminations, lateral and medial robust setae dorsally at M0.8, and two sub apical robust setae medial to the apex, paired penicillate setules sub lateral at M0.85 and a single sub apical penicillate setule as well as one or two marginal naked setae, otherwise without dorsofacial setation.

Description of allotype (female 'b')

Similar to the holotype, except in the following: *Body*: Length 7.5 mm. *Mandibles*: palps three articulate, ratio of article lengths R-20:54:45, L-20:58:45, setae of article three of both 1C, 2D, 4E. *Maxillae*: inner plate of first maxilla bearing L 8, R8 plumose medial and apicomedial setae; palps asymmetric, left palp second article terminating in long strong setae, similar to the holotype, the right palp terminating in strong setae and broad fused tooth spines, differing from the holotype in number of denticulations. *First gnathopod*: first gnathopod small, smaller than gnathopod two, similar to the male holotype except that the palm lacks a notch. *Second gnathopod*: much larger than gnathopod one; propodus large, ovatorectangular; palm without a clearly defined corner, indicated by the extent of robust trigger bearing setae; dactyl slightly shorter than the palm, bearing two facial setules a small recumbent inner tooth spine at the base of the nail and a row of submarginal hooked setae; coxae two to five each bearing, in addition to a flask shaped gill, narrow, moderately setose oostegite, the anterior lobe of coxa six extended ventrally into an elongate curved plate. *Uropods*. *First uropod*: peduncle bearing a robust ventrofacial seta, a dorsolateral row of three robust setae and two apicolateral setae, and a medial row of two dorsolateral robust setae and one apicomedial robust seta; outer ramus bearing two dorsolateral, two dorsomedial and five apical robust setae; inner ramus one dorsolateral, two dorsomedial and five

apical robust setae. *Third uropod*: very similar to the male holotype; inner ramus bearing a second small apical seta; outer ramus of one article, bearing five translateral clusters of robust and slender setae both laterally and medially, and six robust and six very long slender apical setae.

Description of male 8.9 mm

Similar to the holotype, except in the following: *First antenna*: primary flagellum of twenty four articles (apex lost), the first elongate, 2x article two, the accessory flagellum of four articles, extending to M0.7 of article four of the primary flagellum. *First gnathopod*: with a deep palmar notch. *Second gnathopod*: very much larger than the first, propodus enlarged 3.5x the first. *Uropods*. *First uropod*: peduncle with four dorsolateral, two apicolateral, two dorsomedial and one apicomedial robust setae; inner ramus bearing one dorsolateral, three dorsomedial and five apical robust setae; outer ramus bearing two dorsolateral, three dorsomedial, and five apical robust setae. *Second uropod*: peduncle bearing only a single apicolateral robust seta; inner ramus with three dorsolateral, two dorsomedial and five apical robust setae; outer ramus with one dorsolateral, three dorsomedial and five apical robust setae. *Third uropod*: peduncle bearing small basal and lateral facial setae, two apicolateral and two apicomedial robust setae; inner ramus small, scale like, bearing two apical robust setae; outer ramus one articulate, with six transverse medial and lateral clusters of robust and very long slender setae, the apex with five robust and twelve very long slender setae. *Telson*: the right lobe bearing an additional, fifth, lateral robust seta, the left lobe without this addition.

Distribution

Nurina Cave N46 and cave N1327, Roe Plains Western Australia.

4.2 North West Cape, Western Australia:

The genus *Nedsia* was erected by Barnard and Williams (1995) to accommodate a single species of the coastal plain of North West Cape; *N. douglasi*. The species was named from female types only. Male *N. douglasi* are described here, the genus rediagnosed and the species redescribed. Collections by the Western Australian Museum from ground waters on Barrow Island, an isolated extension of the Cape Range, revealed the presence of species of *Nedsia*, which are here described. A

second melitid taxa, *Norcapensis mandibularis* which inhabits pools in the limestone caves of the rugged Cape Range is also described.

4.2.1 *Norcapensis* n.gen.

Etymology

Named for the type location - North West Cape, Western Australia.

Type species

Norcapensis mandibulis n.sp.

Diagnosis

Pleonite six with two small dorso-lateral robust setae, rostrum obsolescent, lateral cephalic lobes strongly projecting, broad, no antennal sinus, eyes absent. First antenna: elongate, longer than second antenna, ratio of peduncular articles 34:31:12, accessory flagellum two articulate, second article tiny. Second antenna: very short, flagellum much shorter than peduncle, calceoli absent. Upper lip: symmetrical, ovate. Mandible: palp three-articulate, articles reduced with few setae; accessory blades (rakers) on mandibles few with two plumose setae anteriorly; few small setae beyond rakers on to base of molar. Lower lip: with inner lobes. Maxillae: moderately to well setose medially; inner plate of first maxilla ovate with medial and distal plumose setae; outer plate with seven or more denticulate robust setae, palps symmetric, each with thin apical robust setae. Inner plate of second maxilla with row of plumose medial setae extending to the apex, some facial; both plates of second maxilla with plumose apical setae of medium to moderate length. Inner plate of first maxilla and medial and lateral margins of second poorly pubescent. Maxilliped: inner plate long with disto-facial row of plumose setae extending apically, blunt naked tooth like robust setae terminally; outer plate large with apical plumose setae continuous with paired rows of curved facial setae extending medially and sub-marginally from the base; anteromedial margin carved into sinuosities without marginal robust setae; palp articles two and three with few lateral setae, moderately setose medially; article three without setae

or comb rows at base of the dactyl, disto-laterally and facially pubescent; apex not produced, dactyl unguiform, multi spinous, facially pubescent with short nail and terminal accessory spinule. Coxae: one to seven short, broader than long; coxae one to four lacking posterior robust setae; coxa one not expanded below; coxa four not excavate posteriorly; coxa five as long as four. Gnathopods: diverse, dactyls lacking inner tooth like robust seta, lacking nail. First gnathopod: small, feeble, carpus equal to propodus, not lobate, merus lacking hyaline lobe, without rastellate seta, palm transverse, robust setae not symmetrically bifid, rather with small sub-apical trigger like extensions; armaments at corner of palm few lateral and medial robust setae, setae along palm sparse and simple. Second gnathopod: enlarged, 3.3x gnathopod one; carpus short and lobate, hand enlarged and ovate, palm strongly oblique, spinose and irregularly setose, defining corner with strong lateral and medial robust setae. Pereopods: three and four of proportions similar to pereopods five to seven; posterior robust seta sets on article six of pereopods three and four unevenly spaced; pereopods five to seven moderately long, pereopods six and seven subequal, longer than five, article two moderately expanded, ovato-rectangular, posteroventrally extended, slightly lobate on peraeopod six, lobate on peraeopod seven; dactyls of pereopods lacking accessory spinules. Coxae two to six each with a single flask-shaped gill, that of coxa six not reduced. No sternal gills. Oostegites: present on coxae two to five; thin, strap like, poorly setose. Epimera: posteroventral tooth of epimera one to three absent; posterior margins smooth to sinuous with few setae; epimera two and three with facial robust setae near the ventral margin. Pleopods: peduncles with few setae, rami extending equally, baso-medial setae of inner rami not bifid; retinaculae two per pleopod, no accessory robust setae. Uropods: apico-lateral corner of peduncles of uropods one and two with one or two robust setae; medio-dorsal margin of peduncle of first uropod spinose, of second naked, medio-distal margin of first uropod with two robust setae; first uropod with basofacial robust seta; lateral rami of uropods one and two shorter than medial, rami of both uropods mostly with two robust seta rows; third uropod: strongly extended,

peduncle short, outer ramus large, inner ramus short, scale like, medial setae of outer ramus sparse, peduncular robust setae few, medial and distal. Urosome: ventrodistal robust seta on urosomite one at base of uropod one absent. Telson: longer than broad, cleft 90%, laterally convex, bearing, short, marginally sub-apical setae with one or two long lateral penicillate setae and small, paired lateral penicillate setules.

Relationship

The relationship of *Norcapensis* to other melitids is obscure. Attention is drawn to the presence of eriopisid characters, including: absence of eyes; medial setosity of the maxillae; symmetricity of the first maxilla palps; dissimilarity of the gnathopods; non-lobate fourth coxa; peduncular basofacial spine present on the first uropod; elongate third uropod; and deeply cleft, apically notched tapering telson bearing few setae. Among the three eriopisid genera, *Norcapensis* has several characters in common with *Victoriopisa* Karaman and Barnard, including: fusion of the basal articles of the flagellum of the second antenna; seven denticulate apical spines present on the outer plate of the first maxilla; elongate carpus and transverse, convex palm on the first gnathopod; broad, ovate coxal gills. The genus differs, however, from *Victoriopisa* in that: C setae are present and A setae absent from the mandibular palp; inner plate of the first maxilliped is ovate rather than ovato-triangular; fourth article of the seventh pereopod is not dilated; outer ramus of uropods one and two are shorter than inner.

This genus appears related to *Nedsia* Barnard and Williams, a marine invader or 'crawlout' from the lowland coastal plains of North West Cape and Barrow Island (Barnard and Williams 1995; Bradbury and Williams 1996a). *Norcapensis*, nevertheless, differs from *Nedsia* in several minor ways: relatively short first and third articles of the peduncle and the longer flagellum of the first antenna; the upper lip is not excavate below; there are three rather than two articles of the mandibular palp; a greater number of setae on the inner plate of the first maxilla; setae of the outer plate of the maxilliped are not blunt and are more numerous and the distal

plumose setae are not accompanied by a bent naked medial robust seta, the apex of the maxillipedal palp is not produced even weakly and the dactyl bears additional accessory setules. The carpus of the first gnathopod is equal in length to the propodus rather than longer, with reduction in the length of the lateral setae at the palmar corner and greater numbers of setae and robust setae along the palm; the second gnathopod is enlarged with a strongly oblique and more setose palm, the palmar corner marked by two or three stout lateral and medial robust setae rather than a single robust seta; the sixth periopod is sub-equal to the seventh, article two of pereopods six and seven is progressively lobate rather than without lobes as found in *N. douglasi* Barnard and Williams. There are additional setae on the peduncle of the pleopods and the rami are equal with no accessory robust setae to the retinacula; the medial margin of the peduncle of the second uropod is without robust setae and the medial ramus bears a single, rather than two robust seta rows; the inner ramus of the third uropod is reduced and the outer ramus long and slender rather than phyllode-like. The telson of *Norcapensis* is cleft 90% rather than 100%, as in *Nedsia*.

The relationship of *Norcapensis* with the other hadzioid genus (*Brachina* Barnard and Williams 1995) from Australian fresh waters is less close. The genus differs from *Brachina* in: mandibular palp is well developed; lower lip bears inner lobes; inner plate of first maxilliped is ovate, medially setose and pubescent; palp of maxilliped disto-facially pubescent and inner plate baso-facially pubescent; coxae reduced, all of about the same length; gnathopods and pereopods one and two bearing long posterior setae on the second article, dactyls of pereopods without nail; second article of third uropod elongate; telson slender, with few apical robust setae or setae, cleft 90% rather than 100%.

4.2.1.1 *Norcapensis mandibulis* n. sp. Figs. 4.6-4.9.

Etymology

Named for the presence of well-developed mandibular palps.

Type locality

Underground water, Cape Range, North West Cape, Western Australia.

Material examined

Cape Range, Western Australia. Holotype (WAM 511-97) female "p" 10mm, in type series; Allotype (WAM 512-97) male "t" 12mm, 7 other female paratypes (WAM 513-97), Western Australia Museum: collection CR1989 3236, in gravel in freshwater pool in deep limestone cave, 22°07'S, 113°59'E, collected by hand net, R.D.Brooks, 23 June,1989. Other material: female "q" 10mm (WAM 514-97), and 4 other females (WAM515-97); station CR1989 3241, in freshwater canal outflow of limestone cave, 22°09'S, 114°00'E, collected by hand net, R.D.Brooks, 29 June,1989; female "r" 9mm (WAM 516-97) and 2 other females (WAM 517-97), station CR1989 3212, freshwater pool in deep limestone cave, 22°05'S, 113°59'E, collected by hand net, B.Vine, 26 June,1989; male "s" (WAM 518-97) and 8 females (WAM 519-97), station CR1989 3225, freshwater pool in deep limestone cave, 22°03'S, 114°01'E, collected by hand net, B.Vine, 27 June,1989.

Diagnosis

As in the genus.

Description of holotype (female 'p')

Body: urosome poorly armed dorsally, length 10mm. *Head*: rostrum obsolescent, eyes absent. *First antenna*: length about 0.7x body, 2.7x second antenna; flagellum longer than peduncle, of twenty six articles; peduncle articles one and two approximately equal, one longest, three shortest, article one with few robust setae or setae, bearing a medio-distal group of three setae but no robust seta, setae sparse on articles two and three; calceoli and aesthetascs absent; accessory flagellum two-articulate, small, second article tiny, extending to M0.5 on first article of primary flagellum. Primary flagellum articles uniform, sparsely setulate. *Second antenna*:

length 0.2x body, peduncle much longer than flagellum, articles four and five equally long, sparsely setulate, other articles with few setae or robust setae; flagellum short, five articulate, few setae, lacking calceoli. *Upper lip*: symmetrical, ovate, apically pilose. *Lower lip*: bi-lobed, outer lobes with spinous setae and pilia medially, inner lobes distally pilose. *Left mandible*: palp three-articulate, ratio of articles 5:7:14, article one naked, article two linear, subequal to article one, with two medial setae, article three sublinear lacking A or B setae, with 3C1D5E setae; incisor five-teeth, lacinia mobilis six teeth, molar with distal plumose seta and peripheral posterior pubescence. *Right mandible*: similar, palp ratio of articles 5:13:13, article two bearing a single distal seta, setae of article three 3C1D7E. *First maxilla*: left and right sides asymmetrical; inner plate ovate to round bearing fourteen plumose apical setae, covered in short pubescence; outer plate bearing seven denticulate terminal robust setae on the left side, ten on the right; palp article two terminating in ten long robust setae on the left, eight on the right. *Second maxilla*: lateral edge of outer plate and baso-medial margin of inner plate pubescent; outer plate terminating in thirteen long plumose setae (the spinules being restricted to the medial face), and one short naked seta; inner plate bearing five long terminal setae, some naked robust setae medio-distal to distal, and many plumose medial setae extending medio-distally on the face. *Maxilliped*: peduncle bearing three facial robust setae basal to inner plate; inner plate bearing a medial submarginal row of pubescence; palp article three with a row of medial robust setae progressing to submarginal/facial distally, a single disto-medial robust seta basal to the dactyl, and two rows of subdistal facial robust setae; adjacent the apex a row of seven robust setae marginal to ventro-facial; distal face covered in non-organised fine setae. *First gnathopod*: coxal plate with two small setae, one antero-dorsal and one ventral; article four posteriorly bulbous, but not lobate, covered in short pubescence; article five sub-quadrate, not lobate, bearing clusters of slender robust setae; propodus trapezoidal, expanded apically, longer than wide, few posterior robust setae, cluster of eight robust setae terminally at dactyl base; palmar corner

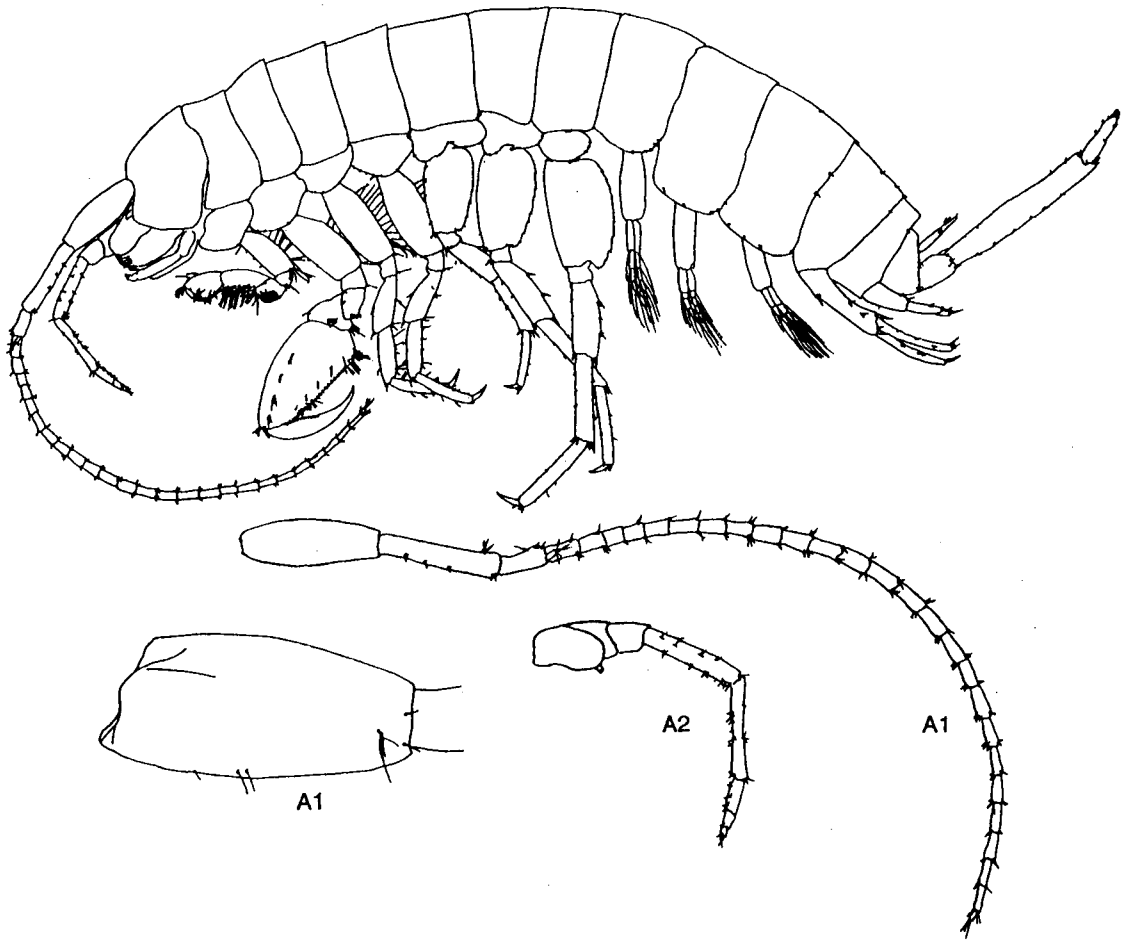

Fig. 4.6. *Norcapensis mandibulis* n. sp. holotype female 'p'; body and antennae.

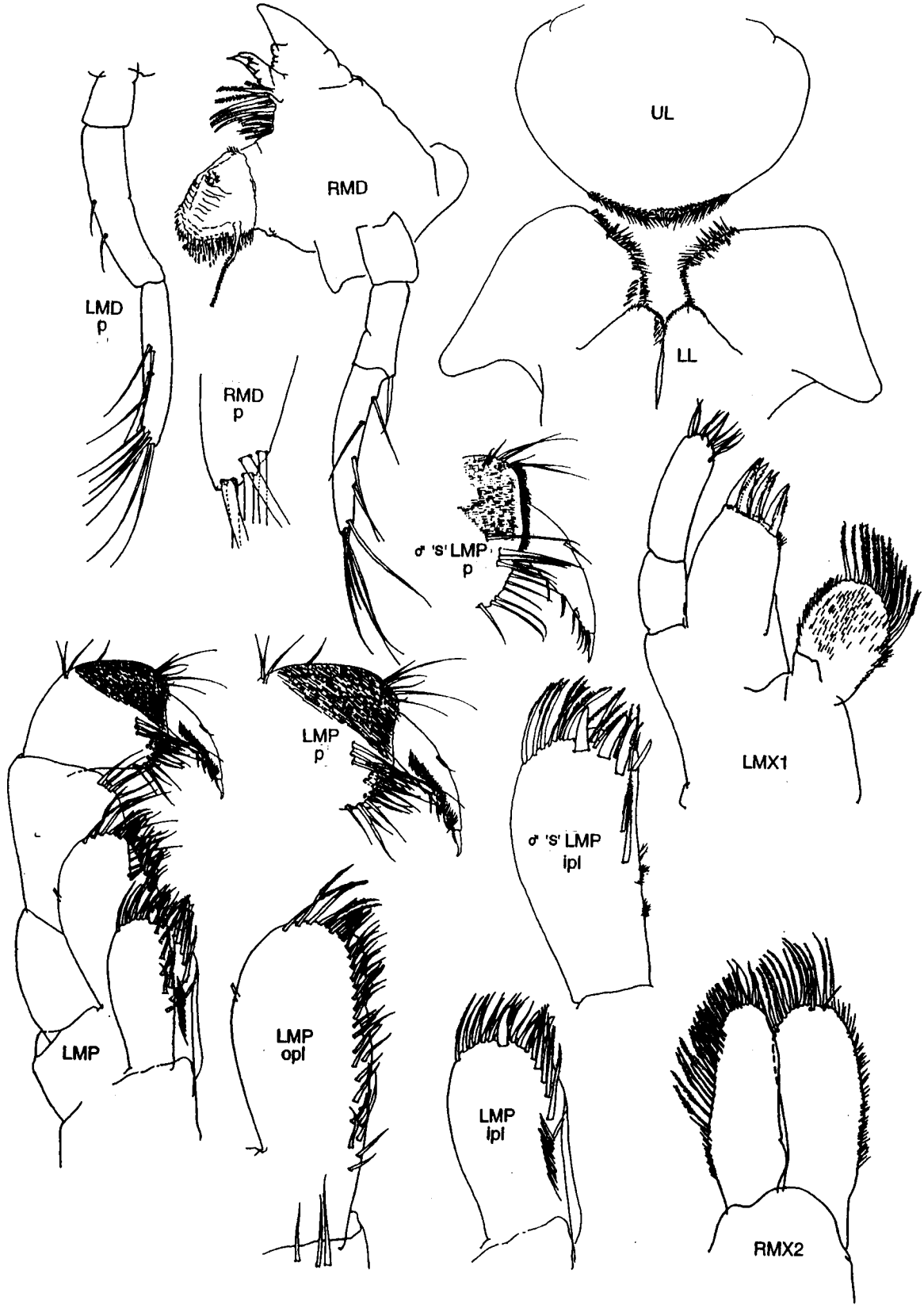

Fig. 4.7. *Norcapensis mandibulis* n. sp. holotype female 'p'; mouthparts (all drawings except those indicated). Male 's' maxilliped inner plate and palp.

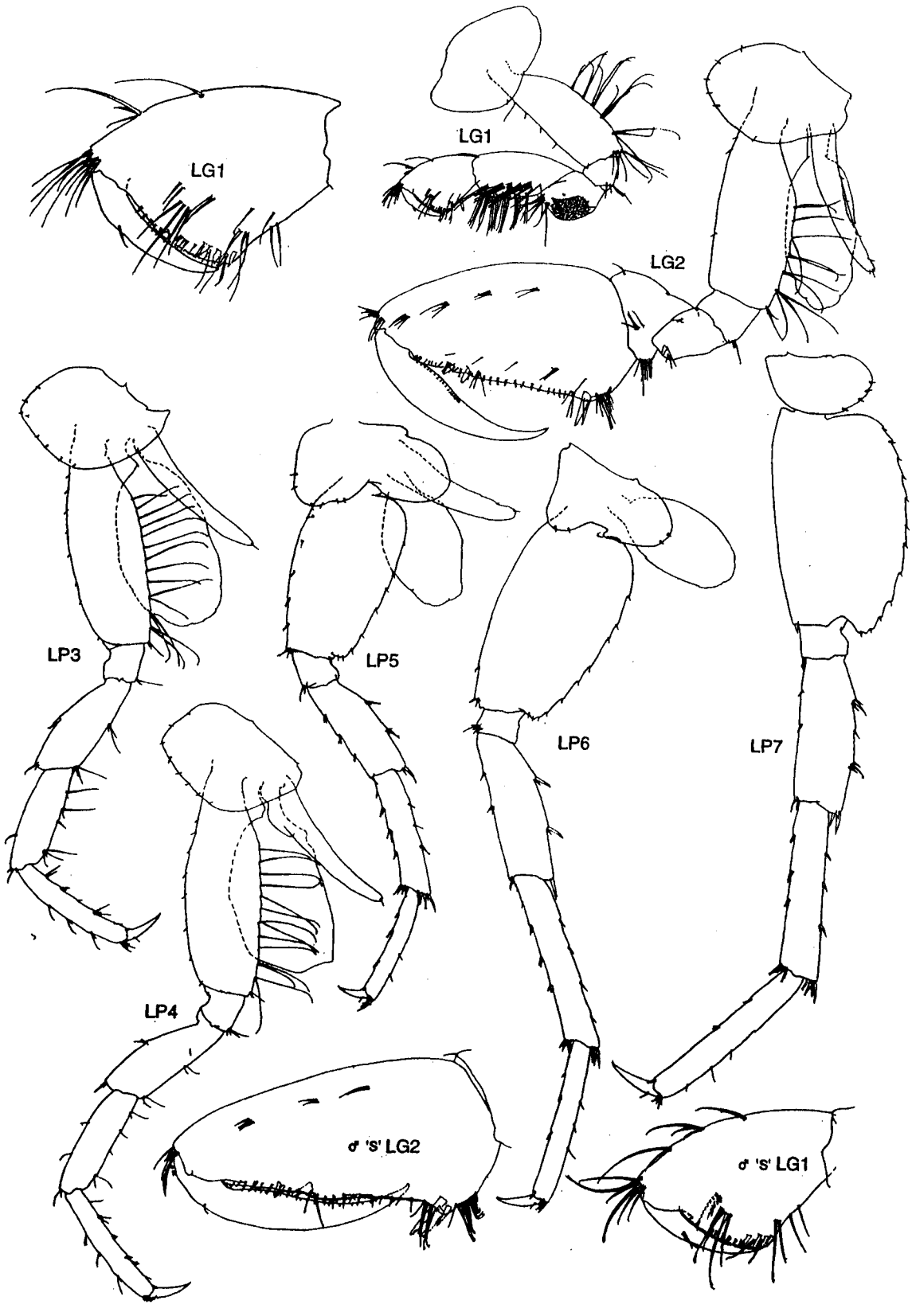

Fig. 4.8. *Norcapensis mandibulis* n. sp. holotype female 'p'; legs (all drawings except those indicated). Male 's' propodus gnathopods one and two.

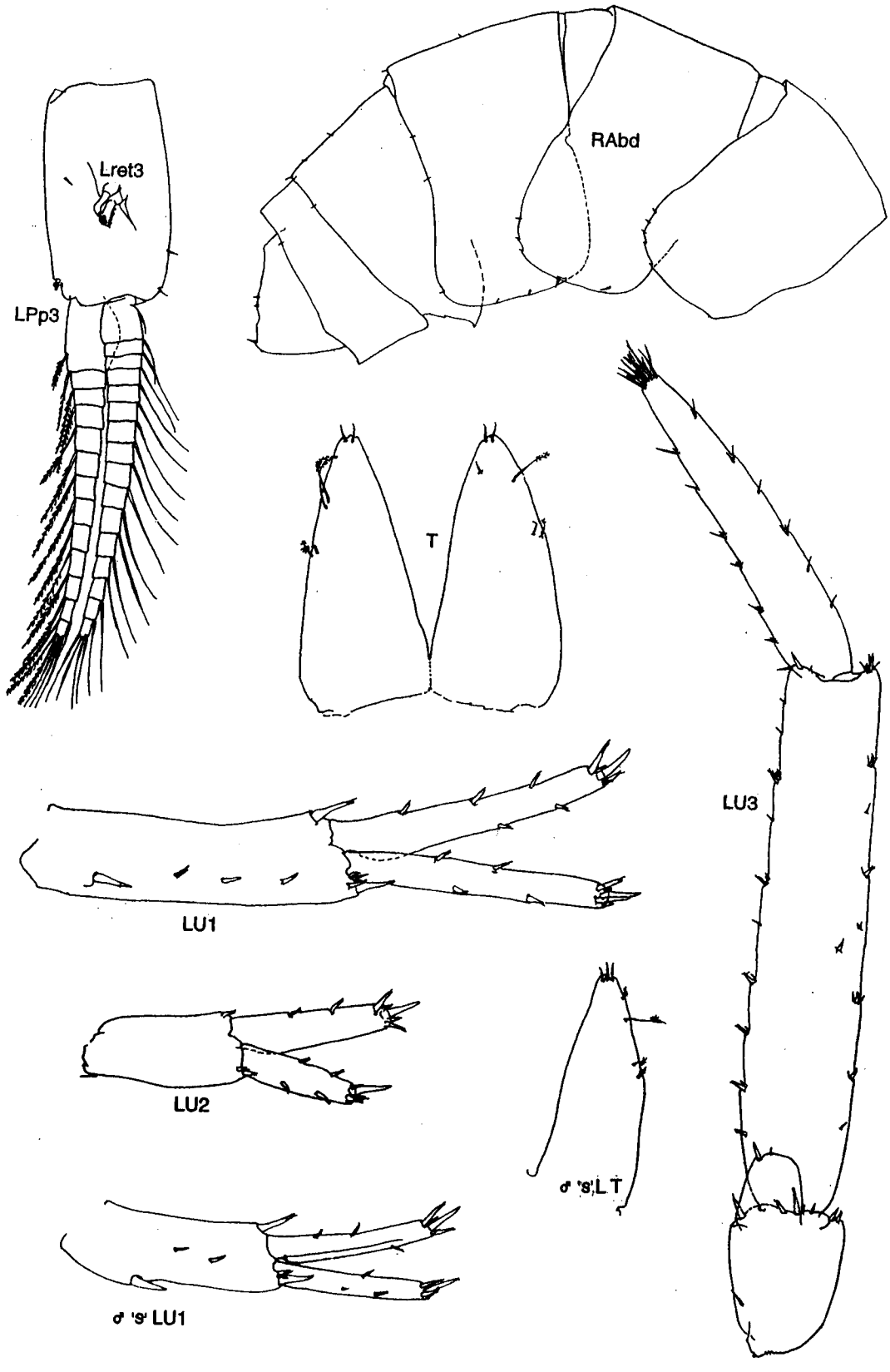

Fig. 4.9. *Norcapensis mandibulis* n. sp. holotype female 'p'; abdomen, pleopod, uropods and telson (all drawings except those indicated). Male 's' left telson.

defined by four stout medial robust setae (the first three evenly spaced) and two slender lateral robust setae, palms convex, transverse to slightly oblique, setae along palm small, slender, mostly sub-marginal, row of fine robust setae proximal to corner; dactyls without medial spination, length short of palmar corner. *Second gnathopod*: coxal plate broadly rounded, few anterior and one ventral setae; article four posteriorly expanded; carpus moderately lobate; propodus enlarged, 3x first gnathopod, ovate, longer than wide, with a row of clusters of facial robust setae dorsally and ventrally; palm strongly oblique, palmar corner rounded, marked by a pair of moderately long, stout robust setae, robust setae along palm mostly small, with triggers, and a pair of distal stout, blunt robust setae; dactyl short of palmar corner, with a sub-marginal row of small trigger robust setae along the proximal edge. *Pereopods*: pereopods three to five equal in length, longer than gnathopods; coxa three rounded, sub-quadrate, slightly broader than long, few marginal setae anteriorly and ventrally; coxa four similar, slightly broader, not posteriorly excavate; coxae 5-6 bilobed, small, irregular, coxa five without posterior setae, coxa six with two small posterior setal robust setae; coxa seven lacking anterior lobe, with four small posterior robust setae. Pereopods three and four, article two with long, straight, distally curved posterior setae, articles three and four with few to moderate armaments, articles five and six with mixed robust setae and setae, the posterior robust seta formulae of articles six = 2s,sS,S,3s,S,S and s,3s,2s,2S,s,S with only single locking robust setae on each. Pereopods five to seven, article six armaments few, articles two to five moderately spinose with strong apical spination on article five, dactyls without accessory robust setae except for a single outer penicillate setule. *Gills*: those of coxae two to six flask-shaped, that of coxa six not reduced. *Oostegites*: present on coxae two to five and simple, strap like, poorly setose. *Pleopods*: each bearing two retinacula with no accessory robust seta, rami equal in length; peduncle of second pleopod with three short median, one apico-posterior and one apical seta, basal articles of rami each with one seta; peduncle of pleopod three bearing one mid-median, one apico-medial, one apical and one short

apico-posterior seta; rami with 1-2 setae on basal articles. *Epimera*: one and two, post-ventrally rounded, bearing five and three small robust setae respectively, epimeron two with one moderate antero-ventral robust seta and one small mid-ventral robust seta; posterior margin of epimeron one slightly concave, epimeron three with small rounded extension posteriorly, one small post- ventral robust seta as well as four small to moderate ventro-marginal robust setae, one post-dorsal and one posterior dorso-lateral small setae. *Pleon*: pleonite three bearing single small posterior dorsal and dorso-lateral setae; three small dorsal setae on pleonite four, pleonites four and five bearing single dorso-lateral setae on the posterior margin, pleonite six with small posterior robust setae paired dorso-laterally and single robust setae ventrolaterally. *Uropods*: length of uropods relative to uropod one: uropod two 0.5x, uropod three 1.8x. Uropod one, peduncle length 1.2x inner ramus, baso-facial robust seta present, and a moderate lateral row of 2-1-1-0-1 robust setae the last being subdistal, two small sublateral distal spurs, one large apico-lateral robust seta and 1 large medial sub apical trigger robust seta; rami of sub-equal length, the inner being the longer, each with lateral and medial rows of two or three robust setae and a cluster of five terminal robust setae. Second uropod smaller than first, peduncle sub-equal to lateral ramus, bearing two apico-lateral and one apico-medial robust setae; outer ramus 0.75x inner with two sparse rows of single marginal robust setae and four apical robust setae; inner ramus lateral robust setae absent, 2 medial robust setae, terminal cluster of five robust setae. Third uropod, strongly extended, 0.3x body, peduncle short, 0.25x length of article one of the outer ramus, bearing a small ventral robust seta at M0.4, a single ventro-distal robust seta, paired medio-distal and latero-distal short robust setae and a pair of short apico-dorsal robust setae; inner ramus small, scale-like, 0.5x peduncle, naked except for a single ventro-distal robust seta and a small distal seta; outer ramus elongate, two articulate, proximal article linear, sub rectangular, width to length ratio of 0.2, armed with marginal ranks of short robust setae and setae and a single facial robust seta at M0.5, a lateral apical cluster of two short robust setae and four

setae, the medial apex bearing one robust seta and two setae, distal article 0.6x proximal, slender, similarly armed marginally, tapering from base to apex, terminating in a cluster of twelve slender robust setae. *Telson*: length twice width, longer than urosomite three (75:60), cleft 90% of length, apices notched, two short marginally sub apical setae on either lobe, with one or two moderately long penicillate dorsal setae at M0.9 and short, paired dorso-lateral penicillate setules at M0.7.

Description of allotype (male 't')

Body: length 12mm. *Mandibles*: palps three-articulate, ratio of articles 5:10:12 (cf. 5:7:14 L or 5:13:13 R), setae of article three left 4C2D5E, right 1C1D4E. *Maxillae*: inner plate of first maxilla bearing twelve (cf. 14 in the holotype) plumose apical setae; palp article 2 terminating in long robust setae, 8L,7R (cf. 10,8). *Maxilliped*: peduncle bearing two (cf. 3) facial robust setae basal to the inner plate; inner plate with plumose medio-distal seta replaced with medium naked robust seta on L side palp article three apex with five rather than seven ventro-facial/marginal robust setae. *First gnathopod*: six anterior apical robust setae of propodus at base of dactyl (cf. 8). *Second gnathopod*: larger than gnathopod one - 3x (cf. 3.3x); defining corner of palm with three strong medial trigger robust setae, and marginally and laterally two long slender trigger robust setae, two similar but distally serrate, and one short slender robust seta distally serrate. *Pereopods*: article six of pereopods three and four with posterior robust seta formulae; peraeopod three ; s,2S,s,s2S,s,S and peraeopod four ; 2sS,2s,S,s,s. *Pleopods*: peduncles without setae except a single apico-lateral seta on pleopod two. *First uropod*: peduncle with lateral row of 1-1-0-1 robust setae (cf. 2-1-1-0-1), without small sub-lateral distal spurs; trigger present on the single apico-lateral robust seta, but absent from the medial sub apical robust seta (cf. reverse in the type). *Second uropod.* peduncle bearing a single apico-lateral robust seta (cf. 2), outer ramus short 0.7x inner (cf. 0.75). *Third uropod*: peduncle without short apico-dorsal robust setae (cf. 2); inner ramus 0.6x peduncle (cf. 0.5) bearing a pair of small distal setae (cf. 1); outer ramus

proximal article bearing a lateral apical cluster of three robust setae and three setae (cf. 2&4) the medial apex two robust setae and two setae (cf. 1&2). The distal article terminating in eleven slender robust setae (cf. 12). *Telson*: apices with a single notch, three short, sub-apical setae on either lobe; plumose dorsal setae at M0.5, 0.6, 0.8; single dorsolateral penicillate setules at M0.7.

Description of other material

Specimen 'q', female

Body: length 10mm. *First antenna*: flagellum of thirty articles. *Mandibles*: ratio of lengths of articles of left palp 5:12:11 (cf. 5:7:14), second article not reduced, longer than article one; setae of article three 3C2D5E; lacinia mobilis with four teeth, ratio of lengths of articles of right palp 5:10:9.5, setae of article three 4C1D5E. *Maxillae*: inner plate of first maxilla bearing thirteen apical plumose setae, right outer plate bearing eleven denticulate terminal robust setae; outer plate of second maxilla terminating in twelve long plumose setae; inner plate of second maxilla bearing one long terminal seta and many short, curved setae. *Maxilliped*: palp inner plate without facial pubescent row, several distomedial robust setae basal to dactyl and five robust setae adjacent the apex. *First gnathopod*: coxal plate bearing eight small setules; three antero-dorsal, one apical, and four ventral. *Second gnathopod*: corner of palm marked by one lateral and two medial robust setae; palmar robust setae include three rather than two stout, blunt distal robust setae. *Pereopods*: coxa of peraeopod five bearing four small sub-marginal and ventral posterior setae; posterior robust seta formulae of articles six of pereopods three and four 2sS,S,s2S,s,S and s2S,S,s2S,s,S respectively. *Uropods*: lengths of uropods relative to uropod one; uropod two 0.6x, uropod three 2.1x; length of peduncle of uropod one 1.1x inner ramus; with lateral row of 1-1-1-1 robust setae; outer ramus of second uropod bearing five apical robust setae; lateral robust setae present on inner ramus, and 1 medial robust seta. Peduncle of uropod three with two small ventral robust setae at M0.4, three mediodistal and latero-distal short robust setae, and three apicodorsal robust setae; medial apex of outer ramus bearing

two robust setae and three setae. *Telson*: apices bearing a single notch, a single terminal robust seta within the notch, displaced laterally, submarginal robust setae at M0.5 and M0.7, long penicillate setules at M0.9 and short single penicillate setule at M0.7.

Specimen 'r', female

Body: length 9mm. *Mandibles*: ratio of articles of palp; 5:12:12, setae of article three of left palp 2C3D5E of right palp 3C1D6E; left lacinia mobilis with four teeth (cf. 6). *Maxillae*: inner plate of first maxilla bearing twelve plumose setae, palp article two terminating in eight robust setae (cf. 10). *Maxilliped*: peduncle bearing two facial robust setae basal to inner plate; palp with row of five robust setae adjacent the apex. *First gnathopod*: coxa bearing a distal marginal row of six setae, two ventral to the apex, four dorsal; corner of palm defined by two stout medial bifid robust setae (cf. 4) and two slender lateral robust setae. *Second gnathopod*: palm with a single stout, blunt distal robust seta (cf. 2). *Uropods*: uropod one peduncle with 0-0-1-1-2 robust setae in lateral row, rami with lateral and medial rows of 1-2 robust seta (cf. 2-3). second uropod; 2 apico-lateral robust setae of peduncle displaced medially, outer ramus with a sparse row of marginal robust setae, inner ramus with one medial robust seta; uropod three peduncle without small ventral robust seta at M0.4; inner ramus small, 0.65x length of peduncle, bearing two rather than a single distal seta; proximal article without facial robust seta at M0.5; lateral apical group of two robust setae and three setae; distal article 0.5x proximal (cf. 0.6). *Telson*: apices notched unevenly, one notch displaced laterally, retaining two short marginally sub apical setae on both sides, but with single short penicillates at M0.9

Specimen "s", male

Body: length 10mm. *First antenna*: flagellum of twenty eight articles (cf. 26). *Mandibles*: palp ratio of articles 5:10:12 (cf. 5:7:14), article two naked, incisor of left mandible with 6 teeth (cf. 5), setae of right palp; 2C2D4E. *First maxilla*: inner plate bearing eleven plumose apical setae (cf. 14); left outer plate bearing five terminal robust setae (cf. 7). *Maxilliped*: peduncle bearing two (cf. 3) facial robust setae basal to the inner plate; inner plate plumose medio-distal seta replaced with medium naked robust seta on left side; palp article three apex with five rather than seven ventro-facial/marginal robust setae. *First gnathopod*: coxal plate with several

small sub-marginal anterior setae rather than one antero-dorsal and one ventral seta; propodus with nine rather than eight robust setae in a terminal cluster at the base of the dactyl. *Pereopods*: coxal plate five bearing a single small posterior seta; coxa seven with three small posterior robust setae (cf. 4); pereopods three and four, articles five and six with posterior robust seta formulae 2sS,S,s2S,s,S and S,sS,s2S,s,S. *Epimera*: posterior margin of epimera one bearing three mid-lateral to dorsal small setae; epimeron three with small post-ventral notch, three rather than four ventral marginal robust setae. *First uropod*: peduncle with 1-1-1-0-1 lateral row of robust setae, no sub marginal lateral distal spurs. *Second uropod*: peduncle bearing one apico-lateral robust seta and a single medial robust seta on the inner ramus. *Third uropod*: peduncle with single (cf. paired) medio-distal and latero-distal short robust setae and a single short apico-dorsal robust seta (cf. 2); outer ramus without facial robust seta at M0.5, but with five rather than three robust setae at the medial apex: distal article short (perhaps regenerate) 0.28x proximal, with few marginal armaments, terminating in a cluster of eight (cf. 12) slender robust setae. *Telson*: apices with single rather than paired notches bearing single setae; single dorso-lateral setae at M0.6, M0.7 and M0.9. *Penis*: paired penial processes laterally on sternum adjacent coxal plates of P7.

Distribution

Cape Range, North West Cape, Western Australia.

4.2.2 *Nedsia* Barnard and Williams 1995

Introduction.

This genus was erected by Barnard and Williams (1995) for a single species collected from North West Cape in Western Australia; only females were represented in the collection. The genus is redefined and expanded, to include description of male *N. douglasi* and characters of ten new *Nedsia* species.

Expansion of the original diagnosis encompasses: additional dorsal spination of the pleonites, variation in the ratio of lengths of articles of the peduncle of the first antenna and length of the second antenna, variation in the medial setation of the

maxillae, asymmetry of the palps of the first maxilla, greater relative length of some coxae with more posterior spines, provision for some variation of length of the inner ramus of the third uropod and division of the telson. Additional diagnostic features include allowance for a symmetrical non-excavate upper lip, presence of three, rather than two, blunt naked spines on the inner plate of the maxilliped, and lack of a contiguous naked tooth spine on the maxillipedal outer plate. Reference to exclusively blunt sub-marginal setae is deleted, as are variation of the apex of the maxillipedal palp, additional numbers of peduncular setae of the pleopods, equal pleopodal rami, and reduction of the spination of the rami of the first and second uropods.

The species described are congeneric with the hitherto mono-typic genus *Nedsia*. All the Barrow Island species of *Nedsia* display apically dentate palmar spines on the first gnathopod, and several also bear posterior 'hadziid' setae on the second gnathopod. Whilst the descriptions of *Nedsia* and *N. douglasi* (Barnard and Williams 1995) do not make reference to bifid palmar spines, examination of others of the species from North West Cape indicates their presence in all cases. Included in the redefinition is information on sexual differences, since the original description was based only on females; male material is now available.

4.2.2.1 Rediagnosis of the genus *Nedsia*.

Pleonites with few dorsal robust setae. *Head*: rostrum weak; lateral cephalic lobes moderately to strongly projecting, very broad; no antennal sinus present; eyes absent. *First antenna*: elongate, longer than A2; ratio of peduncular articles from 3:2:1 to 2.7:2.6:1; accessory flagellum 2 articulate. *Second antenna*: short to very short; flagellum much shorter than peduncle; calceoli absent. *Mandible*: palp reduced, 2 articulate; ratio of mandibular palp articles variable, article 1 not setose, terminal article linear or tapered, sub-truncate; setae few or nil C or D, 2 or 3 E. *Lower lip*: with inner lobes. *Maxillae*: moderately to well setose medially; inner plate of maxilla 1 ovate with variable number of medial setae, outer plate with denticulate spines, palps symmetric or nearly so, with thin apical spines; inner plate of maxilla 2 with row of medial setae extending onto face apically, other medial setae few or absent. *Coxae* 1-7: mostly short, broader than long, with few or no

posterior spines; coxa 1 not expanded below; coxa 4 not excavate posteriorly; coxa 5 as long as 4. *Gnathopods* 1-2 diverse: first gnathopod small, feeble; carpus longer than propodus, not lobate; merus lacking hyaline lobe; palm transverse, spines simple, some bearing trigger hairs and thus asymmetrically bifid, some apically dentate; spines at corner of palm = lateral 2-4 long, medial 2-5 short; setae along palm moderate to sparse and simple; second gnathopod weakly enlarged; carpus short and lobate; propodus of medium enlargement and ovate; palm oblique, irregularly spinose and sparsely setose, defining corner with 1-3 spines. *Pereopods* 5-7 moderately elongate: pereopod 7 longer than pereopods 5-6; article 2 moderately expanded, ovato-rectangular, postero-ventrally extended but not lobate; dactyls of pereopods 3-7 lacking accessory spinules. *Coxae* 2-6 each with flask-shaped gill; coxal gill 6 not reduced; coxae 2-5 each with a thin, poorly setose oostegite. *Thoracic segments*: lacking sternal gills. *Uropod* 3: strongly extended, parviramous; peduncle short; outer ramus 2 articulate, huge; inner ramus scale like, reaching to M0.15-0.25 on article 1 of outer ramus. *Telson*: longer than broad; cleft 90-100%; lobes weakly convex laterally, with sub-apical setation; setal spines, where present, lateral; single lateral penicillate setules at M0.6 to M0.7 on each side.

Additional Description. *Upper lip*: symmetrical or asymmetrical; sometimes weakly excavate below. *Mandibles*: accessory blades (rakers) very few (3-4) on right side, with or without interraker plumose setae between each main raker; both mandibles with few or no additional serrations beyond rakers. *Maxillae*: both plates of second maxilla with apical setae of medium length; inner plates of maxillae 1-2 and medial and lateral margins of maxilla 2 poorly covered with pubescence. *Maxilliped*: inner plate very long with distal row of several plumose setae and 3 blunt naked spines, and short medial row of plumose setae; outer plate large, with few distal plumose setae, continuous with a blunt naked tooth spine in some; medial margin carved into sinuosities, spineless; sub-marginal face with pairs of setae; palp articles 2-3 weakly setose laterally, article 2 moderately setose medially, article 3 with setae or comb rows of setae near the base of the dactyl, apex weakly or not produced, dactyl unguiform, with short to moderate length nail. *Gnathopods*: dactyls lacking inner tooth spine, lacking nail; *first gnathopod* without rastellate seta of article 4. *Pereopods*: 3-4 of proportions similar to pereopods 5-7; posterior spine sets on

article 6 of pereopods 3-4 unevenly spaced. *Pleopods*: similar; peduncles with 1-3 setae each; rami extending sub-equally to equally, basomedial setae of inner rami of some bifid; retinaculae 2 or 3, no more than one accessory retinaculum present. *Epimera*: postero-ventral tooth of epimera 1-3 usually absent; posterior margins smooth, and/or sinuous and sparsely setulose; some bearing facial spines near ventral margin. *Uropods*: apico-lateral corner of peduncles on uropods 1-2 with 1 and 2 spines (thus with no more than 1 ventrally displaced spine on U2); dorsal margins with or without spines; medial margin of uropod 1 with 1 or 2 apical spines; rami of uropod 1 extending sub-equally; outer ramus of uropod 2 shortened; uropod 1 with basofacial spine; most rami of uropods 1-2 with two spine rows, albeit reduced; medial setae of outer ramus of uropod 3 sparse, usually with sub-distal peduncular setae or spines. *Urosome*: ventro-distal spine on urosomite 1 at base of uropod 1 absent.

4.2.2.2 Re description: *Nedsia douglasi* Barnard and Williams 1995.

Diagnosis

Body: only pleonite 6 with 2 dorsal robust setae. Lateral cephalic lobes: strongly projecting. *Antennae*: ratio of length of peduncular articles of first antenna = 45:35:8. *Upper lip*: asymmetrical; weakly excavate below. Mandibles: accessory blades (rakers) very few (3-4), no additional serrations beyond rakers; mandibular palp 2 articulate, ratio of articles 5:8, article 2 linear, sub-truncate, setae 2 or 3 E. *Maxillae*: inner plates of maxillae 1-2 poorly covered in pubescence; well setose medially; inner plate of maxilla 1 with 6 medial setae, palps symmetric; inner plate of maxilla 2 with no setae other than medial row extending onto face apically. *Maxilliped*: naked tooth spine of outer plate blunt, palp articles 2-3 weakly setose laterally, setae of article 3 organised into comb rows near base of dactyl; nail of dactyl short. *Coxae*: 1-7 short; coxae 1-4 lacking posterior spines. *Gnathopods* 1-2 diverse in female (male unknown): palmar spines of *first gnathopod* asymmetrically bifid, spines at corner of palm = lateral 3 long, medial 4 short; setae along palm sparse and simple; defining corner of *second gnathopod* with 1 spine. *Gills*: coxae 2-4 each with flask shaped gill. *Oostegites*: present on coxae 2-5. *Pleopods*:

peduncles with 1 seta each; retinaculae = 2, accessory retinaculae = 1. *Epimera*: postero-ventral tooth of epimera 1-3 absent. *Uropods*: apico-lateral corner of peduncles on uropods 1-2 with 1 and 2 spines (thus with 0-1 ventrally displaced spines), dorsal margins spinose, medial margin of uropod 1 with 2 apical spines, all rami of uropods 1-2 with 2 spine rows, albeit weakly furnished; inner ramus of uropod 3 reaching to M0.16 on article 1 of outer ramus. *Telson*: cleft 100%; setal spines, where present, lateral; single lateral penicillate setules at M0.6 on either side.

Description of holotype

Description of Holotype female 'g': remains as recorded by Barnard and Williams 1995.

4.2.2.3 Description of male *N. douglasi* Figs 4.10 - 4.11

A single male specimen was collected from a related site on North West Cape. This specimen, male 'c', bears many similarities to the female holotype, and is believed to represent the same species. Variations from the holotype are set out within the description below.

Material examined

Male "c", 5mm.: Cape Range, Western Australia. North West Cape region, subterranean fresh waters of the coastal plain. Western Australian Museum sample # BES186. Not from type locality.

Description of male "c"

Body. 5mm. *First antenna*: ratio of peduncular articles 50:48:18 (converts to 45:43:16 compared with female type = 45:35:8). *Upper lip*: apex rounded, not excavate, connection symmetrical. *Left mandible*: palp article 1 shorter than 2; article 2 with 2 apical setae, 10 short sub-apical setae; incisor 5 teeth; lacinia mobilis with 4 or 5 teeth; 5 setose accessory blades. *Right mandible*: incisor with 5 teeth; lacinia mobilis bifid; 4 moderately setose accessory blades. *Maxilliped*: 3 blunt naked tooth spines on the inner plate. *Gnathopods*: palm of G1 more setose than female type, of G2 similar. *Pereopods*: similar to female type. *Uropods*: lengths relative to U1 = 1:0.6:1.6 (vs. 1:0.5:1.33 in the female type): U1 peduncle 1.14X outer ramus (vs 1.3X); inner ramus 1.14X outer; apices of both rami bearing 4 spines (vs 4-6); U2 rami with marginal spines 1-1 and 1-2 (vs 1-1 and 1-3.

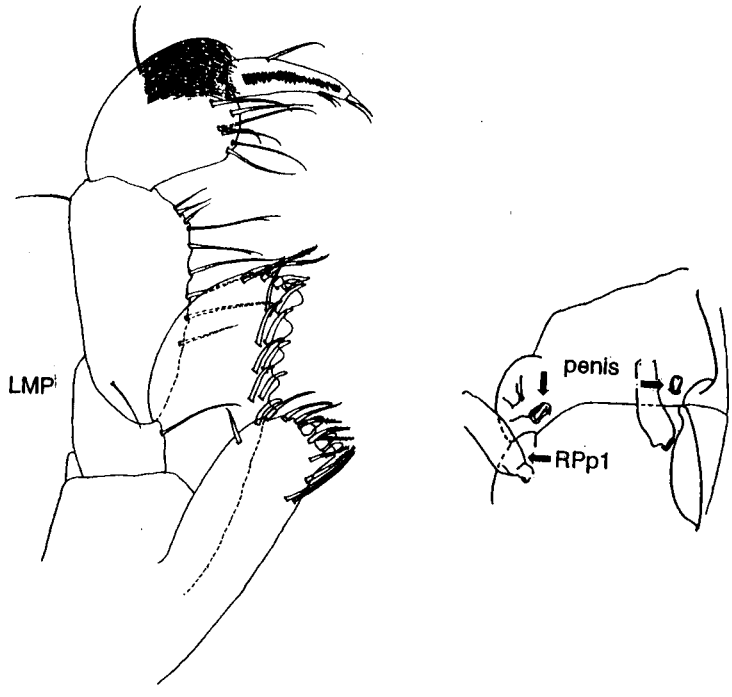

Fig. 4.10. *Nedsia douglasi* male 'c' 5mm. Maxilliped and penis.

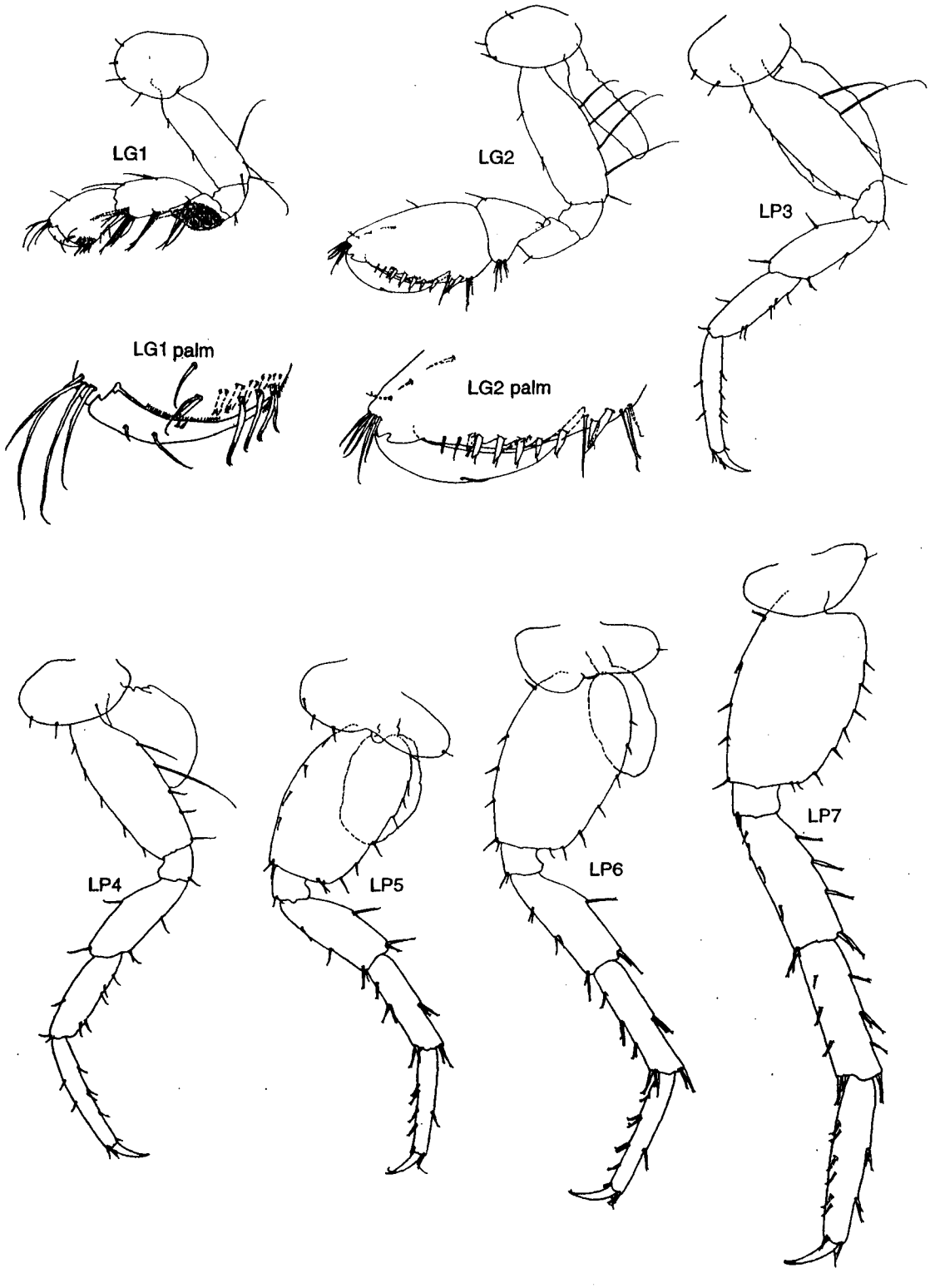

Fig. 4.11. *Nedsia douglasi* male 'c' 5mm. Legs.

Telson: fewer dorsal setae than the female type. *Penis*: small penial processes borne on either side of the posterior ventral surface of the seventh thoracic segment.

Distribution

Coastal plain, North West Cape, Western Australia, Western Australian Museum sample BES186.

4.3 Barrow Island, Western Australia:

Introduction

Barrow Island is, geologically, an isolated extension of the Cape Range peninsula, about 55km off the coast of Western Australia about 115°24'E, 20°46'S. Little, or no, surface water is to be found across the greater area of the island, and permanent surface waters are absent (Humphreys 1999). Aquatic invertebrates nevertheless abound, but are restricted to cave systems, ground waters or underground streams, which are widespread. Barrow Island is one of the few Western Australian marine karst areas studied in any detail (Humphreys 1993a,b; 1999), and, like other stygobiont sites in Western Australia where any intensity of sampling has been carried out (Watts and Humphreys 1999), has proved to be a significant, species rich region. Extensive collections by the Western Australian Museum, in association with geological exploration, yielded numbers of amphipods. Ten new species of the genus *Nedsia* (type species *N. douglasi* Barnard and Williams 1995, North West Cape) are described from Barrow Island. All are small, ranging in size between 2.0 and 5.5mm.

4.3.1 *Nedsia straskraba* n.sp. Figs. 4.12 - 4.14.

Etymology

Named for Milan Straškraba, noted limnologist and early contributor to our knowledge of the taxonomy of Australian freshwater amphipods.

Type locality

Barrow Island, Western Australia, Western Australian Museum sample BES531

Material examined

Holotype (Western Australian Museum WAM 1-96) male "a", 3mm; male "b", 2.5mm (collected at same site, at different date. Western Australian Museum sample BES539).

Diagnosis

Pleonite 6 without dorsal spines. *First antenna*: ratio of peduncular articles about 3:2:1. *Second antenna*: very short. *Upper lip*: margin not excavate; apically rounded and pilose. *Mandibles*: mandibular palp 2 articulate, article 2 cone like, setae 2E or 2D2E; interraker plumose setae absent; no additional serrations beyond rakers. *Maxillae* moderately setose medially: *first maxilla* inner plate with 4 medio-distal setae; palps almost symmetric. *Maxilliped*: inner plate moderately long, no additional setae (plumose or naked) medially; outer plate with a blunt, naked tooth spine medially, the second pair of sub-marginal facial setae reduced to a single seta; palp article 3 lacking comb rows of setae near the base of the dactyl, facial comb row of setae from dactylar base to nail, nail of moderate length with similar length distal spine. *Coxae*: coxa 1 not expanded below; C1-2 longer than broad with 1-3 posterior spines respectively; C3-4 lacking posterior spines. *First gnathopod*: palmar spines evenly bifid; spines at corner of palm = lateral 2 long, medial 2 stout and bifid; setae along palm sparse; cutting edge of palm with many fine serrations. *Second gnathopod*: carpus only slightly lobate; defining corner of palm with 2 spines. *Pereopods*: posterior spine sets of article 6 of P3-4 reduced to 2 spines on P3. *Gills*: coxal gills 5-6 slightly reduced. *Pleopods*: peduncles with 0 or 1 seta each; rami extending sub-equally; baso-medial seta on inner rami not bifid; retinaculae 2 on each pleopod, accessory retinaculae 1,0,1. *Uropods*: apico-lateral corner of peduncles of U1-2 each with 1 spine; dorsal margins of U2 naked; spine rows of rami of U1-2 reduced to 1 (U1) and 2 (U2) medial spines. *Telson*: cleft 100%.

Description of holotype (male "a")

Body: 2.7 mm. *Urosome*: poorly armed dorsally. *Head*: rostrum obsolescent; eyes absent. *First antenna*: length 0.9X body, 3.2X A2; flagellum longer than peduncle (470:188); peduncular article 3 shortest, article 1 longest, ratio of lengths = 88:68:32; setae sparse; aesthetascs present on articles 8, 9, 11, 12, 14; calceoli absent; flagellum of 18 articles; accessory flagellum 2 articulate, reaching M0.7 of article 1 of primary flagellum, article 2 tiny; articles of primary flagellum not uniform, sparsely setulate. *Second antenna*: length 0.28X body (206:745); peduncle much longer than flagellum, articles 4-5 equally long, 3-5 with weak ventral setation, article 3 with 1 dorso-medial spine; flagellum 4 articulate, no calceoli. *Upper lip*: margin not excavate. *Mandibles*: left mandibular palp 2 articulate, articles un-equal in length (17:10), article 2 with 2 long apical setae (E2) and 2 short setae (D2); incisor 5 toothed; lacinia mobilis with 4 denticles; 5 setose accessory blades; molar without distal plumose seta (probably lost by damage to specimen), triturative; no other pubescence; right mandibular incisor 4 toothed; lacinia mobilis bifid, broad, finely denticulate; accessory blades of 5 plumose spines; palp 2 articulate, length ratio of articles 17:10. *First maxilla*: palp article 2 with 5 thin apical spines, all naked on R, one plumose on L. side; outer plate of left with 7 denticulate spines, of right with 6; inner plate bearing 4 terminal plumose setae medially, medial margin pubescent. *Second maxilla*: outer plate devoid of pubescence; inner plate pubescent on baso-medial margin. *Maxilliped*: nail of palp short (11:32 of dactyl), article 3 with few thin setae at inner edge, none proximal; inner plate with single ventro-facial spine and short spur at M0.5 and 0.6, and a single sub-marginal medial naked spine at M0.8. *First gnathopod* : coxal plate with several short setae apically and one post-ventrally; article 4 slightly bulbous posteriorly, carpus not lobate; propodus trapezoidal, expanding slightly apically, longer than wide, the posterior edge naked, corner of palm rounded, 2 long, naked lateral spines, 2 stout bifid spines medially, palm slightly convex, dactyl reaching beyond the palm. *Second gnathopod*: palm with 2 medial and 2 lateral spines, all but the corner spines being bifid, and 2 long and 1 medium setae; spines at palmar corner = 1 medial and 1 lateral (naked); coxal plate similar to first with 1 anterior and 3 posterior setae. *Pereopods*: coxa 3 with setae similar to C1, arranged 1 anterior, 1 posterior; coxa 4 similar, both setae anterior; P3-(4) longer than G2; P3-5 approximately equal, articles 4,5 sparsely setose posteriorly, the posterior margin of

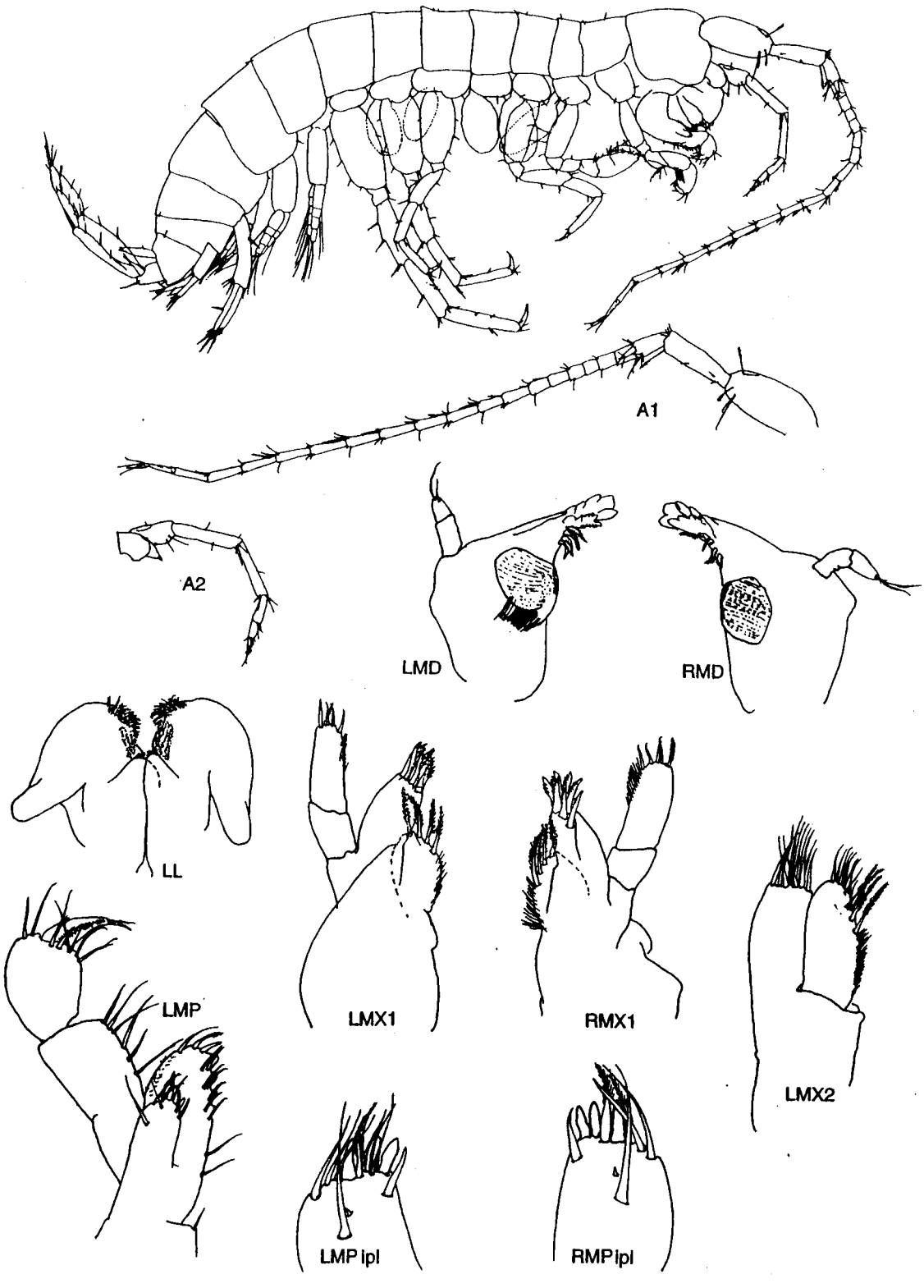

Fig. 4.12. *Nedsia straskraba* holotype male 'a' 2.7mm. Body, antennae, mouthparts.

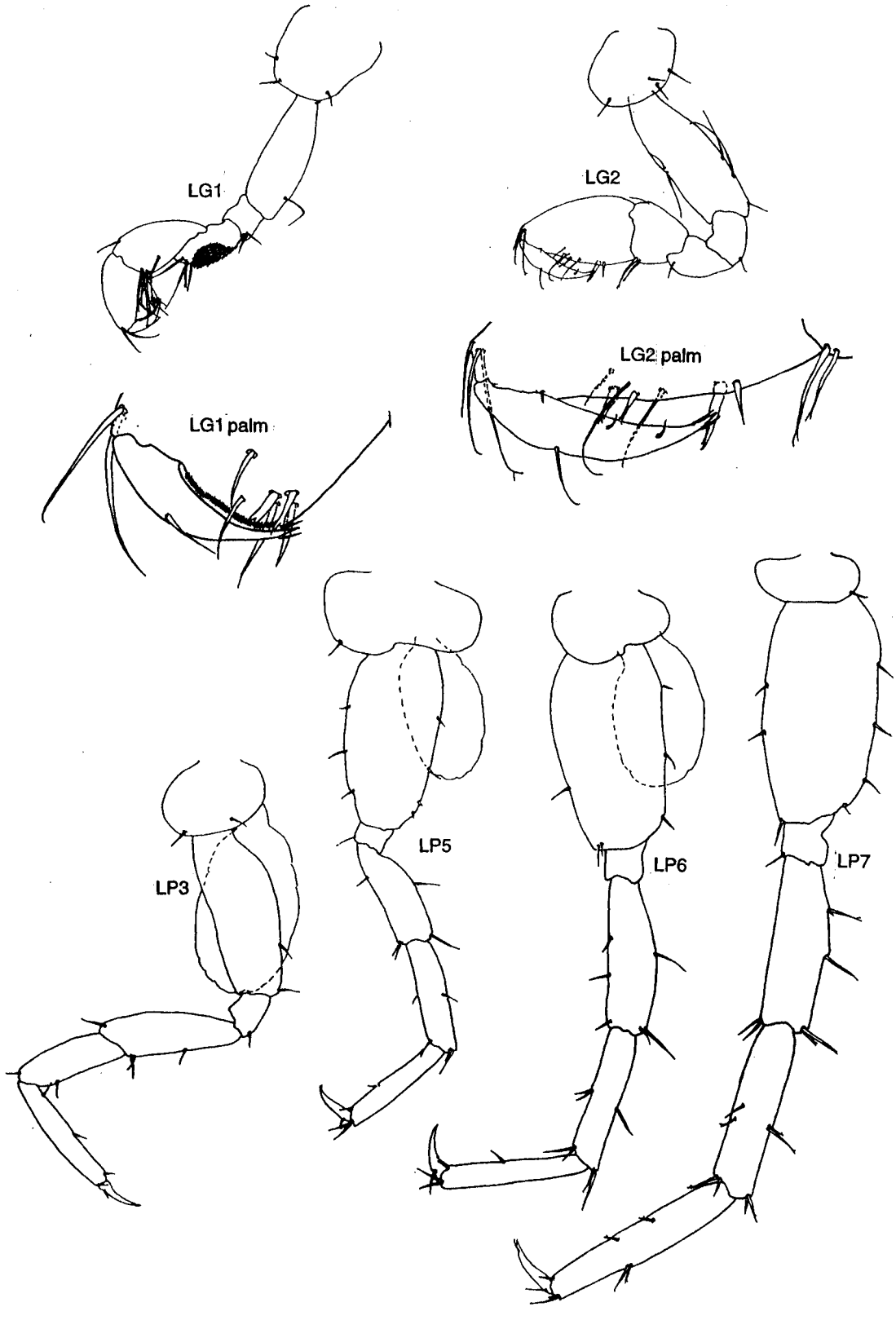

Fig. 4.13. *Nedsia straskraba* holotype male 'a' 2.7mm. Legs.

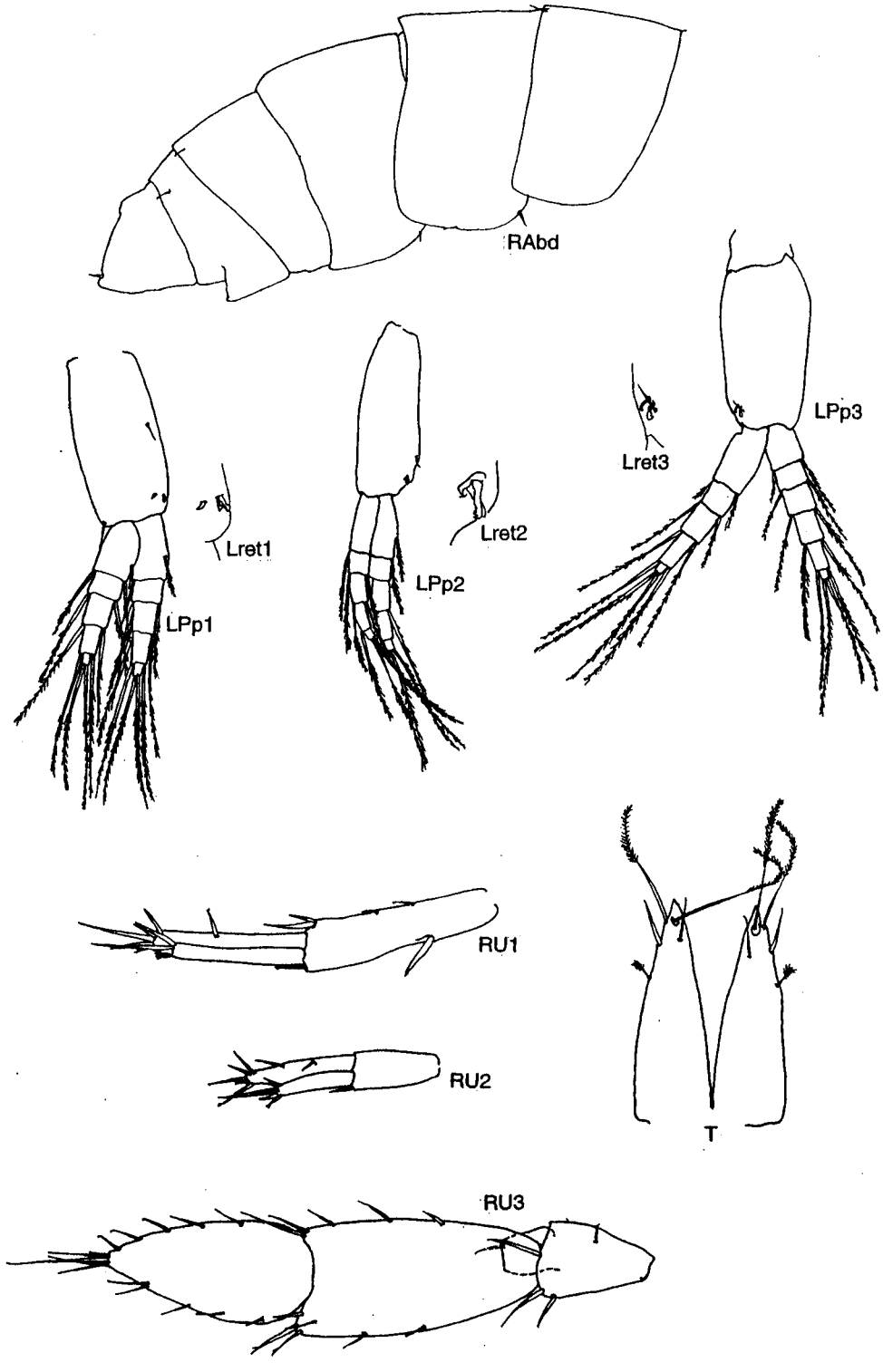

Fig. 4.14. *Nedsia straskraba* holotype male 'a' 2.7mm. Abdomen, pleopods, uropods, telson.

article 6 (P3 only) with armament formula = ---1--1, thus with only one locking spine; P5-7 similar but consecutively elongate, with 1,2,1 locking spines; P7 anterior spines of articles 5 and 6 displaced inward by keel-like expansion of the segment; coxae 5-7 bearing 0,0,1 setae on posterior lobes, article 2 weakly expanded progressively from P5 to P7, not lobate, but extended posteriorly and bearing few setae on P5, becoming increasingly robust in P6 and P7; dactyls of P3-7 simple, naked except for an anterior basal penicillate setule, with the addition of an outer terminal setule on P7. *Gills*: coxae 2-6 with flask shaped gills, gill of C3 largest, of C5-6 slightly reduced. *Pleopods*: retinaculae 2 per pleopod, one accessory each; peduncles 1 and 3 with an apico-lateral seta, 2 without; rami extending sub-equally, the inner with 5:5:5 articles, the outer with 6:6:5; no bifid setae on basal articles. *Epimera*: epimera post-ventrally quadrate; posterior margins scarcely convex on 1-2, concave on E3, all smooth, with few or no setae; E2-3 with 2 and 1 weak ventral spines, lacking lateral oblique ridge. *Pleon*: pleonites 1-4 with dorso-lateral posterior setae; pleonite 6 with 1 dorso-lateral and 1 disto-ventral spinule. *Uropods*: uropod lengths relative to U1 are U2=0.6X , U3=1.5X; U1 peduncle length 1.3X inner ramus, the outer margin bearing a single apico-distal spine and reduced row of 2 mid-dorsal spines, the medial apex bearing 2 spines; rami of sub-equal length (inner : outer = 62:54), both naked except for a single mid-dorsal spine on the inner ramus; both rami with 5 terminal spines; U2 peduncle length 0.9X inner ramus, bearing a single apico-lateral spine only; inner ramus length 1.4X outer, the medial margin bearing 2 spines only, 5 terminal spines; outer ramus shorter, devoid of any but 5 terminal spines; U3 strongly extended beyond uropods 1-2 in entire animal; peduncle length 0.14X outer ramus, shorter than urosomite 3 (25:50), bearing single mid-dorsal and latero-distal marginal setae, 1 sub-apical lateral seta, and 1 small mid-medial sub-marginal, facial seta; outer ramus proximal article with few marginal setae, 2 apico-medial setae, 3 apico-lateral setae and 1 sub-apical sub-marginal lateral seta, article 2 shorter (80:100), similarly armed, terminating in a cluster of 5 spines; inner ramus scale like, sub-quadrate, length 0.13X outer, bearing a single apico-medial spine. *Telson*: length 1.5x width, widest at base, sub-equal in length to urosomite 3 (45:50), cleft 100%; apices slightly notched laterally female), apex of right lobe notched minutely medially; sub-apices with 2 long plumose setae, 1 sub-marginal medial seta and 1

lateral seta at M0.8, no other dorsal setae except for single penicillate setules on both lobes laterally at M0.7.

Description of other material

Specimen 'b', male: length 2.5mm. *Pleonite* 6 with a single dorso-lateral spine. *First antenna*: flagellum of 20 articles, aesthetascs present on articles 8,9,10,12,13,14,16. *Mandibles*: ratio of length of palp articles 1-2 = 15:12; setae of terminal article = 2E; interraker plumose setae present between accessory blades. *Left mandible*: palp article 2 shorter than in type; 15:12, setae = 2E; distal plumose seta present on both molars. *Maxillae*: spines of palp of left first maxilla not plumose *Maxilliped*: palp article 3 with rows of setae basal to dactyl; nail of dactyl short. *First gnathopod*: coxal plate without post-ventral seta. *Pleopods*: accessory spines adjacent to retinaculae = 1,0,0. accessory spine present adjacent retinacula of pleopod 1 only. *Uropod*: lengths relative to U1; U2 0.7X , U3 2X; peduncle of U1 1.9X length of inner ramus, of U2 equal to ramus; U2 inner ramus 1.3X outer; peduncle of U3 0.27X length of outer ramus (longer than in type ; 0.14X), second article of outer ramus relatively longer than in type (90:102).

Relationship

N. straskraba varies from *N. douglasi* in that pleonites lack dorsal spines, the second peduncular article of the first antenna is relatively shorter, the mandibular palp is similar being 2 articulate, with reduced terminal setation, the inner plate of the second maxilla has fewer medial setae, coxae 1-2 are longer than broad versus broader than long, the palmar spines of the first gnathopod are apically dentate, not asymmetrically bifid, there are no setae along the palm and the inner edge is finely serrate, the second gnathopod is weakly enlarged, melitid, the carpus less lobate, the palm more strongly oblique with few spines or setae and palmar corner poorly defined, the fifth and sixth coxal gills are reduced slightly compared with *N.douglasi*. The principle feature separating this species from all but *N. fragilis* and *N. humphreysi* is the absence of marginal pubescence on both plates of the second maxilla, and from *N. macrosculptilis*, *N. sculptilis*, *N. fragilis* and *N. humphreysi* the absence of dorsal spines or sculpturing of the pleon and of facial spines on the epimera. *N. straskraba* is unlike *N. fragilis* in that the palmar corner of the G1 is sub-quadrate, and unlike *N. hurlberti* in lacking a spine like extension of the first urosomite.

Distribution

Barrow Island, Western Australia.

4.3.2 *Nedsia hurlberti* n. sp. Figs. 4.15 - 4.17.

Etymology

Named for S. H. Hurlbert, noted biostatician and salt lake limnologist.

Type locality

Western Australia, Barrow Island, Western Australian Museum, Western Australian Museum sample site BES545

Material examined

Holotype (Western Australian Museum WAM 2-96) female 4.5 mm, unique specimen.

Diagnosis

Pleonite: 6 small dorsal spines, displaced laterally. *First antenna*: ratio of peduncular articles 45:40:15. *Second antenna*: very short. *Upper lip*: symmetrical, not excavate. *Mandible*: palp 2 articulate, article 1 not setose, article 2 linear, setae = 2E; plumose interraker setae present between each main raker; no additional serrations beyond rakers. *Maxillae*: well setose medially. *First maxilla*: inner plate with 7 plumose medial setae; palps symmetric with 7 thin apical spines. *Second maxilla*: inner plate with a row of medial setae barely extending onto face apically, no other medial setae. *Maxilliped*: outer plate large, with 2 stout plumose setae distally and a single naked tooth-spine; paired sub-marginal medial setae of the outer plate blunt, apically curved; palp articles 2-3 with single lateral setae, article 3 naked basally, moderately setose distally, with rows of short setae adjacent the base of the dactyl, the apex not produced. *Coxae*: C1-4 lacking posterior spines. *First gnathopod*: palm slightly oblique, palmar spines apically dentate. *Second gnathopod*: defining corner with 2 spines. *Epimera*: without setae, each with some facial spines adjacent ventral and posterior margins. *Pleopods*: peduncles of pleopods 1-2 without setae, of pleopod 3 with 2 lateral setae; basomedial setae of inner rami bifid, no accessory retinaculae. *Telson*: cleft 100%.

Description of holotype (female)

Body: 4.5 mm. *Head*: rostrum obsolescent; eyes absent. *First antenna*: length 0.5X body (broken at article 17), longer than A2, flagellum much longer than peduncle; peduncle article 1 longest, 3 shortest, setae sparse; flagellum of many articles (17+),

without calceoli or aesthetascs; accessory flagellum of 2 articles, article 2 tiny, extending to M0.7 of article 1 of the primary flagellum; articles of primary flagellum variable in length. *Second antenna*: short, length 0.27X body; peduncle very much longer than flagellum, articles 4-5 equally long, articles 3-5 with weak ventral setation of 0-2-7 naked setae and 1-2-1 plumose setae, article 3 without dorso-medial spines; flagellum 4 articulate, without calceoli. *Upper lip*: without excavation of the apical margin, connection to the epistome symmetrical. *Left mandible*: palp article 1 shorter than 2 (11:35), setae of article 2 = 2E: incisor 4 toothed; 4 setose accessory blades; lacinia mobilis bearing a row of short facial setae; plumose setae lying between each raker extend to the base of the molar; molar lacking distal plumose seta, without pubescence. *Right mandible*: incisor 5 toothed; lacinia mobilis 4 toothed and bearing facial setae; accessory blades of 5 plumose spines. *Maxillae* : *first maxilla* palps of both sides bearing 7 thin apical and sub-apical spines; outer plate with 7 denticulate spines, the inner plate 7 medial setae; second maxilla, medial and apico-medial margin of both plates pubescent as is baso-medial margin of inner plate. *Maxilliped*: palp article 3 with moderate setae on the inner edge, dactyl bearing a row of mid-facial setae and terminal accessory spine slightly longer than the nail. *First gnathopod*: coxal plate bearing 4 short setae apically, without post-ventral spines; article 4 posteriorly bulbous and facially pubescent; carpus not lobate; propodus trapezoidal, expanding slightly apically, longer than wide, the posterior edge naked, corner of the palm almost square marked laterally by 2 moderate unarmed spines and 1 long trigger spine, and medially by 4 stout trigger spines, palm convex, dactylus reaching the palmar corner, bearing 3 small spines sub-marginal to the inner edge. *Second gnathopod*: coxal plate broader than C1, poorly setose, with 3 anterior setae; propodus 2X that of G1, palm bearing 5 lateral trigger spines, single unarmed distal spine, single medial trigger spine at M0.5 and a single long seta at M0.2 from the palmar corner; the palmar edge is finely serrated, the corner defined by a single long slender trigger spine, 1 long, stout trigger spine and 2 long setae. *Pereopods*: coxa 3 slightly larger than C2, C4 more irregular, both with similar setae = 3 anterior, none posterior, coxae 5-7 with few setae on the ventral margin of posterior lobes (0-0-2); P3-7 longer than G2, progressively elongate; P3-4 posterior armament formula of article 6 = S-S-S-S and S-2S-S-S, thus both with a single locking spine; P5-7 each with 2 locking spines; article 6 of P7 without posterior keel like expansion; article 2 of P5-

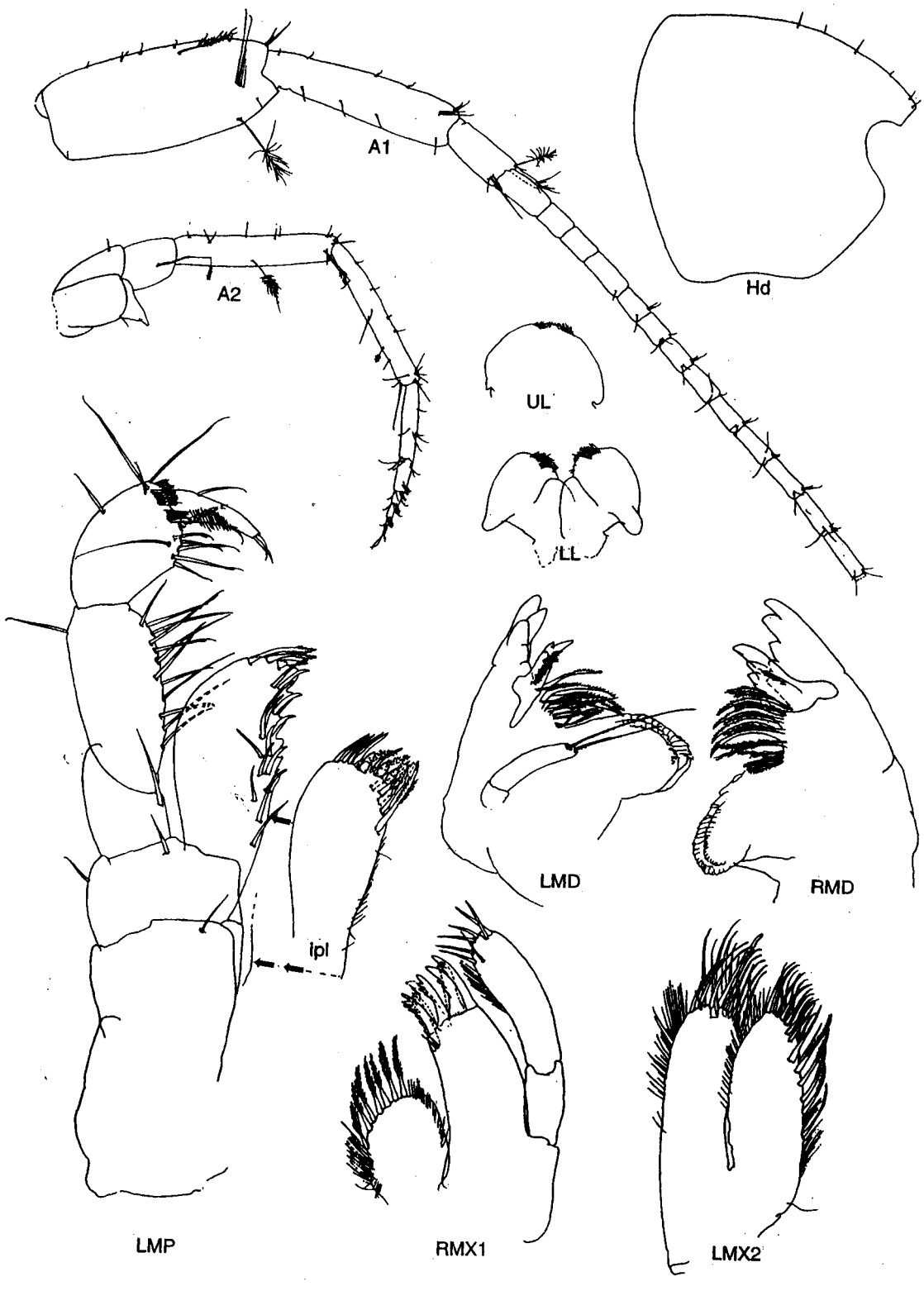

Fig. 4.15. *Nedsia hurlberti* holotype female 4.5mm. Head, antennae, mouthparts.

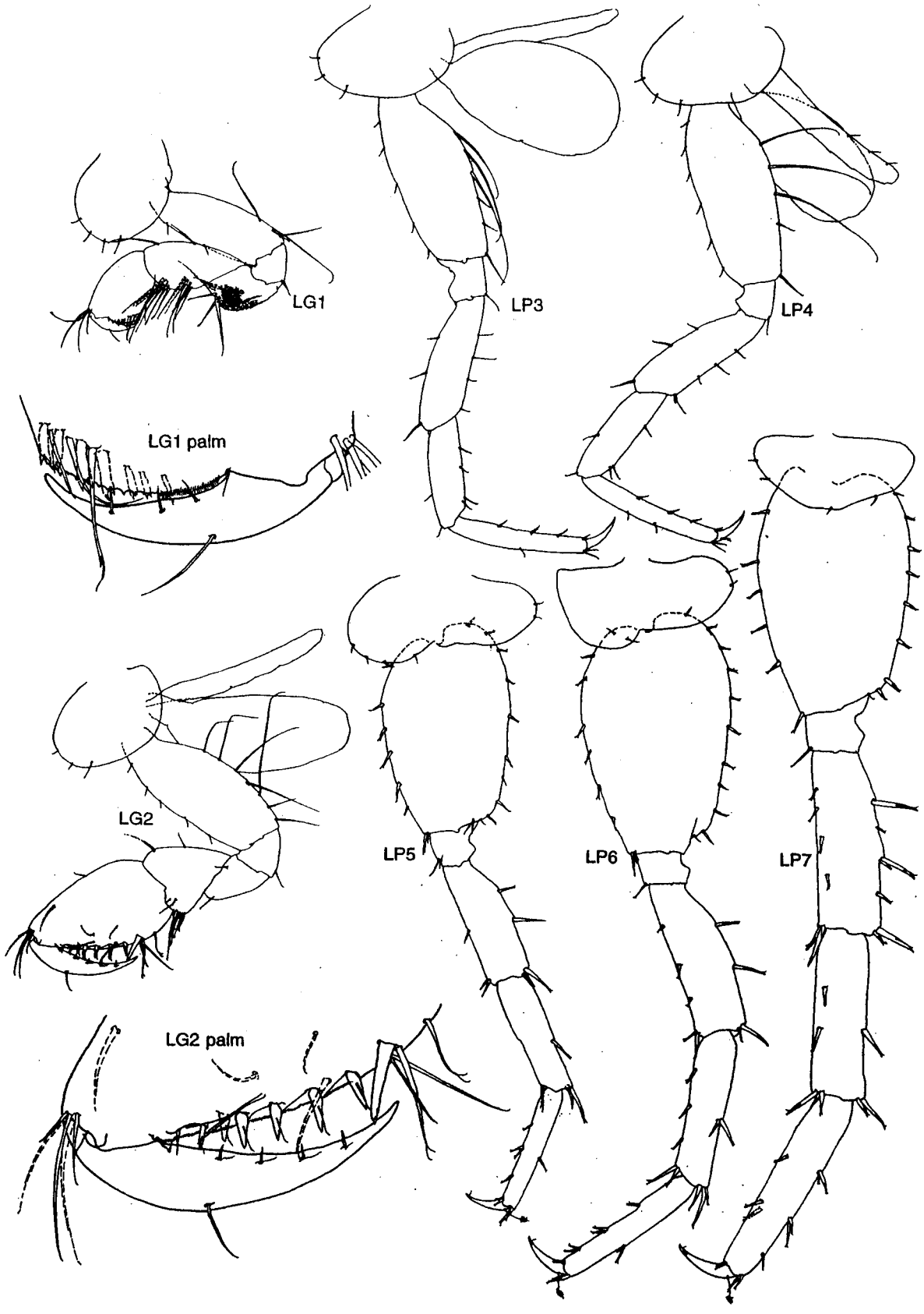

Fig. 4.16. *Nedsia hurlberti* holotype female 4.5mm. Legs.

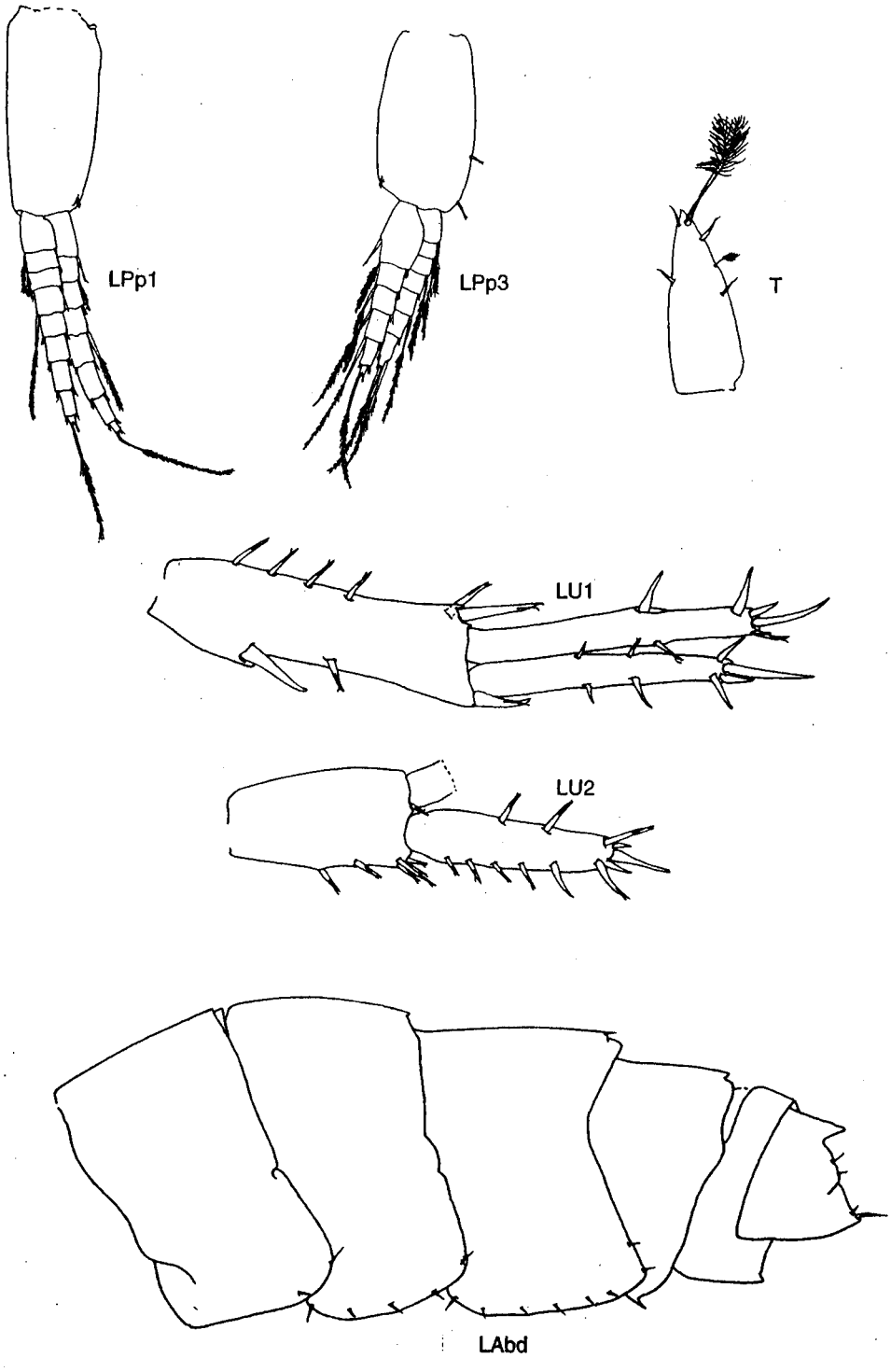

Fig. 4.17. *Nedsia hurlberti* holotype female 4.5mm. Abdomen, pleopods, uropods, telson.

7 expanded, but not post-ventrally lobate, bearing small trigger spines; P3-7 dactyls simple, naked, with an outer basal penicillate setule and a short sub-terminal seta. *Gills*: flask shaped gills on coxae 2-6; gill of C6 not reduced. *Oostegites*: thin, strap like and poorly setose, present on C2-5. *Pleopods*: 2 retinaculae per pleopod, without accessory retinaculae, peduncle 3 only bearing a single apico-lateral seta, rami extending sub-equally, the inner rami bearing 9-9-8 articles, the outer 9-9-6; basal article setae of rami 1-2 = 1-1-1-1, of which the inner seta is bifid on each. *Epimera*: E1-2 post-ventrally curved; E3 sub-quadrate, the post-ventral corners with 1-1-2 setae; posterior margins smooth, barely setulose, ventro-facial spines present as 1-4-6. *Pleon*: pleonite 3 with a tiny posterior dorsal seta, pleonite 6 with 2 disto-lateral and 2 disto-ventral spines; U3 strongly extended beyond U1-2 in entire animal. Uropod: lengths relative to U1 = U2 0.6x, (U3 1.3X). *Urosome*: ventro-distal spine at base of U1 on urosomite 1 absent, although urosomite 1 extended ventro-distally in a spine like projection. *Uropods*: U1 peduncle length equal to medial ramus, the outer margin bearing a single apico-distal spine and row of 4 dorsal spines, the medial margin 2 apical spines; rami sub-equal, both with 2 sparse rows of marginal spines, spines of the apex = 4 and 5; U2 peduncle 0.9X length of outer ramus, bearing, as well as 2 apico-lateral spines, single lateral and dorsal sub-apical spines, 1 dorso-lateral spine at M0.7, 1 lateral spine at M0.5 and 1 mid-apical dorsal spine; no apical spines of the medial margin; (outer ramus shorter than inner) (both) with 2 rows of marginal spines of the form 5-1,(1-3), spines of the apex = (4)-5; U3 (lost; similar to others of genus i.e. peduncle much shorter than outer ramus, shorter than urosomite 3, with sub-distal seta, an apico-lateral cluster of 5 spines, the outer ramus proximal article with several irregular spine/seta ranks, article 2 shorter but similarly armed; inner ramus much shorter than outer (0.4X) with a single apical spine). *Telson*: 1.3X longer than broad, shorter than urosomite 3 (0.75X); cleft 100% of length; apices barely notched, 2 long penicillate setules and 1 shorter naked seta sub-apically, dorsal setae at M0.5 and M0.8, single medial seta at M0.6, and a single penicillate setule dorso-lateral at M0.6.

Relationship

N. hurlberti varies from *N. douglasi* in the shorter relative length of the first antenna and the variable length of the articles of the primary flagellum, no excavation or asymmetry of the upper lip, reduced dentition of the L mandibular incisor, inner plate of the first maxilla with an extra seta, the inner plate of the second maxilla

apically pubescent, palp and dactyl of maxilliped more spinose, as are the propodus and dactyl of the gnathopods, absence of a posterior keel like extension of the sixth article of the seventh pereopod, the posterior margins of the epimera sinuous and E2 bearing an additional ventral seta, pleopods bearing an accessory retinaculum, the telson longer and more slender. *Nedsia hurlberti* differs from *N. straskraba*, *N. fragilis* and *N. humphreysi* in that the margins of both plates of the second maxilla bear pubescence, from *N. macrosculptilis* and *N. sculptilis* in that the pleon is not sculpted, nor the epimera bearing facial spines, and from *N. urifimbriata* in the presence of few ventro-facial spines on the second and third epimera, a spine like extension of the first urosome at the base of the first uropod, less than six articles of the pleopodal rami, and in the absence of organised comb rows of setae at the base of the dactylus of the maxillipedal palp.

Distribution. Barrow Island, Western Australia.

4.3.3 *Nedsia humphreysi* n. sp. Figs. 4.18 - 4.19

Etymology

Named for W.F.Humphreys, biologist, instrumental in the collection of Western Australian cave specimens.

Type locality

Barrow Island, Western Australia, Western Australian Museum sampling site BES710.

Material examined

Holotype (Western Australian Museum WAM 3-96) male 2 mm.

Diagnosis

Dorsal spines absent from pleonites 4-6. *Head*: lateral cephalic lobes slightly projecting. *Upper lip*: symmetrical, slightly excavate below. *Mandibular palp*: 2 articulate, 2E setae only; lacking interraker plumose setae *Maxillae*: without pubescence, sparse to moderately setose medially. *First maxilla*: palps asymmetric with thin apical plumose or serrate spines. *Second maxilla*: medial margins sparsely setulate, without pubescence. *Maxilliped*: apex of third article of palp slightly produced, dactyls with moderate nail and accessory spine of almost equal length. *Gnathopods*: (diverse, G2 dominant); G1 palmar spines bifid, spines at corner of palm sub-marginal = 2 lateral, 3 medial; palmar margin serrate, with sub-marginal

row of fine setae. *Pereopods*: P3-4 lacking posterior spine sets on article 6. *Coxal gills*: gills 5-6 smaller but not substantially reduced. Sternal gills absent. *Epimera*: E1-2 with 1, E3 with 2, posterior spines at the corner, ventro-facial spines absent. *Pleopods*: peduncles without setae, retinaculae = 2-3-2, accessory retinaculae absent. *Uropods*: apico- lateral corner of peduncles on U1-2 without spines, dorsal margins spineless, medial margins of both with 1 apical spine; rami of U1-2 without spine rows except for inner ramus of U1. *Telson*: cleft 100%; lobes with a small mid-lateral concavity.

Description of holotype, (male)

Body 2 mm. *Head*: rostrum obsolescent; eyes absent. *First antenna*: length 0.6 x body, 2 x A2, flagellum 1.6 x peduncle, peduncular article 1 longest without medio-distal spines or setae, article 3 shortest, setae sparse, flagellum of 9 articles, sparsely setulate, no aesthetascs or calceoli; accessory flagellum 2 articulate, article 2 tiny, total length 0.6X article 1 of the primary flagellum; length of articles of primary flagellum variable, article 7 longest. *Second antenna*: length 0.3 x body, peduncle longer than (3 x) flagellum, articles 4-5 equally long, articles 3-4-5 with sparse ventral setation, article 3 with apico-dorsal setae, no dorso-medial spines. Flagellum 4 articulate, no calceoli. *Upper lip*: apical margin rounded, symmetrical. *Mandibles*: L. mandibular palp 2 articulate, article 1 very reduced, bud like, naked; incisor 5 toothed; lacinia mobilis with 4 teeth and 6 setose accessory blades; molar triturative with a short distal plumose seta, lacking other setae or pubescence; R mandible palp 2 articulate, article 1 naked, short, bud-like, article 2 reduced, tapered, setae 2E only; incisor with 5 teeth; lacinia mobilis with 7 denticles their size increasing distally; accessory blades of 3 plumose spines; a line of setae extending onto the base of the molar. *Maxillae*: *First maxilla*; L. palp 2nd article with 5 serrate apical spines, terminally rounded with 3 small to moderate apico-medial setae; R palp article 2 with 4 plumose apical spines, terminally sub-quadrate, 4 apico-medial setae; outer plate of both sides with 7 terminal spines, some of the left without denticles; L inner plate with 4 apico-medial and apical plumose setae, moderately setose basally; R inner plate with 4 apico-medial and apical plumose setae, moderately setose medially. *Second maxilla*; inner and outer plates devoid of pubescence. *Maxilliped*: palp article 3 with apical pair of slender setae, 1 marginal, 1 sub-marginal; medial face with 5 slender setae, the basal pair denticulate. Inner plate without ventro-facial spine. *First gnathopod*: coxal plate with 1 short seta

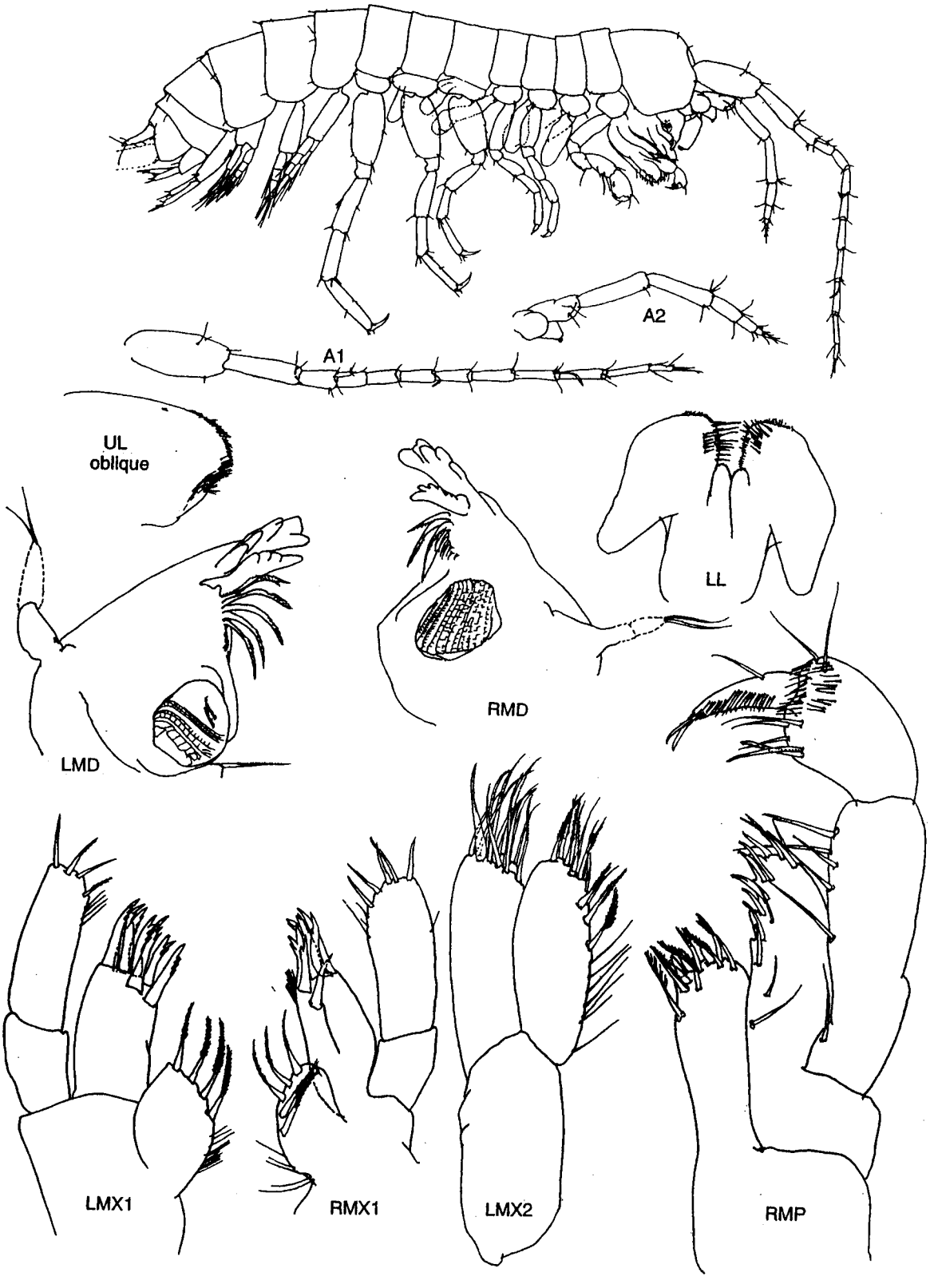

Fig. 4.18. *Nedsia humphreysi* holotype male 2mm. Body, antennae, mouthparts.

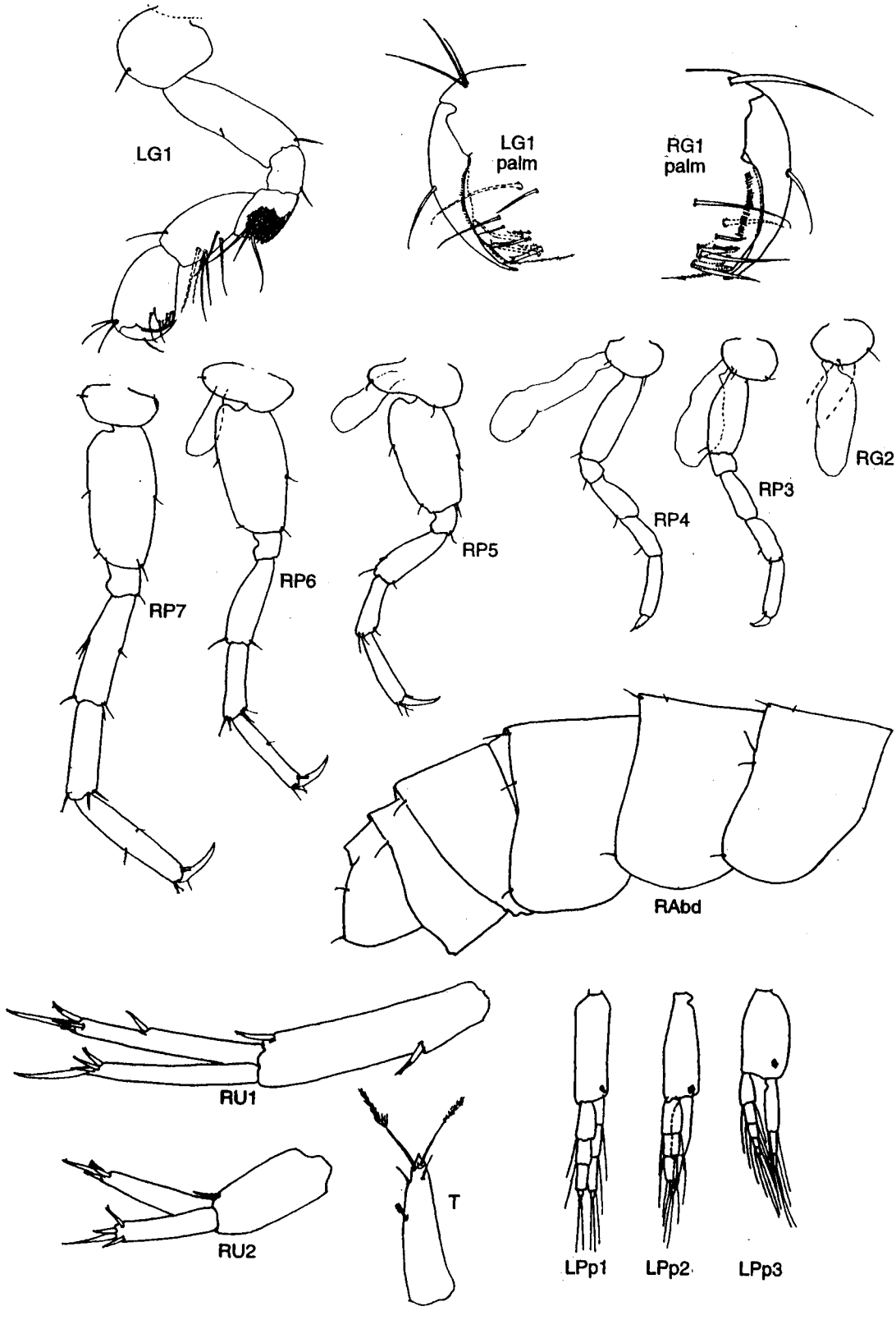

Fig. 4.19. *Nedsia humphreysi* holotype male 2mm. Legs, abdomen, pleopods, uropods, telson.

apically, without post-ventral spines; article 4 posteriorly bulbous, carpus not lobate, propodus trapezoidal, expanding apically, longer than wide, posterior edge almost naked, corner of palm almost square, with 2 lateral and 3 medial spines and several lateral and medial setae set back from the corner; palm convex and serrate; dactylus reaching slightly beyond the corner of the palm. *Second gnathopod.*: coxal plate equal to C1, with a single ventral spine. *Pereopods*: coxa 3 with 1 anterior and 1 posterior ventral setae only; coxa 4 similar; pereopods 3-4-5 longer than G1; pereopods consecutively elongate from P3 to P7; ratio of lengths = 137:-:140:155:185:220:270; all pereopods sparsely setose, posterior armaments of article 6 of P3-4 =1-0, thus only P3 with 1 locking spine; P5-7 significantly longer than P3-4 with locking spines; 1,2,2; single anterior spines on art 6 of P6-7, one posterior spine on P7 only; no keel like expansion of art 6 of P7; coxae 5 and 7 bearing 1 anterior and 1 post-ventral seta and C6 one anterior seta only; article 2 of P5-7 weakly expanded posteriorly, each with only 2 setae; dactyls of P3-7 simple, naked except for outer basal penicillate setule evident on P4-7 only. *Gills*: of coxae 2-6 flask shaped, of C5-6, smaller, but not reduced. *Pleopods*: retinaculae present on each pair, arranged 2-3-2, accessory retinaculae absent; peduncles without setae; rami extending equally, outer rami of 4-4-3 articles, inner 4-3-5. No setae bifid. *Epimera*: each post-ventrally rounded, posterior margins slightly convex, smooth, without setae except for a single seta marking the posterior corner of E1-2 and two on E3; ventro-facial spines absent; lacking oblique lateral ridge. *Pleon*: pleonites with few posterior dorsal or lateral setae; pleonite 1 with 1 dorsal, 2 lateral, pleonite 2 with 1 sub-marginal and 1 marginal dorsal, pleonite 3 with 2 lateral, pleonites 4 and 5 with 1 lateral, pleonite 6 with 1 mid-lateral and 1 disto-ventral seta. *Uropods*: U1 peduncle length 1.4x outer ramus, 1.2x inner ramus, apico-distal spines absent, bearing a single medial sub-apical spine, and basofacial spine at M0.3; inner ramus only with a mid-medial spine; both rami with 4 terminal spines; U2 peduncle sub-equal to length of inner ramus, 1 apico-dorsal spine slightly sub-distal; other spines and setae absent; outer ramus shorter than inner (0.8x), both rami without spines, except 3-4 terminal spines. *Telson*: longer than broad (1.8x), as long as urosomite 3; cleft 100%; apices pointed, not notched, each with 2 long plumose sub-apical setae, 2 apical setae, and a single lateral penicillate setule at M0.6 .

Relationship

N. humphreysi differs from *N. douglasi* in the reduced number of articles of variable lengths of the first antenna and relatively longer second antenna, a symmetrical and non-excavate upper lip, greater number of mandibular setose accessory blades and presence of a plumose molarial seta and basal molarial setae, palps of first maxilla asymmetrical, the inner plate with an extra seta, the second maxilla devoid of pubescence, the inner plate of the maxilliped without a ventro-facial spine, palmar corner of the first gnathopod with fewer armaments, the palm serrate and the dactyl reaching beyond the corner. The coxal plate of the second gnathopod is narrower, post-ventral margins of epimera rounded, epimera lacking ventro-facial spines, first uropod lacking apico-distal spines, second uropod peduncle les spinous, relatively shorter with only a single apico-dorsal spine, the telson more slender, the apices pointed, not notched. *Nedsia humphreysi* is similar to *N. straskraba* and *N. fragilis*, but distinct from *N. hurlberti*, *N. urifimbriata*, *N. macrosculptilis* and *N. sculptilis*, in that marginal pubescence is not present on both plates of the second maxilla. *N. humphreysi* differs from *N. straskraba* in that the pleonites bear dorsal spines, and from *N. fragilis* in that the first epimeron lacks disto-lateral spines, the peduncle of the first uropod is without a row of facial spines, the palmar corner of the first gnathopod is sub-quadrate rather than rounded, and the outer plate of the maxilliped is not tapering and is armed with distinct medial cusps.

Distribution

Barrow Island, Western Australia.

4.3.4 *Nedsia urifimbriata* n. sp. Figs. 4.20 - 4.22.

Etymology

Named for the presence of marginal pubescence on the third uropod.

Type locality

Barrow Island, Western Australia. Western Australian Museum sampling site BES733.

Material examined

Holotype (Western Australian Museum WAM 4-96) male 2.5mm. Allotype female 3mm.

Diagnosis

Mandibular palp: 2 articulate, setae = 2E. *Second maxilla*: inner plate with sub-marginal medio-distal row of plumose setae barely extending onto the face apically, without medial setae, without pubescence. *Maxilliped*: inner plate with a reduced medial row of 1 facio-distal and 1 barely facial (sub-marginal) ventral seta; outer plate lacking a blunt naked tooth spine contiguous with distal plumose setae, an additional sub-marginal facial group of 4 setae at M 0.3; palp article 3 with comb rows at the base of the dactyl, the apex weakly produced, dactylar nail moderately long, with a sub-equal accessory seta. *First gnathopod*: carpus equal to propodus in male, palmar spines symmetrically bifid. *Pereopods*: posterior spine sets of article 6 evenly spaced. *Pleopods*: peduncle 3 with 1 apico-lateral seta, baso-medial seta of inner rami not bifid; each with 2 retinaculae, no accessory retinaculum. *Epimera*: post-ventral tooth of E1-3 present, posterior margins without setae, without facial spines. *Uropods*: U1-2 apico-lateral corners of peduncles with 2 and 1 spines, both rami of both uropods with only a single, poorly represented spine row; U3 without sub-distal peduncular setae. *Telson*: cleft 100%, lobes weakly convex laterally and medially; setation sub-apical, lacking lateral setal spines, single lateral penicillate setules at M0.3-0.5 .

Description of holotype (male 'x')

Body: 2.5 mm. *Urosome*: poorly armed dorsally. *Head*: rostrum obsolescent, eyes absent. *First antenna*: elongate, longer than A2, broken at article 6 of flagellum - broken length 0.6X body, (length >2x A2); flagellum longer than peduncle, peduncular article 1 longest and bearing a strong medio-distal spine at M0.85, article 3 shortest, ratio of lengths 90:70:30, setae sparse; flagellum of many articles (broken at article 6), uniform, sparsely setulate; calceoli absent, no aesthetascs;

accessory flagellum 2 articulate, reaching M0.5 article 1 of primary flagellum, second article tiny. *Second antenna*: with weak ventral setation, article 3 without dorso-medial spines; flagellum 5 articulate, lacking calceoli. *Upper lip*: (asymmetrical, weakly excavate below). *Left Mandible*: palp 2 articulate, article 1 shorter than 2 (35:47), article 2 bearing 2 apical E setae; incisor 5 toothed, lacinia mobilis 5 toothed bearing on the medial face a row of short spines, 4 setose accessory blades and 3 inter-raker plumose setae; molar triturative, with a moderately long distal plumose seta. *Right mandible*: palp absent, incisor 5 toothed and lacinia mobilis 5 toothed with medio-facial spine row as on left side, 4 setose accessory blades and 2 inter-raker plumose setae; molar triturative, without distal plumose seta. *Maxillae*: first maxilla palp article 2 bearing thin apical and sub-apical spines, configuration of the left side being; 4 naked, 1 denticulate, and 1 setate, the right side having one less naked spine, the outer plate of both sides with 7 denticulate spines; inner plate with 4 plumose medio-distal setae and 1 sub-distal naked seta; second maxilla outer plate latero-apical margin pubescent, inner plate baso-medial margin pubescent; apical spines of both plates mostly setate, but some naked. *Maxilliped*: palp article 3 with 3 thin setae on the inner edge, no other facial setae; inner plate with a single mid-medial sub-marginal plumose spine. *First gnathopod*: coxal plate bearing 1 or 2 short setae apically and 1 post-ventral spine; article 4 posteriorly bulbous and pubescent; carpus not lobate, propodus trapezoidal, expanding apically, length greater than width, the posterior edge naked; palmar corner rounded, marked by 2 lateral setae and 3 stout, bifid medial spines; palm convex, transverse, lined with fine setules; dactylus reaching slightly beyond the corner of the palm. *Second gnathopod*: palm bearing 3 lateral and 6 medial spines, the spine at the palmar corner medial; coxal plate no broader than C1, poorly setose. *Pereopods*: C3 bearing 1 anterior seta only, C4 similar but with 1 small posterior seta; P(3)-4 longer than G2, P(3) approximately equal to P4; articles 4-5 of P4 sparsely setulose posteriorly; posterior margin of article 6 of P(3)-4 armament formula 1-1-1-1-1, i.e. with 1 locking spine; P 5-7 absent; C5-7 bearing few (1) setae on the ventral margin of posterior lobes; dactyls (3-7) simple as in P4, but without any basal penicillate setule. *Gills*: coxal gills of limbs 2-4 flask shaped, none present on C5-6(7); sternal gills absent. *Pleopods*: peduncle of pleopod 3 only with an apico-lateral seta; two retinaculae on each peduncle, without accessory spines; rami extending sub-equally, all with 5 articles; setae on basal articles = 3 for

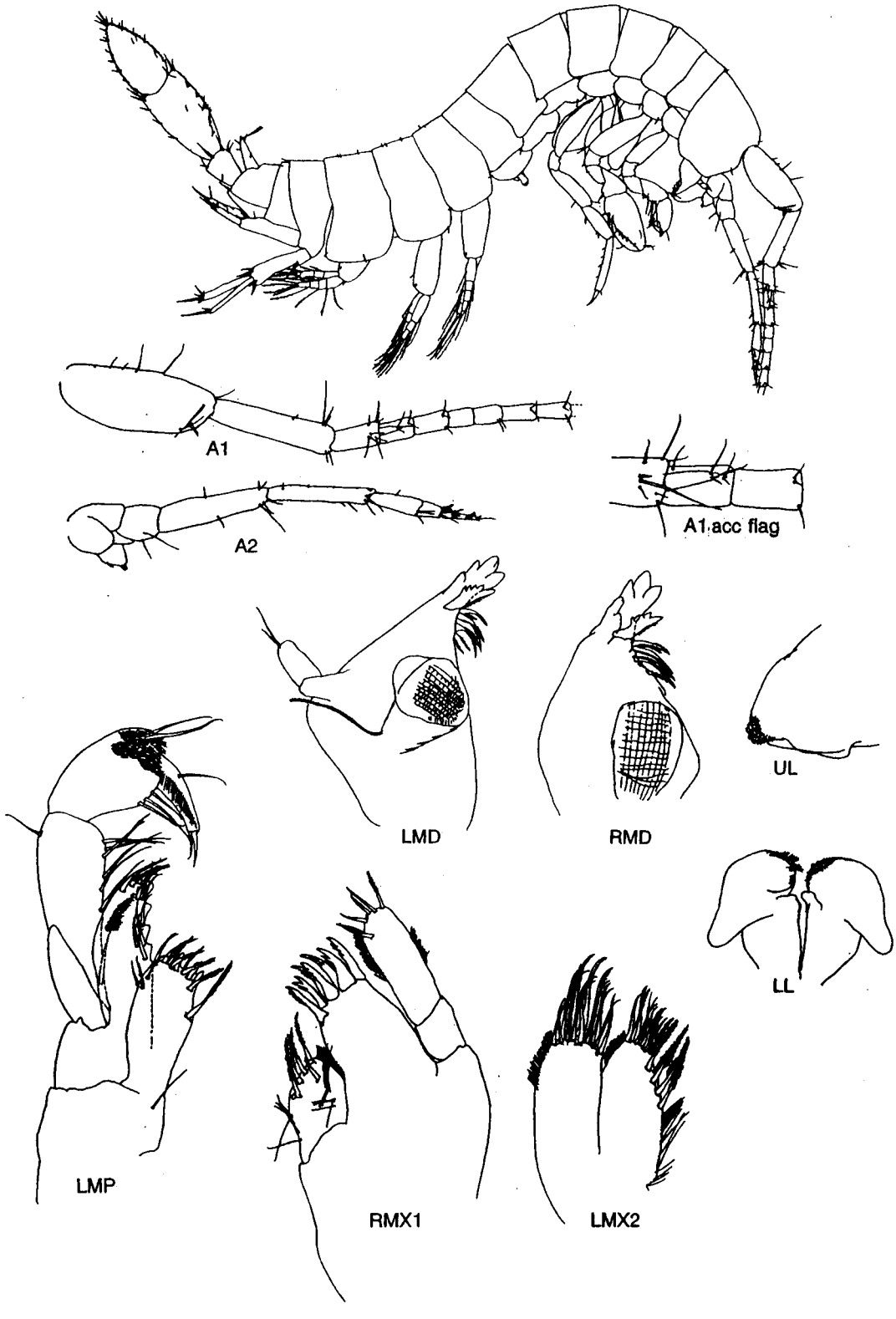

Fig. 4.20. *Nedsia urifimbriata* holotype male 2.5mm. Body, antennae, mouthparts.

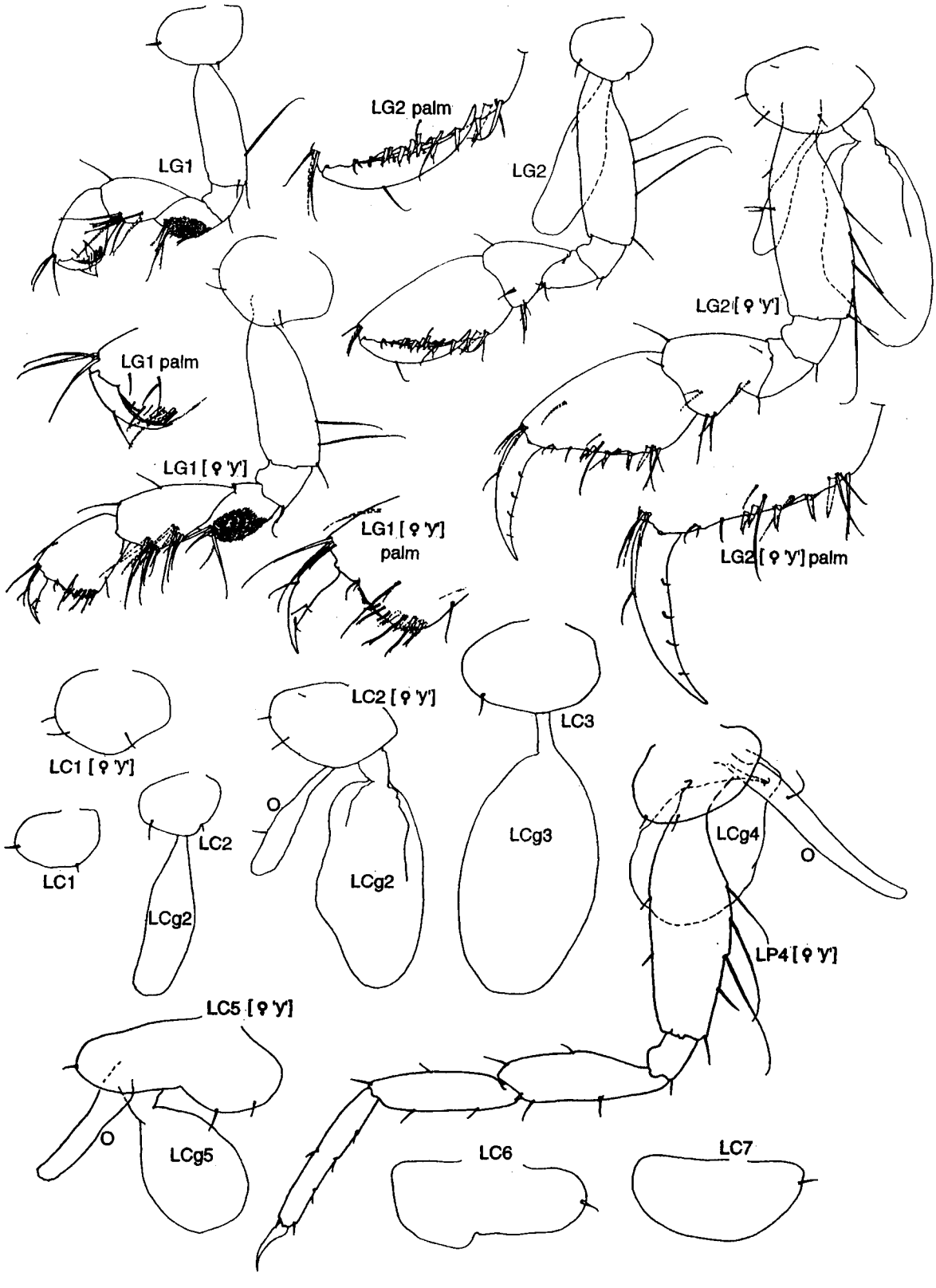

Fig. 4.21. *Nedsia urifimbriata* holotype male 2.5mm. all drawings except those indicated as female 'y'. Legs.

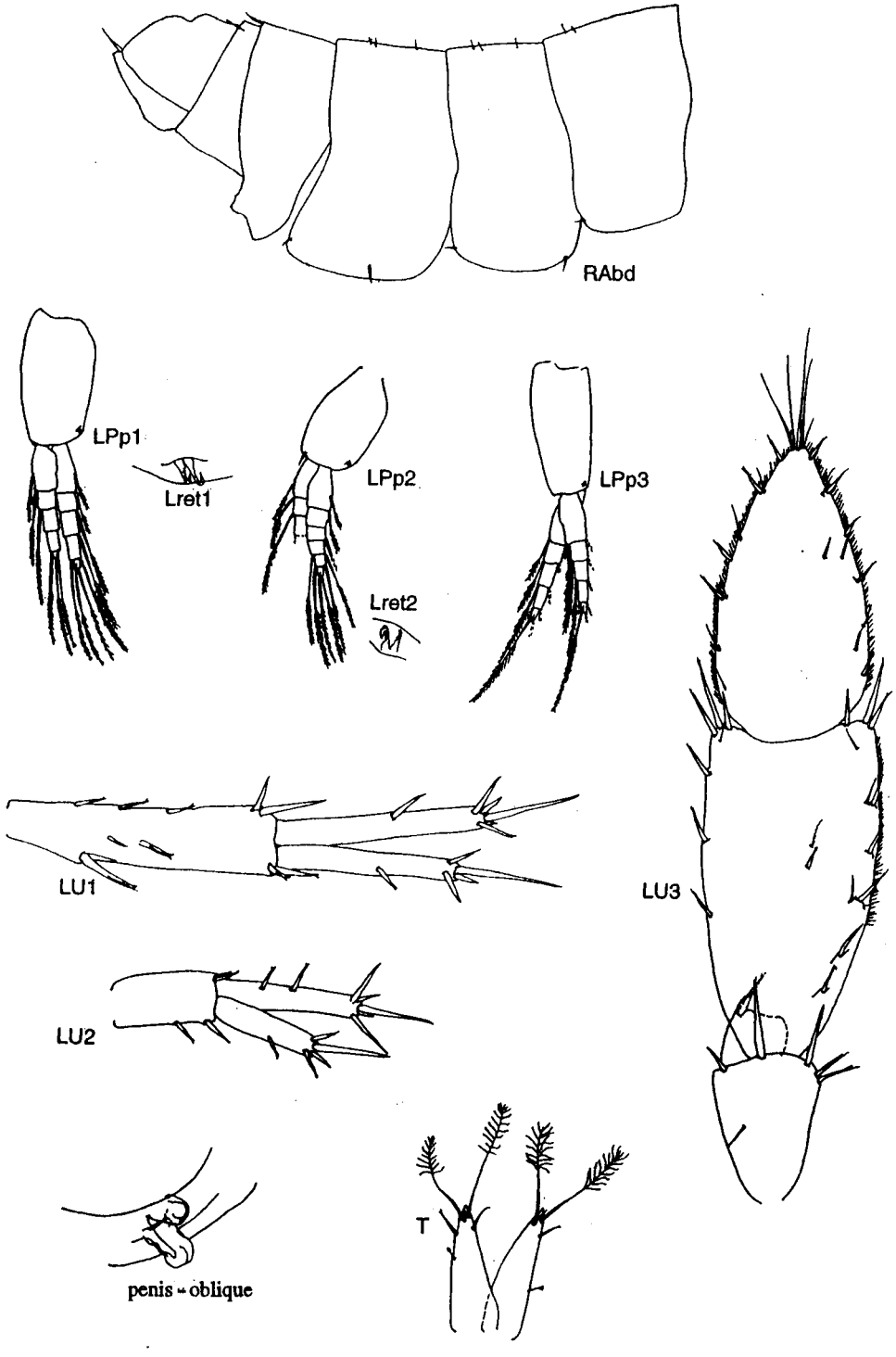

Fig. 4.22. *Nedsia urifimbriata* holotype male 2.5mm. Abdomen, pleopods, uropods, telson, penis.

all rami, none bifid. *Epimera*: epimera 1 and 3 posteriorly quadrate, E2 more rounded; posterior margins of E1-2 weakly convex, of E3 linear; smooth, not setulose with no ventro-facial spines, lacking an oblique ridge. *Pleon*: pleonites 4 and 5 with disto-lateral posterior seta, pleon 6 with disto-ventral spine. *Uropods*: uropod lengths relative to U1 (300) - U2 (165) = 0.55x, U3 (485) = 1.6x; U1 peduncle length 1.3x inner ramus, outer margin without an apico-distal spine, with 2 apico-medial and 2 apico-lateral spines, bearing a short row of 2 dorsal and 3 medial spines; rami of sub-equal length (lateral : medial = 116:130), both rami bear a single mid-dorsal spine, medial ramus with 5 terminal spines, the lateral with 4; U2 peduncle 0.7x length of inner ramus, no apico-dorsal spines, 1 mid-lateral spine, 1 sub-apico-lateral spine, and 2 apico-medial spines; outer ramus shorter than inner (70:95), both with marginal spines; lateral ramus with 1 mid-lateral spine, medial ramus with 2 medial spines; apices of rami with 4 (lateral) and 5 (medial) terminal spines; U3 peduncle length 0.24X outer ramus, shorter than urosomite 3 (47:52), with no sub-distal setae, an apico-lateral group of 3 spines, single mid-distal spine, single apico-medial spine, and single small mid facial spine; outer ramus lateral margins of both articles and medial margin of distal article, bearing short, marginal pubescent fringe; proximal article with several irregular spine-seta ranks, these sub-marginal laterally, a pair of mid-facial setae, sparse medial setae, 3 apico-lateral and 3 apico-medial setae, terminal article shorter (190:200), similarly armed, distally with a group of 4 long and 2 short setae. *Telson*: 1.5X longer than broad, as long as urosomite 3, cleft 100%; apices minutely notched, sub-apices each with 2 long distal plumose setae, 2 or 3 distal and marginal setae, each lobe bearing a single penicillate setule at M0.3 or 0.5. Small penial processes borne on sternum of thoracic article.

Description of allotype (female "y")

Body 3mm. *First gnathopod*: coxa with 2 anterior setae, article 2 with 2 long posterior setal spines and 1 distal seta, merus with elongate seta of the pubescent posterior lobe and short setae antero-distally; carpus bearing 12 rather than 9 long spines, propodus and dactyl more spinous than male. *Second gnathopod* more setose and spinous than male; coxa without posterior seta, bearing 3 (rather than 1) anterior setae. *Oostegites*: G2-P5 each bearing a simple strap like oostegite with few setae or spines.

Relationship

N. urifimbriata differs from *N. douglasi* in that the peduncle of the first antenna bears a strong medio-distal spine, the second antenna is slightly longer, the molar is triturative with a moderately long distal plumose seta, the palps of the first maxilla are symmetrical, the maxillipedal palp bears an extra medial seta, the inner plate a single mid-medial, sub-marginal plumose spine, the first gnathopod bears fewer palmar spines, the dactyl reaches beyond the palmar corner, the palm of the second gnathopod bears more spines, apical setae of the peduncles of the pleopods are present on pleopod 3 only, the first uropod lacks an apico-distal spine, and the rami with single mid-dorsal spines each, the peduncle of the second uropod is relatively short, without apico-dorsal spines, and the telson longer than wide, as long as urosomite 3. *N. urifimbriata* differs from *N. straskraba*, *N. fragilis*, and *N. humphreysi* in the presence of marginal pubescence on both pates of the second maxilla, from *N. hurlberti* in the presence of ventral sub-marginal spines on the second and third epimera, of organised comb rows of setae at the base of the maxillipedal dactyl, and of more than six flagellar articles on the pleopods, and in the absence of a spine like extension of the first urosome at the base of the first uropod. *N. urifimbriata* differs from *N. macrosculptilis* and *N. sculptilis* in the presence of anterior spines, but absence of setae, on the first coxal plate, the absence of dorsal setae on the telson and of sculpturing of the pleon, and in possessing a long outer plate on the maxilliped.

Distribution

Barrow Island, Western Australia.

4.3.5 *Nedsia fragilis* n. sp. Figs. 4.23 - 4.24.

Etymology

Named for the fragile nature of the appendages.

Type locality

Barrow Island, Western Australia., Western Australian Museum sampling site BES738.

Material examined

Holotype (Western Australian Museum WAM 5-96), male 2.4 mm.

Diagnosis

First antenna: (broken), ratio of peduncular articles = 82:23:- . *Upper lip*: symmetrical, not excavate below. *Right mandible*: bearing inter-raker plumose setae, *left mandible* without; palp 2 articulate, article 1 reduced, sub-truncate; article 2 linear, sub-truncate, setae = 2E. *Maxillae*: inner plate of both maxillae without pubescence of medial or lateral margins; outer plate of first maxilla bearing 5 denticulate and 2 naked terminal spines. *Coxae*: C1 longer than broad, slightly expanded below, C2 lacking posterior marginal spines, C3-4 with posterior spines. *Maxilliped*: inner plate with distal row of 4 plumose setae, lacking medial plumose setae; outer plate medial margin barely sinuous, paired sub-marginal setae curved and blunt, reduced in number; apex of palp article 3 not produced, setae not organised into combs; dactyl bearing a row of comb setae, single dorsal spine seta, moderate nail and equally long accessory spine. *First gnathopod*: palmar spines curved, not bifid except at palmar corner where spines = 3 lateral, 2 medial. *Second gnathopod*: defining corner of palm bearing 1 long lateral seta and 1 slender medial trigger spine. *Epimera*: post-ventral tooth present on E2-3, E3 with small ventro-marginal spine at M0.6. *Pleopods*: peduncles without setae, baso-medial setae of inner rami not bifid, 2 retinaculae on each peduncle, without accessory retinaculum. *Uropods*: dorsal margins of peduncles of U2 not spinous, spine rows of rami reduced to 0 or 1 spine each. *Telson*: cleft 100%; single disto-lateral spine at M0.8; single lateral penicillate setule at M0.7 on either lobe.

Description of holotype (male)

Body: 2.4 mm. *Urosome*: poorly armed dorsally. *Head*: rostrum obsolescent, eyes absent. *First antenna*: ratio of peduncle articles = 82:23:- . Setae of peduncular article 1 limited to single dorsal and ventral sub-marginal setae, one sub-marginal ventral and one long medio-distal setae; article two naked. *Second antenna*: length

0.3x body, peduncle longer than flagellum, article 4 longer than article 5 (63:52), articles 3-4-5 with weak ventral setation, article 3 with 1 dorso-medial spine, flagellum of 4 articles, without calceoli. *Upper lip*: apical margin rounded, not excavate, connection to epistome symmetrical. *Mandibles*: left mandibular palp of 2 articles (broken), incisor 5 toothed, lacinia mobilis 5 toothed, 6 barely setose accessory blades, no inter-raker plumose setae; molar triturative, lacking distal plumose seta, slight pubescence around base of accessory blades; right mandible incisor 5 toothed, lacinia mobilis denticulate, accessory blades of 6 plumose spines; molar triturative, with distal plumose seta; palp 2 articulate, reduced, ratio of articles 2:16, articles truncate, naked, terminal article with 2 E setae only. *Maxillae*: first maxilla palp article 2 bearing (5 spines), outer plate with 7 spines; 2 naked, 5 denticulate, inner plate (bearing fine medial setae); second maxilla outer plate, outer apical margin lacking pubescence with few fine setae; inner plate lacking pubescence; terminal spines of both plates half rastellate, half finely setulate. *Maxilliped*: palp article 3 with a pair of long sub-terminal setae medially, diagonal distal row of 3 facial setae, apex with sub-terminal transverse row of unorganised comb setae; nail of moderate length with an accessory spinule of equal length; palp article 2 bearing mid-medial serrations; inner plate with a pair of plumose facial spines and two distal sub-marginal medial spines, one small and sharp the other moderate, stout and blunt. *First gnathopod*: coxal plate with 1 moderate apical seta, several (3) anterior and posterior (2) facial setae, without a post-ventral spine; article 4 posteriorly bulbous and pubescent; carpus not lobate; propodus trapezoidal, slightly expanded apically, longer than wide; posterior edge naked except for an apical pair of long setae basal to the dactyl; palmar corner rounded, marked by 3 naked lateral spines and 2 stout bifid medial spines; palm convex, finely serrated, dactylus reaching the end of the palm. *Second gnathopod*: palm with 4 setae; 2 lateral, 2 medial, the fourth marking the corner medially, along with a strong elongate lateral spine; palm finely serrate along most of its length; dactyl bearing a single dorsal spinule at M0.3, and small bent spinule latero-facial at M0.6; coxal plate 2 broader than C1, poorly setose with 1 post-ventral marginal spine and a ventro-facial spine both at M0.6, as well as a single antero-ventral spine at M0.1. *Pereopods*: coxa 3 with 1 antero-ventral spine, 1 post-ventral sub-marginal seta-spine; C4 similar; P(3)-4 longer than G2, P(3) equal to P4; P4 articles 4-5 sparsely setose posteriorly, (P5-7 similar, consecutively elongate, with 2

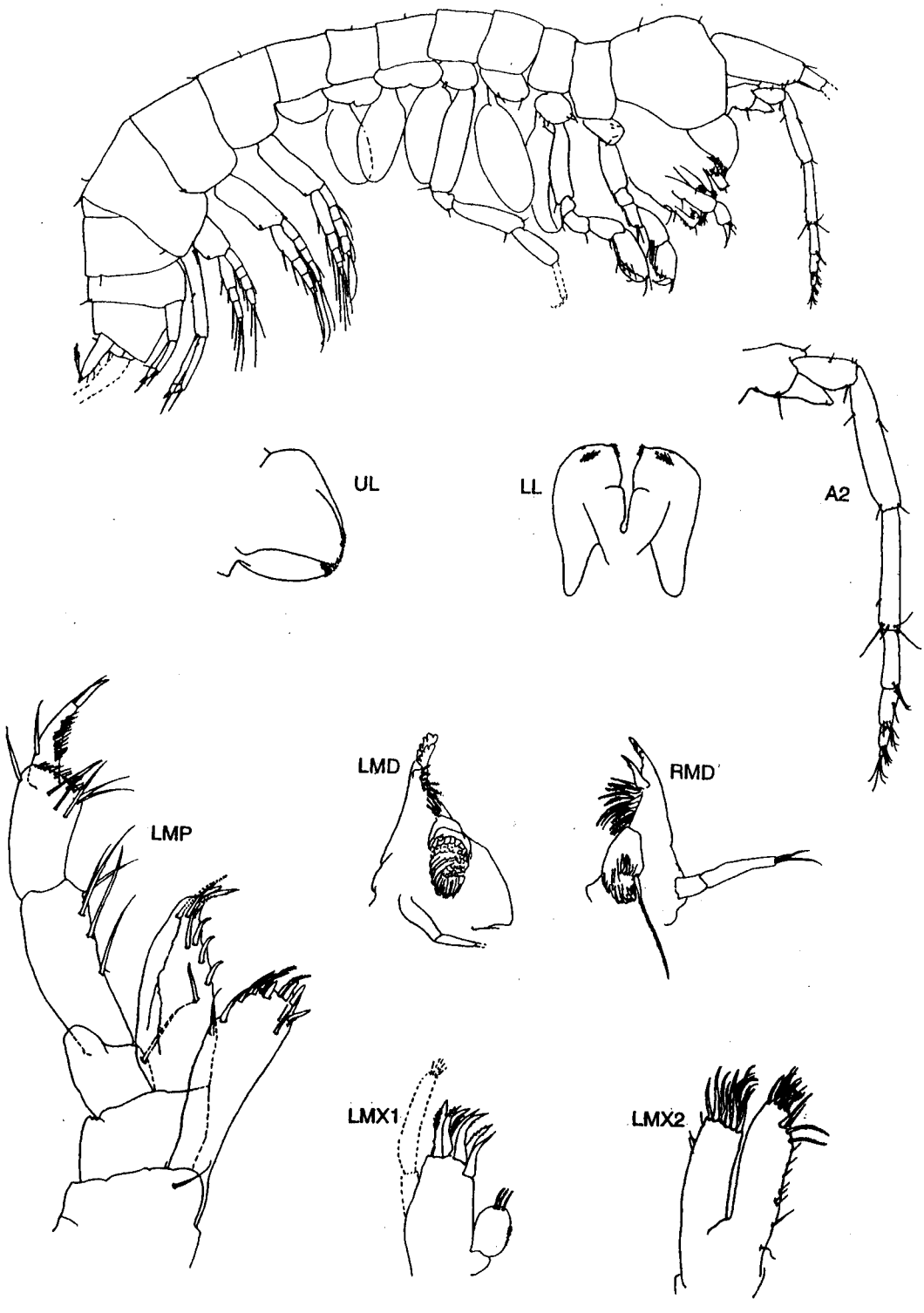

Fig. 4.23. *Nedsia fragilis* holotype male 2.4mm. Body, antenna, mouthparts.

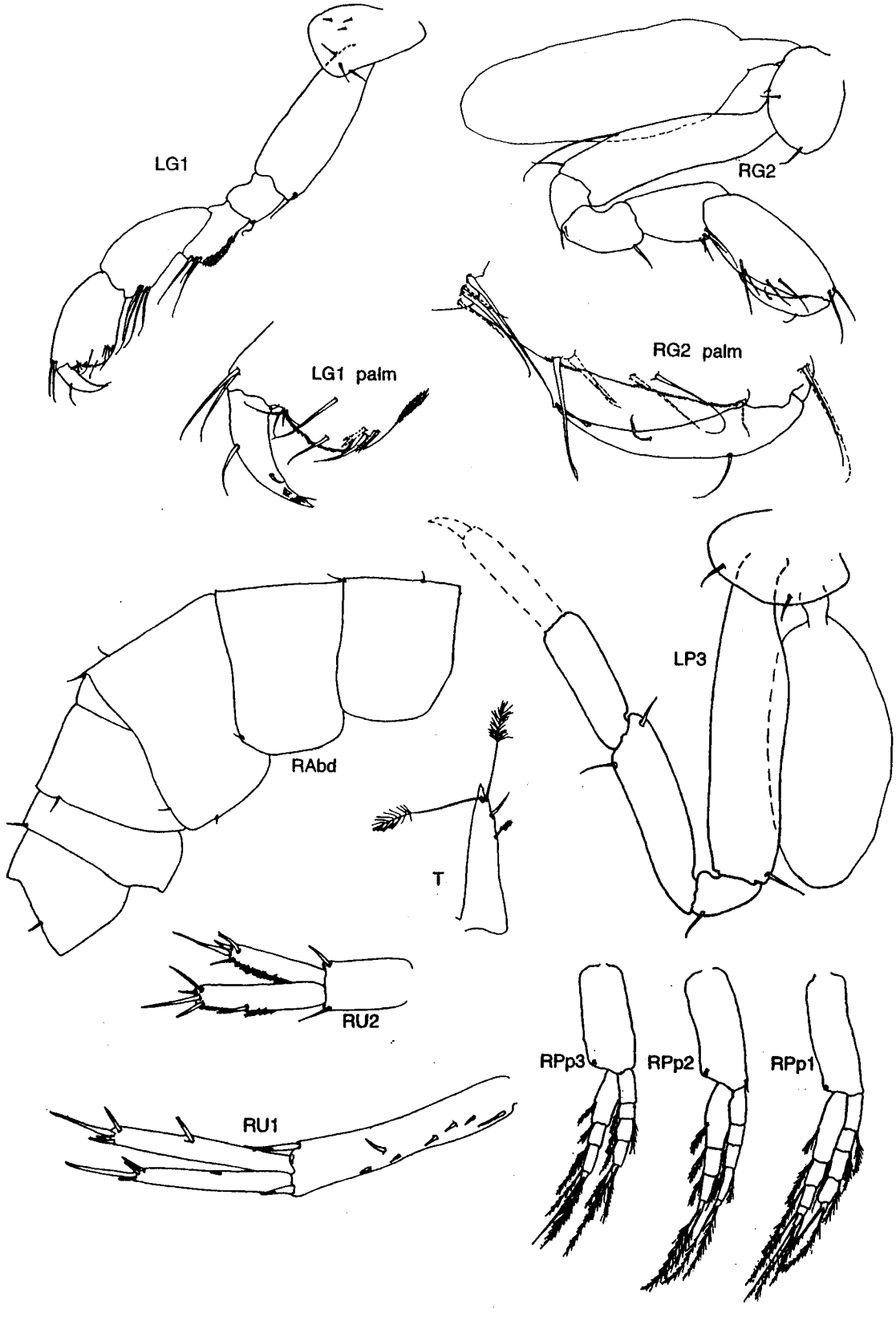

Fig. 4.24. *Nedsia fragilis* holotype male 2.4mm. Legs, pleopods, uropods, telson, abdomen.

locking spines, P7 article 6 anterior spines displaced by an anterior keel); C5-7 bearing no setae on ventral margins of the posterior lobes, article 2 weakly expanded, (not lobate but extended posteriorly, with thin, short posterior setae); C3-7 dactyls simple, with no accessory spinules. *Gills*: coxal gills of limbs 2-6 flask shaped, simple, gill 6 not reduced, gill C2 largest, gill C5-6 smallest but not significantly reduced. *Pleopods*: two retinaculae per pleopod, with no accessory retinaculae; peduncle 2 only with apico-lateral seta; rami extend sub-equally, outer rami with 5 articles each, the inner with 5-4-4; setae of the basal articles = 1-1-1-1- , none are bifid. *Epimera:* each post-ventrally quadrate, though E2 barely so; posterior margins scarcely convex, smooth, and barely setulose; E3 with 1 ventro-facial spine, lacking lateral oblique ridge. *Pleon*: pleonite 2 only without dorsal or dorso-lateral posterior setae; pleonite 6 no dorso-lateral or disto-ventral spines. *Uropods*: lengths relative to U1. U2 = 0.5, U3 absent; U1 peduncle length 1.3x medial ramus, outer margin with a row of 5 small sub-marginal spines and 1 moderate latero-facial spine at M0.6, single apico-medial and apico-lateral trigger spines, basofacial spine weak, the medial ramus longer than the lateral; both rami with sparse setation, terminating in 4 spines; peduncle of second uropod 0.6x length of inner ramus, single apico-medial and apico-lateral spines; medial margin of both rami pubescent; outer ramus shorter than inner (62:81), both bearing few marginal spines and 4 terminal spines; U3 absent. *Telson*: length 1.6x width, as long as urosomite 3, cleft 100%; apices notched, sub-apices with 2 long plumose setae; 1 marginal seta at M0.8, each lobe bearing a single penicillate setule marginal at M0.7

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Relationship

Nedsia fragilis varies from *N. douglasi* in the relative length of the second antenna, the greater length of the second peduncular article, the presence on the third article of a dorso-medial spine, a round and symmetrical upper lip, mandible bearing additional accessory blades, the molar bearing a distal plumose seta, palp of right mandible with elongate first article, second maxilla lacking pubescence, terminal spines of both plates either rastellate or terminally setulate, first gnathopod palmar corner rounded not square, with fewer medial spines, palm of second gnathopod with fewer spines, retinaculae of pleopods not associated with an accessory, rami of pleopods with fewer articles, epimera 2-3 without ventro-facial spines, pleonite six without dorso-lateral or disto-ventral spinules or spines, basofacial spine weak,

peduncle of the second uropod short and less spinous, rami marginally pubescent with fewer terminal spines, telson more slender. *N. fragilis* differs from others of the genus in lacking marginal pubescence on both plates of the second maxilla, except for *N. straskraba*, from which it differs in possessing dorsal pleonal spines, and from *N. humphreysi* in lacking disto-lateral spines on the first epimeron, possessing a row of facial spines on the peduncle of the first uropod, the outer plate of the maxilliped tapers apically and is weakly cuspidate, and the palmar corner of the first gnathopod is rounded.

Distribution

Barrow Island, Western Australia.

4.3.6 *Nedsia macrosculptilis* n. sp. Figs. 4.25 - 4.27.

Etymology

Named for the deep sculpturing of the pleon.

Type locality

Barrow Island, Western Australia, Western Australian Museum sampling site BES786.

Material examined

Holotype (Western Australian Museum WAM 6-96) female 5.5 mm Barrow Island, Western Australia.

Diagnosis

Pleonites: 5-6 with 3 pairs of small dorso-lateral spines. *Head*: rostrum absent, lateral cephalic lobes moderately projecting. *First antenna*: ratio of peduncular articles about 3:3.5:1 *Upper lip*: symmetrical, apically rounded. *Mandible*: palp of 2 small articles, truncate, cone like, setae of art 2 = E2; accessory blades (rakers) = 5 R or 6 L with 3R and 4L interraker plumose setae between each main raker. *Maxillae*: first maxilla inner plate facially pubescent with 8 plumose medial setae, both plates of the second maxilla with disto-lateral fine pubescence, outer plate with fine pubescence medially. *Maxilliped*: medial setae of inner plate sub-marginal to facial, with 1 short, naked, sub-marginal spine at the base of the first of these, medial margin of face of outer plate scalloped and bearing rugosities; palp third article apex setae not organised to comb rows, apex not produced; dactyl facially setose with 2 medial and 1 terminal accessory spines, the latter as long as the

moderate nail. *Coxae*: C1-4 lacking posterior spines. *First gnathopod*: palmar spines symmetrically bifid, and without triggers, spines at corner of palm = lateral 4 long and medially a continuous row of 5 bifid and 2 naked spines, palmar edge finely serrated anteriorly. *Second gnathopod*: enlarged, 2x G1, carpus moderate, shorter than propodus; defining corner of palm with 1 enlarged spine. *Epimera*: posterior margin of E3 sculptured; epimera with facial and ventral sub-marginal spines. *Coxal Gills*: 5-6 reduced slightly. *Uropods*: rami of U1-2 with 2 spine rows; U3 medial setae of outer ramus moderately long; spines of peduncle apical and mid-lateral. *Telson*: cleft 100%.

Description of holotype (female)

Body: 5.5 mm. pleonite 6 with 3 dorso-lateral spines and 2 disto-ventral spines; pleonite 5 with 4 dorso-lateral spines. *Head*: rostrum obsolescent, eyes absent. *First antenna*: length about 1.5x body, 2.9x A2, flagellum longer than peduncle, peduncle article 2 longest, 3 shortest, article 1 bearing a strong medio-distal spine; setae moderate, flagellum of many articles (44), and a few aesthetascs; accessory flagellum 2 articulate, 2nd article tiny; article 1 of primary flagellum fused, other articles shortest proximally, longest distally. *Second antenna*: moderately short, length 0.4x body; peduncle longer than flagellum, articles 4-5 equally long, with weak ventral setation, article 3 without dorso-medial spines; flagellum 5 articulate, lacking calceoli. *Upper lip*: apical margin convex, slightly extended, spinose and pilose, connection to epistome symmetrical. *Left mandible*: left mandible palp missing, incisor 5 toothed, lacinia mobilis 5 toothed and very broad; 6 setose accessory blades; molar with distal plumose seta, triturative, an area of pubescence leading from accessory blades to the base of the molar. *Right mandible*: palp 2 articulate, reduced, article 1 short, naked, second article tapered, setae = 2E; lacinia mobilis with 3 smooth teeth and small denticle medial between 1st and last tooth, 5 setose accessory blades and 3 plumose interraker setae; line of pubescence leading to edge of molar. *Lower lip*: bearing prominent inner lobes, outer lobes apically pilose and spinose. *First maxilla*: right and left palp article 2 bearing 4 naked thin apical setae, 3 with fine distal setulate rugosities, and 1 plumose thin apical seta; outer plate with 6 denticulate, and 1 naked spines; inner plate ovate and pubescent, with 8 medial plumose setae. *Second maxilla*: both plates with the outer margin pubescent, as well as the median distal margin of the outer plate; basomedial margin of the inner plate with 5 fine setae grouped 2,3. *Maxilliped*: palp article 3 with 2

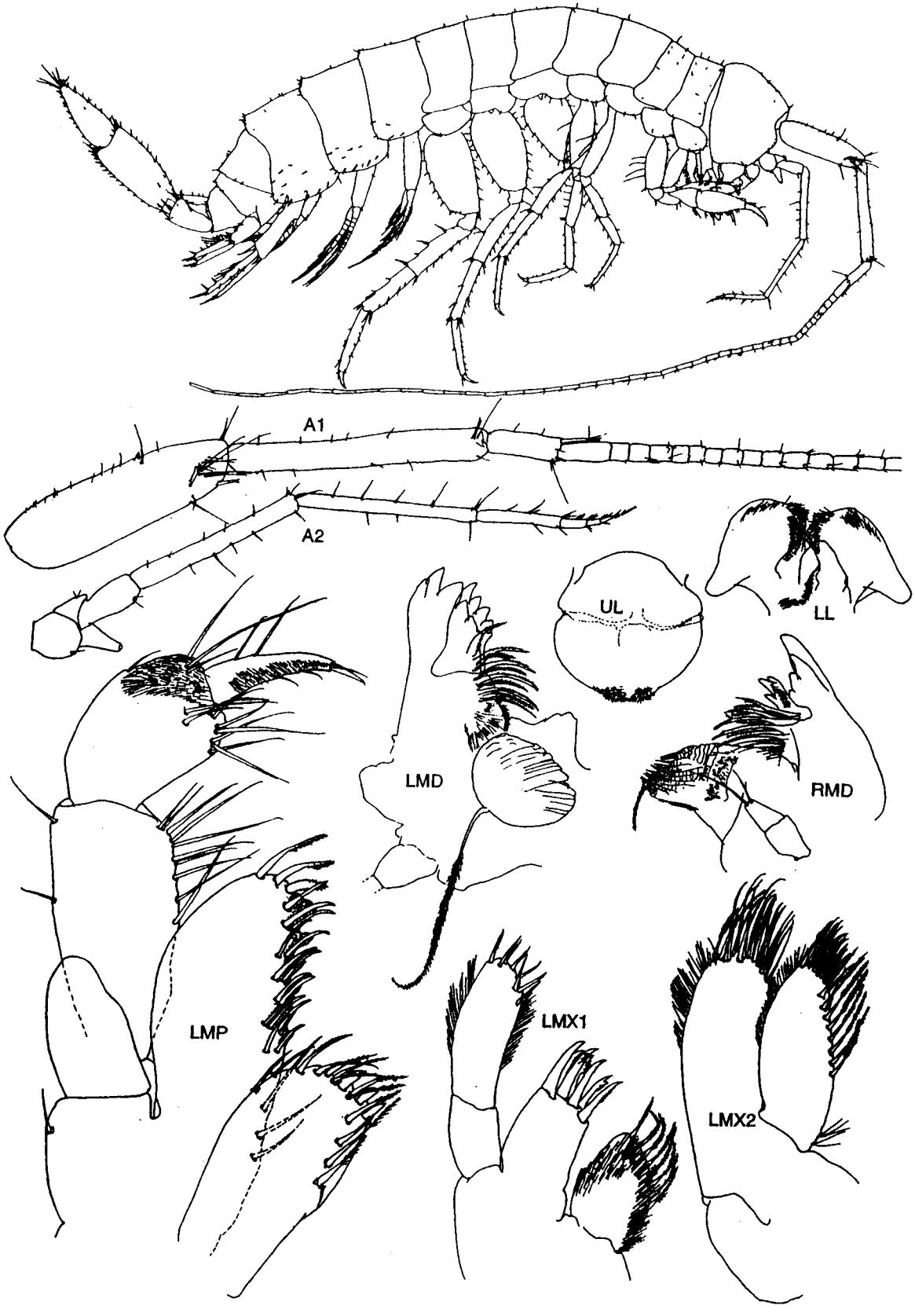

Fig. 4.25. *Nedsia macrosculptilis* holotype female 5.5mm. Body, antennae, mouthparts.

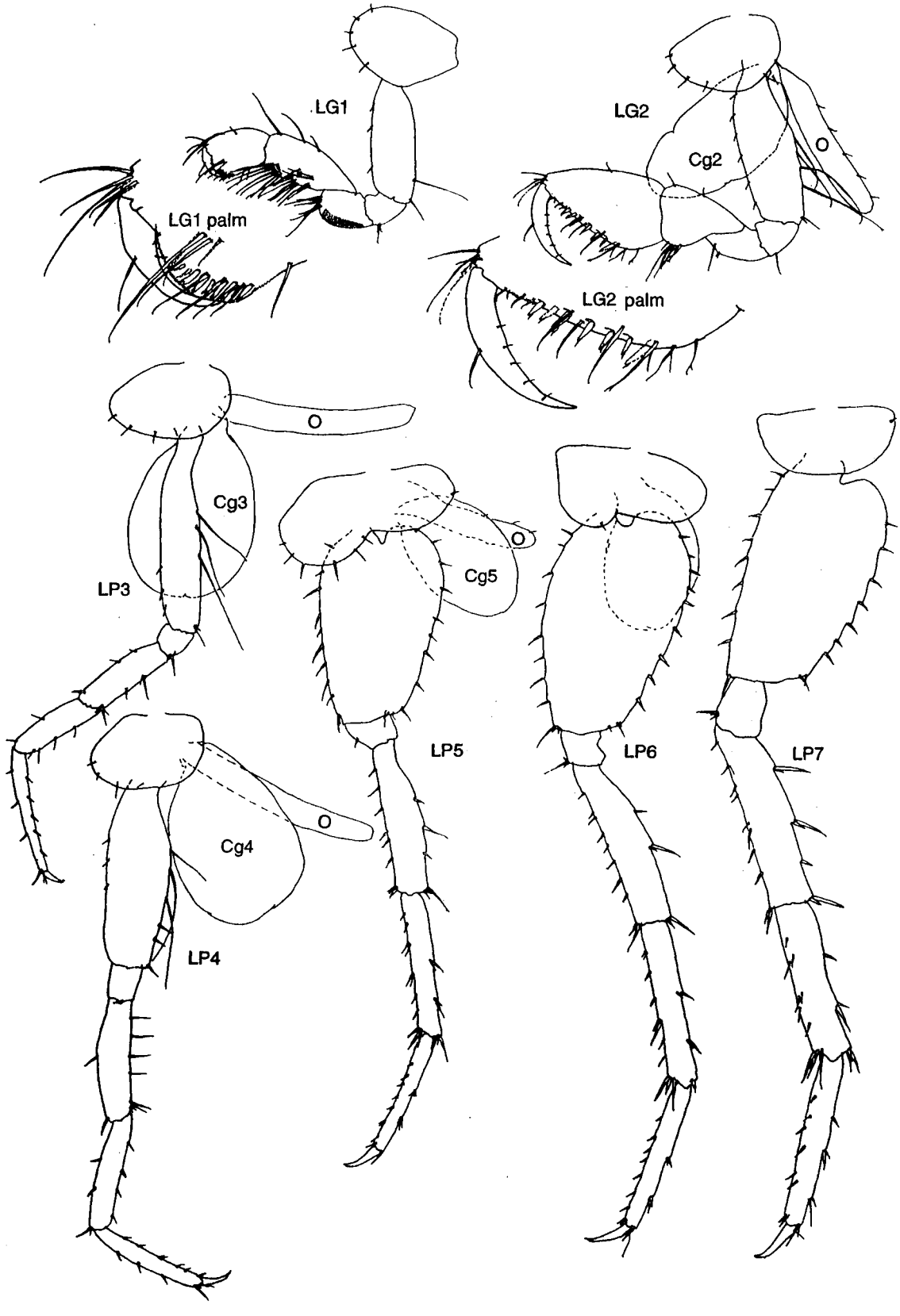

Fig. 4.26. *Nedsia macrosculptilis* holotype female 5.5mm. Legs.

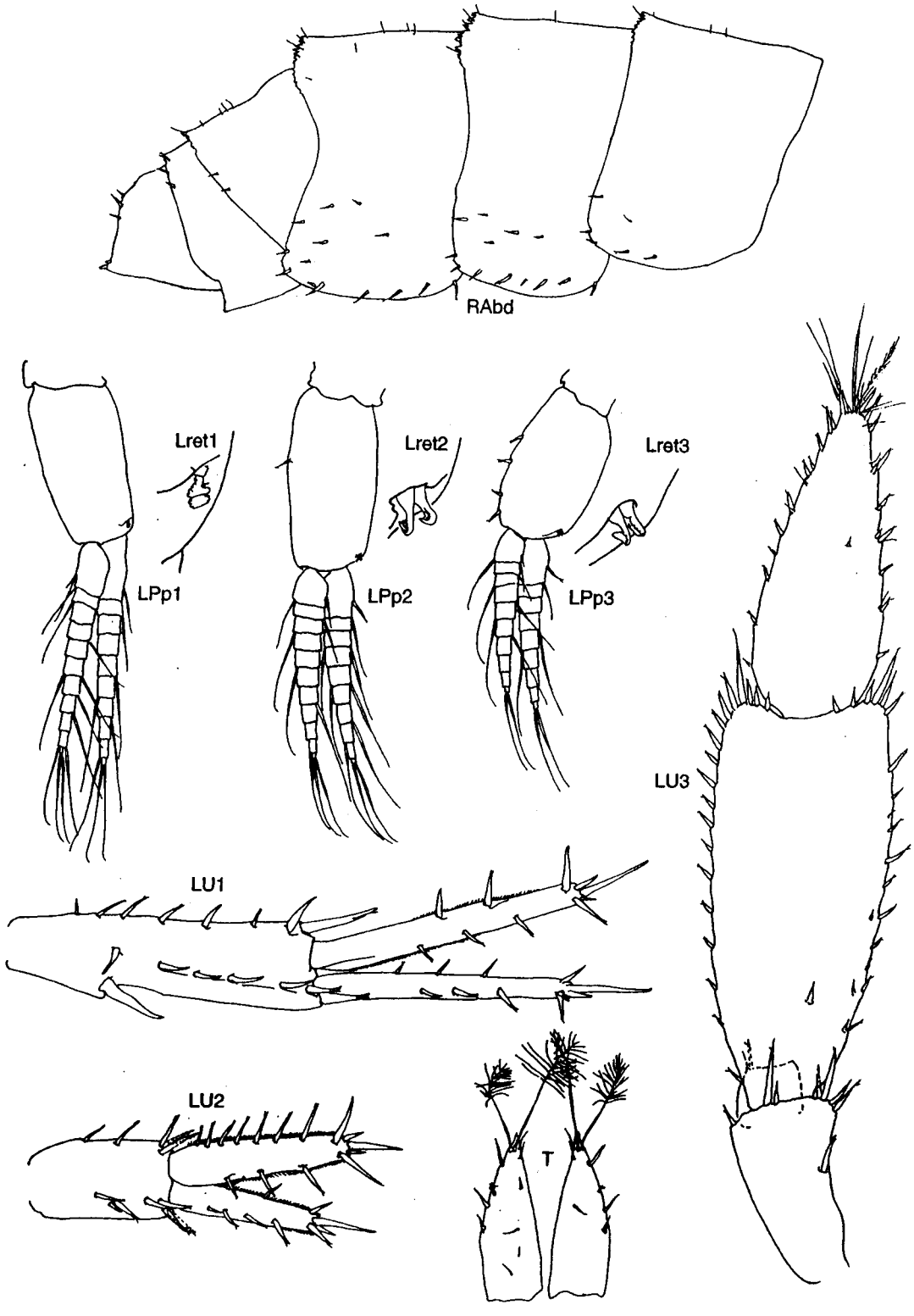

Fig. 4.27. *Nedsia macrosculptilis* holotype female 5.5mm. Abdomen, pleopods, uropods, telson.

thin, moderately long setae sub-dactylar on the inner face, and a longer pair on the outer face; article 3 moderately setose distally leading to the base of the dactyl. *First gnathopod*: coxal plate with 5 short setae apically, without posterior ventral spines; article 4 posteriorly bulbous, marginally pubescent, but without a hyaline lobe; carpus not lobate, propodus trapezoidal, slightly expanded apically, longer than wide, posterior margin almost naked with 2 setae only; corner of palm rounded, not clearly defined, with row of 4 lateral setae, medially 2 naked spines and 5 bifid spines; palm convex, dactyl not reaching corner. *Second gnathopod*: palm strongly oblique with 5 lateral and 2 medial spines all unevenly bifid with triggers; defining spine near corner medial, dactyl reaching spine, but not corner of palm; coxal plate broader than long, 4 anterior, 1 posterior setae. *Pereopods*: coxa 3 with 3 antero-ventral setae, similar; coxa 4 with 4 similar setae; P3-4 longer than G2 (287,250:215), P3 shorter than P4, articles 4,5 sparsely setose posteriorly; posterior armament formulae of P3-4; S,S,S,S,S,0 and S,S,sS,S,S,S thus with a single locking spine on P4 only; P5-7 similar but consecutively elongate, each with 3 locking spines; slight inward expansion of the anterior spines of article 6 of P7 revealing a slight keel; coxae 5-7 bearing single post-ventral setae on posterior lobes; article 2 of P5-7 moderately expanded, not lobate, but extended posteriorly, bearing short but moderately stout posterior setae; dactyls of P3-7 simple with single basal outer penicillate setule, and no accessory setules. *Gills*: of coxae 2-6 flask shaped, gills 5-6 smaller but not significantly reduced; gill 4 largest, gills 5-6 smallest. *Oostegites*: of coxae 2 small, 3-5 thin, strap like, only those of C5 with a few small setae. *Pleopods*: retinaculae 2 each, no accessory retinaculae; peduncle of the first pleopod with no setae, of the second with 1 seta, of the third with 4; setae unevenly bifid with triggers; rami extending equally, the inner with 10,10,9 articles, the outer with 11,11, 10 articles. Setae on basal articles of rami = 1-1,1-1,1-0. *Epimera*: E1-2 post-ventrally sub-quadrate, E 3 slightly lobate; posterior margins slightly convex, of E 1 smooth, of E 2 sculptured at the postero- ventral corner and posteriorly sinuous, of E 3 finely sculptured posteriorly; epimera with facial and sub-marginal spines, posterior corners marked with 2-2-1 spines, each lacking an oblique ridge, but with an incomplete row of facial spines. *Pleon*: pleonites 1-4 bearing dorsal and dorso-lateral posterior setae, and posterior margins sculptured into sharp serrations; pleonites 4-6 with lateral and / or dorso-lateral posterior spines - pleon 4 = 2 lateral, pleon 5 = 4 dorso-lateral, pleon 6 = 3 dorso-lateral as well as 2

blunt ventro-lateral spines. *Uropods*: U 3 strongly extended in entire animal; uropod lengths relative to U1 - U2 = 0.6x, U3 = 1.3x; U 1 peduncle length sub-equal to inner, longer ramus (175:165), outer margin with 1 long apico-distal spine besides a row of 6 dorsal spines (the 6 th spine sub-apical), one apico-medial spine and a medial row of 7 spines (the 7 th. spine sub-apical); rami of U 1 sub-equal in length, the medial ramus being the longer (155:165); both rami with two rows of marginal spines, and 5 terminal spines, distal margins of the inner ramus finely pubescent; U 2 peduncle 0.85x length of inner (longer) ramus, outer margin with 1 apico-dorsal and 1 apico-ventral spines, dorso-lateral row of 5 unevenly spaced spines, medial margin with 2 apico-ventral spines and 2 sub-distal apico-dorsal spines, 1 mid sub-marginal spine and a single baso-marginal spine at M0.3; outer ramus shorter than inner, both with 2 rows of marginal spines in formulae 4,3 and 3,7; disto-lateral and medial margins of the outer ramus and both margins of the inner ramus finely pubescent; both rami terminating in 4 apical spines; U 3 peduncle length 0.24x outer ramus, longer than urosomite 3 (50:40), bearing an apical cluster of 4 dorso-lateral spines, 1 mid-lateral spine; all spines marginal; outer ramus proximal article long, 2.3x peduncle, with lateral and medial marginal trigger spines, regularly spaced, an irregular, medial sub-marginal row of 4 small spines, one displaced toward the mid line, the medial and lateral apices each with a cluster of 4 spines extending partially across the distal margin; article 2 shorter, 0.8x article 1, margins bearing regularly spaced trigger spines, paired distally, the medio-distal and apical margins setate, setae increasing in length distally and with a single apical plumose seta; inner ramus scale like, of 1 article, length 0.1x the length of the proximal article of the outer ramus (16:117), bearing 1 short and 1 medium length apico-lateral trigger spines and 1 postero-mid-lateral, sub-marginal medium length trigger spine. *Telson*: length 2.9x width, longer than urosomite 3 (47:40), cleft 100% of its length; sub-apices with sinuous lateral notch, long, paired, plumose setae arising sub-apically, a short row of 2 distal medial setae, 3 lateral trigger spines and weak dorsal setation; single small sub-marginal lateral penicillate setule at M0.6 on either lobe.

Relationship

N. macrosculptilis varies from *N. douglasi* in that the pleon is more spinous and setous, the posterior margins of pleosome 1-4 finely sculpted and setate and of 5-6 dorso-laterally spinous, the flagellum of the first antenna extremely long bearing

aesthetascs, the second peduncular article is longest, the first article bearing a strong medio-distal spine, and moderately setate, the first article of the primary flagellum is fused and subsequent articles increase in length distally. The second antenna is proportionally longer, the flagellum 5 articulate, the upper lip is slightly convex apically, extended and symmetrical. L molar bearing long plumose distal seta, is pubescent from the accessory blades to the base of the molar. R mandibular palp 2 articulate, with a medium length plumose molarial seta, and pubescence. Palp of first maxilla bearing 8 thin apical setae, symmetrical, inner plate with 8 medial plumose setae, second maxilla baso-medial margin of inner plate bearing 5 fine setae in 2 groups, maxillipedal palp article 3 with moderate distal setae leading to the base of the dactyl, Gnathopod 1 palmar corner rounded, not clearly defined with more setae and spines, The second gnathopod is more spinous in the palm, epimera with facial and sub-marginal spines and posterior corners with 2-2-1 spines, pleon sculptured to sharp serrations, and bearing setae and dorso-lateral spines on pleon 5-6, peduncle of U1 shorter than in *N. douglasi* , distal margins of inner ramus finely pubescent, U2 shorter, outer ramus shorter than inner, disto-lateral and medial margins of outer ramus and all of inner ramus covered in fine pubescence, U3 peduncle longer than urosomite 3, all spines marginal, article 2 0.8x article 1, inner ramus relatively longer than in *N. douglasi*, telson much longer than wide, sub-apical notch broader, telson more spinous. *N. macrosculptilis* differs from *N.sculptilis* in the absences of spines on the post-lateral margins of the 4th pleonite and of rugosity on the medial face of the maxillipedal outer plate, and in reduced scalloping of the medial margin of that plate. *N. macrosculptilis* differs from all the other *Nedsia* in the presence of deep sculpturing of the pleonic posterior margins and of facial spines on the epimera. The species differs from *N.straskraba*, *N. fragilis* and *N humphreysi* in bearing marginal pubescence on both plates of the second maxilla.

Distribution

Barrow Island, Western Australia.

4.3.7 *Nedsia sculptilis* n. sp. Figs. 4.28 - 4.30.

Etymology

Named for the sculpturing of the pleon.

Type locality

Barrow Island, Western Australia. Western Australian Museum sampling site #BES 787

Material Examined

Holotype (Western Australian Museum WAM 7-96) male 4.0 mm

Diagnosis

Pleonites: without dorsal spines. *Head*: rostrum obsolescent, lateral cephalic lobes moderately projecting. *First antenna*: bearing aesthetascs, *Second antenna*: short. *Upper lip*: symmetrical, not excavate. *Mandibular palp*: 2 articulate, articles equal in length, terminal article tapered terminating in 2 E setae; accessory blades on rakers = 6L, 4R, with one interraker plumose seta on the right and one additional seta beyond the left rakers. *Maxillae*: without medial setae or pubescence except for the lateral margins of the second maxilla; inner plate of the first maxilla ovato-triangular with six mid-medial to medio-distal plumose setae; palps symmetric; inner plate of the second maxilla with a row of medial setae barely extending onto the face apically with few other medial setae. *Coxae*: short, broader than long with few posterior spines. *Maxilliped*: inner plate bearing three distal plumose setae and three blunt naked terminal spines, without plumose medial setae, the outer plate bearing two distal plumose setae contiguous with a blunt naked tooth spine; palp articles 2-3 weakly setate laterally, setae at the dactylar base not organised into comb rows, the palp apex weakly produced, the dactyl with a moderately long nail. *First gnathopod*: palmar corner marked with one long lateral spine, moderate numbers of setae along palm. *Second gnathopod*: carpus barely lobate. *Pereopods*: 3-6 without accessory spinules on dactyls, posterior spine sets on article six of P3 evenly spaced, those on P4 uneven; dactyl of P7 with an extra terminal spinule. *Gills*: present on coxae 2-6. *Pleopods*: peduncles with 0,2,2 setae, 2 retinaculae and no accessory retinaculae. *Epimera*: E3 only with a small postero-ventral tooth. *Uropods*: apico-lateral corners of peduncles of uropods 1-2 with 3 and 2 spines respectively, the dorsal margins bearing few spines, the medial margin of U1 with 2 apical spines. *Telson*: longer than broad, cleft 85%, bearing some medial spines.

Description of holotype (male)

Body: 4 mm. *Pleonite*: 6 without dorsal spines, bearing two latero-distal and single ventro-distal spines; pleonite 5 with distal dorso-lateral spines. *Head*: rostrum obsolescent, eyes absent. *First antenna*: longer than second (broken at article 11); flagellum longer than peduncle; peduncular articles 1-2 equal in length, 2.7x article 3, the first article bearing a cluster of ventral sub-distal spines and setae, a row of small ventral spines, a dorsal row of three strong spines and a weak distal seta; flagellum moderately setate, bearing aesthetascs on some articles, article 1 of the primary flagellum fused, accessory flagellum two articulate, second article tiny, extending to M0.8 of the first article of the primary flagellum. *Second antenna*: moderately short, 0.3x body length; peduncle longer than flagellum, articles 4-5 sub-equal with weak setation, article 3 bearing a single dorso-medial spine and 4 ventro-distal spines; flagellum of 5 articles of diminishing dimension, lacking calceoli or aesthetascs. *Upper lip*: apically convex, pilose and spinose; symmetrical. *Left mandible*: without palp (broken), incisor 5 toothed, lacinia mobilis 5 toothed and elongate, extending to the apex of the incisor; mandible bearing 6 large setose and 1 small naked accessory blades between the incisor and molar, without interraker plumose setae or pubescence; molar triturative, without distal seta. *Right mandible*: bearing a short palp of two sub-equal articles, the first truncate and naked, the second cone like bearing 2 short apical E setae; incisor of 5 teeth; lacinia mobilis shorter than incisor, bifid, bearing anteriorly a median row of short spines , posteriorly a marginal row of setae; mandible bearing 4 accessory blades, the first denticulate, the remainder setose, with a single interraker seta lying between first and second blades, and a row of setae extending posteriorly; molar triturative, without a distal seta. *Lower lip*: bearing prominent inner lobes extending to M0.7 of the outer lobes; anterior surfaces of both lobes rugose, inner lobes naked, outer lobes bearing apico-medial spines and setae. *First maxilla*: palps of two articles, almost symmetrical, the left side more slender than the right, possibly regenerent, each with 5 apical and 1 sub-apical slender naked spines; inner plate ovato-triangular, without pubescence except for a small lateral terminal cluster, bearing on the medial margin to the apex 6 plumose setae; outer plate bearing two naked and five denticulate terminal spines. *Second maxilla*: outer distal margin of both plates pubescent, facial and medial regions lacking pubescence, outer plate bearing a single distal spine additional to the terminal setae; both plates without

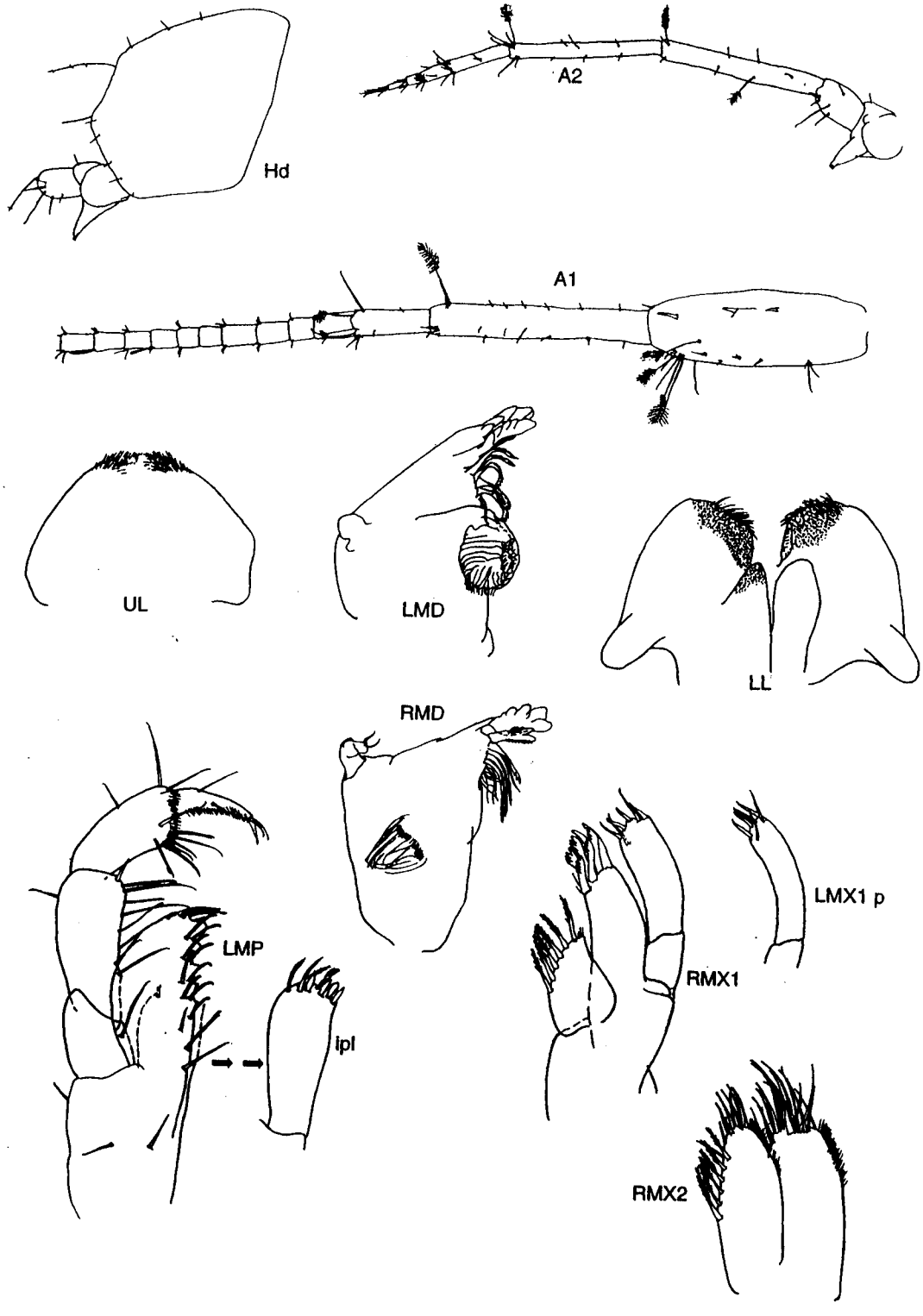

Fig. 4.28. *Nedsia sculptilis* holotype male 4mm. Head, antennae, mouthparts.

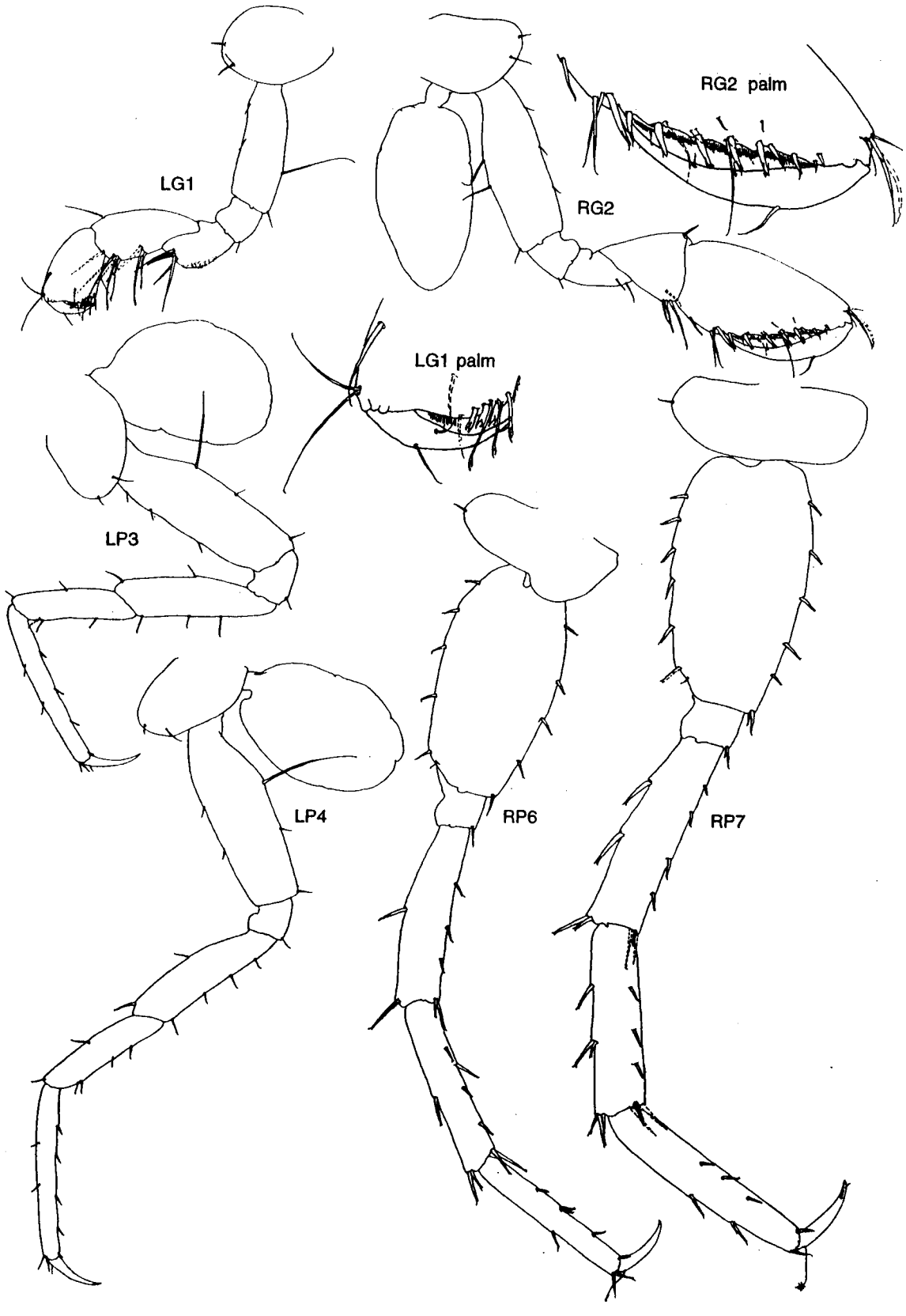

Fig. 4.29. *Nedsia sculptilis* holotype male 4mm. Legs.

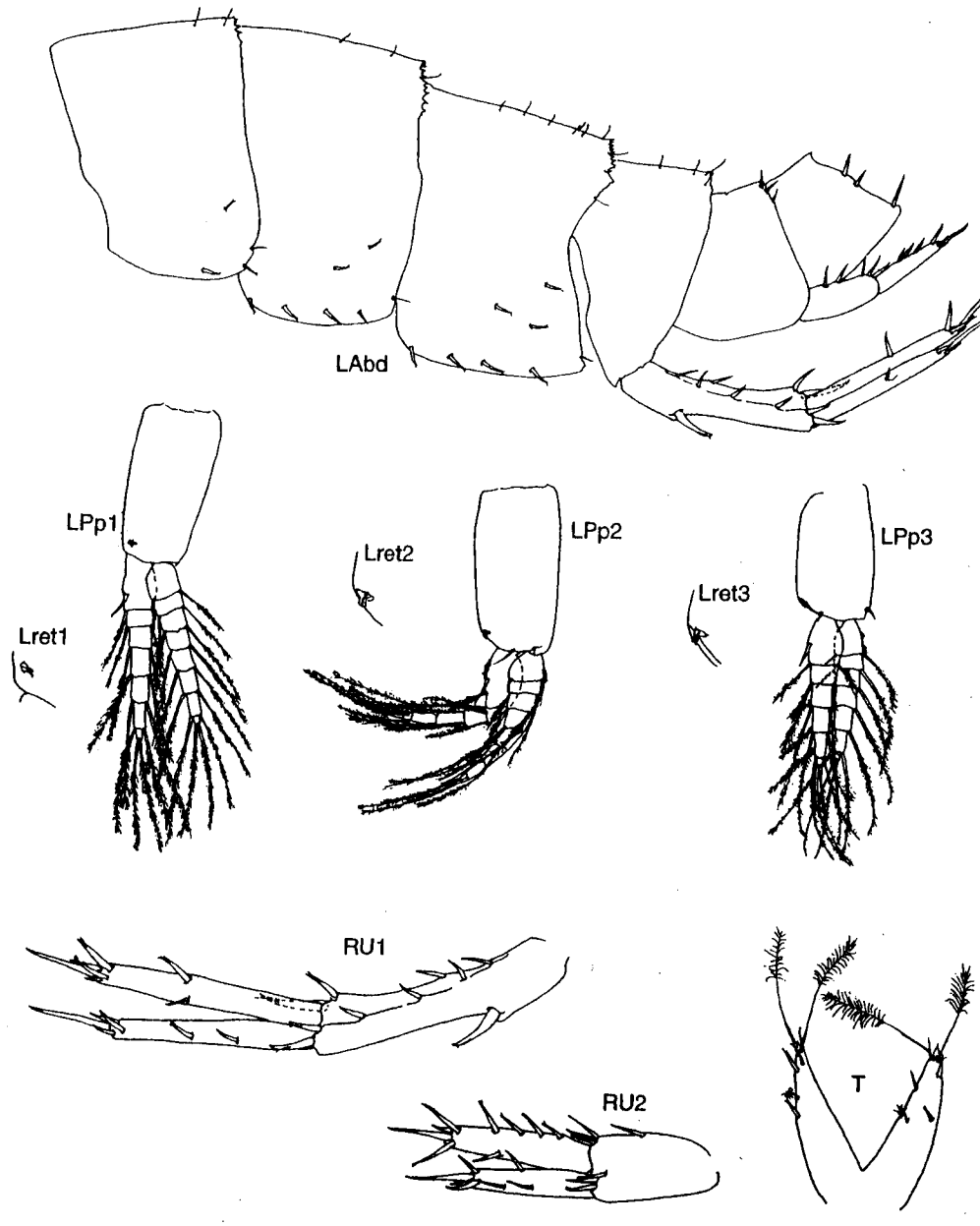

Fig. 4.30. *Nedsia sculptilis* holotype male 4mm. Abdomen, pleopods, uropods, telson.

other setae. *Maxilliped*: palp third article with medial setae confined to the margin of the apex, bearing a single facial spine adjacent the dactylar base; apical setae marginal, not organised to comb rows; dactyl with two accessory spines arising adjacent the base of the nail and as long as the nail; medial margin of the outer plate carved into 4 sinuous indentations, without marginal spines, but associated with each a pair of long sub-marginal, curved, blunt spines. *First gnathopod*: coxal plate bearing 2 apical setae, the fourth article posteriorly bulbous and pubescent, carpus not lobate; propodus trapezoidal and slightly expanded apically, longer than wide, posterior margin naked but for a single sub-marginal spine and a pair of long apical spines; margin of the palm lined with fine setae anteriorly, posteriorly the palmar corner rounded, marked by a single long lateral bifid spine, the posterior margin of the hand pubescent; adjacent the palmar corner three stout bifid spines and two long terminally bifid spines; dactyl bearing a sub-terminal accessory spinule extending to the nail-less apex, which reaches to the palmar corner. *Second gnathopod* : coxa bearing 2 anterior setae, the palm strongly oblique, bearing 7 lateral and 2 medial stout trigger spines and marginally bordered with short setae, the palmar corner defined by a long lateral trigger spine; dactyl bearing 3 small spines along the inner margin, and extending to a point slightly short of the palmar corner. *Pereopods*: coxae 3-4 with 2 anterior setae only, P3-4 longer than G2, P3<P4, both sparsely armed, P6-7 similar, P6<P7, articles 5 of P6 and 5-6 of P7 bearing a slight anterior keel, the anterior spines consequently slightly sub-marginal; coxae 6-7 bearing single posterior spines, articles 2 of P6-7 posteriorly expanded but not lobate and bearing stout trigger spines; dactyls of P3-6 without accessory spinules, P7 bearing a single sub-terminal spinule on the dactyl. *Gills*: flask shaped, present on coxae 2-6, gill 6 not reduced. *Sternal gills* absent. *Pleopods* each with 2 retinaculae, without accessory retinaculae, peduncles bearing 0,1,1 setae and 0,1,1 spines, all distal, the lateral spine of peduncle 3 bearing a trigger; rami extending sub-equally, of 7,6,6 inner and 8,8,7 outer articles; setae of basal articles of rami = 3-2,3-2,3-2. *Epimera*: first epimera post-ventrally rounded, second post-ventrally quadrate, third slightly extended posteriorly and bearing a small postero-ventral tooth, otherwise posterior margins smooth; E1-3 bearing facial and sub-marginal ventral spines, the posterior corners marked by 2-1-1 spines, E2 bearing a single antero-ventral marginal spine. *Pleon*: pleonites 1-4 bearing dorsal and dorso-lateral posterior setae, the posterior margins sculptured, with many serrations, less so on pleonite 4;

without spines except for pleonite 5 which bears 3 dorsal and dorso-lateral spines of moderate length, and pleonite 6 with 2 lateral and 1 ventro-lateral posterior spines. *Uropods* : first uropod 1.9x length of second, peduncle length greater than rami, outer margin bearing a strong baso-facial spine and row of 4 dorso-lateral spines, the last sub-apical, the medial margin bearing 2 anterior and 1 sub-apical dorsal spines; distal apices of peduncle bearing 1 medial and 1 lateral spines; inner ramus longer than outer, with single marginal spine at M0.6, and terminating in 5 spines, the outer ramus with 2 lateral spines at M0.4 and M0.6, terminating in an apical cluster of 4 spines; second uropod peduncle sub-equal to outer ramus, outer margin with 3 apical spines, inner margin with 1 mid-marginal and 3 apical spines; outer ramus bearing 1 mid-medial and 2 lateral spines at M0.5 and M0.7, and 4 terminal spines; inner ramus with 1 lateral spine at M0.7, a row of 4 medial spines and 4 terminal spines. U3 absent. *Telson*: length equal to width, as long as urosomite 3; cleft 85% of its length, the sub-apex notched around an apical spine like extension, the notches bearing long plumose setae; left lobe bearing small lateral spines at M0.6 and M0.8, medial spines at M0.7 and M0.9, and a single penicillate facial setule at M0.5; right lobe bearing small lateral spines at M0.6 and M0.8, facial spines at M0.85, and single lateral penicillate spinule at M0.7.

Relationship

N. sculptilis in the form of the pleonites which are setate and complexly sculptured, and the epimera which are facially and sub-marginally spinous is similar to *N. macrosculptilis* and differs from other *Nedsia* in these ways. *N sculptilis* is distinguishable from *N. macrosculptilis* in that the posterior margins of the fourth pleonite are without spines, and the medial margin of the outer plate of the maxilliped is without facial rugosity and is carved into 4 rather than 5 indentations.

Distribution

Barrow Island, Western Australia.

4.3.8 *Nedsia chevronia* n. sp. Figs. 4.31 - 4.33.

Etymology

Named for Chevron Australia Pty. Ltd., whose assistance enabled this study to be initiated.

Type locality

Underground water, MW15, Barrow Island, Western Australia, 20°, 46', 58" S, 115°, 27', 53" E.

Material examined

Holotype: male 'a', 4mm (WAMC 28207) Western Australian Museum collection number BES 3424, 20°46'58"S, 115°27'53"E, 23 October 1998, W. F. Humphreys and S. M. Eberhard. Paratypes: male 'b', 3.5mm., (WAMC 28208) 3 other males 2.5 – 3.0mm. (WAMC 28311). Same data as holotype. Other material: 17 specimens, all small, all damaged (WAMC28312), Barrow Island, Western Australia, Western Australian Museum collection number BES 3395, 20°46'58" S, 115°27'53" E, 22October 1998, W. F. Humphreys and S. M. Eberhard.

Diagnosis

Pleonites with few dorsal setae. *Head*: rostrum obsolescent; lateral cephalic lobes moderately projecting, very broad; no antennal sinus present; eyes absent. *First antenna*: longer than A2; ratio of peduncular articles from 7:6:3; accessory flagellum 2 articulate. *Second antenna*: short; flagellum much shorter than peduncle; calceoli absent. *Mandible*: palp reduced, 2 articulate; ratio of mandibular palp articles 1:1, article 1 not setose, terminal article tapered, sub-truncate; setae 2 E. *Upper lip*: symmetrical. *Lower lip*: with inner lobes. *Mandibles*: 4 accessory blades (rakers), with inter-raker plumose setae between each main raker. *Maxillae*: moderately medially; inner plate of maxilla 1 ovate with 5 medial setae, outer plate with denticulate setae, palps symmetric, with thin apical setae; inner plate of maxilla 2 with row of medial setae extending onto face apically, other medial setae few. *Maxilliped*: outer plate with no blunt naked tooth seta continuous with distal plumose setae, palp article 3 apex not produced, dactyl with moderate length nail. *Coxae*: short, broader than long, with few posterior setae. *Gnathopods* diverse. *First Gnathopod*: palm transverse; setae at corner of palm = lateral 2 long, medial 4 short. *Second Gnathopod*: propodus palm defining corner with 2 setae laterally. *Pleopods*: similar; rami extending equally, basomedial setae of inner rami bifid; retinaculae 2, no accessory retinaculum present. *Epimera*: postero-ventral tooth of

epimera 1-3 absent; posterior margins smooth; E2-3 bearing facial setae near ventral margin. *Uropods*: apico-lateral corner of peduncles on uropods 1-2 with 2 setae; dorsal margins with setae; rami of uropods with no or one setal rows; outer ramus of uropod 3 with distal peduncular setae; inner ramus reaching to M0.17 on article 1 of outer ramus. *Telson*: cleft 100%; single lateral penicillate setules at M0.6 on each side.

Description of holotype (male "a")

Body: 4 mm. *Urosome*: poorly armed dorsally. *Head*: bearing few slender setae dorsally; rostrum obsolescent; eyes absent. *First antenna*: length 0.6x body, 2.4x A2; flagellum longer than peduncle ; peduncular article 3 shortest, article 1 longest, ratio of lengths = 22:18:9; setae sparse; flagellum of 18 articles; aesthetascs present on articles 3-15; calceoli absent; accessory flagellum 2 articulate, reaching M0.6 of article 1 of primary flagellum, article 2 tiny; articles of primary flagellum sub-uniform, sparsely setulate. *Second antenna*: length 0.25x body; peduncle much longer than flagellum, article 4 longer than 5, 3-5 with weak ventral setation; flagellum 4 articulate, the apical article bearing a small aesthetasc. *Upper lip*: margin not excavate. *Mandibles*: left mandibular palp 2 articulate, short, articles equal in length, article 2 with 2 long apical E setae; incisor 5 toothed; lacinia mobilis with 5 denticles; 4 setose accessory blades and plumose inter-raker setae; molar without distal plumose seta, triturative, a few small setae basal to the molar; right mandibular incisor 4 toothed; lacinia mobilis barely bifid, broad, finely denticulate anteriorly; accessory blades of 4 plumose setae with few inter-raker plumose setae; molar triturative, bearing a long distal plumose seta; palp 2 articulate, articles of approximately equal length, the distal article tapering, bearing 2 E setae. *First maxilla*: palp article 2 with 6 thin apical setae, all naked; outer plate with 7 denticulate setae; inner plate bearing 5 mediodistal to terminal plumose setae, medial margin and face pubescent. *Second maxilla*: outer plate distolaterally pubescent; inner plate pubescent on baso-medial margin, bearing mediomarginal to distofacial row of 5 plumose setae. *Maxilliped*: nail of palp moderately long, dactyl bearing also accessory distal seta as long as the nail, facially bearing fine setae, apex of article 3 not produced, with few thin setae basal to the dactyl, none proximal; inner plate with a distofacial row of 4 plumose setae, 3 apical naked tooth setae and 4 rastellate or naked setae; outer plate bearing 5 mediomarginal indentations and a row of 11 terminally hooked long slender setae, mostly arranged

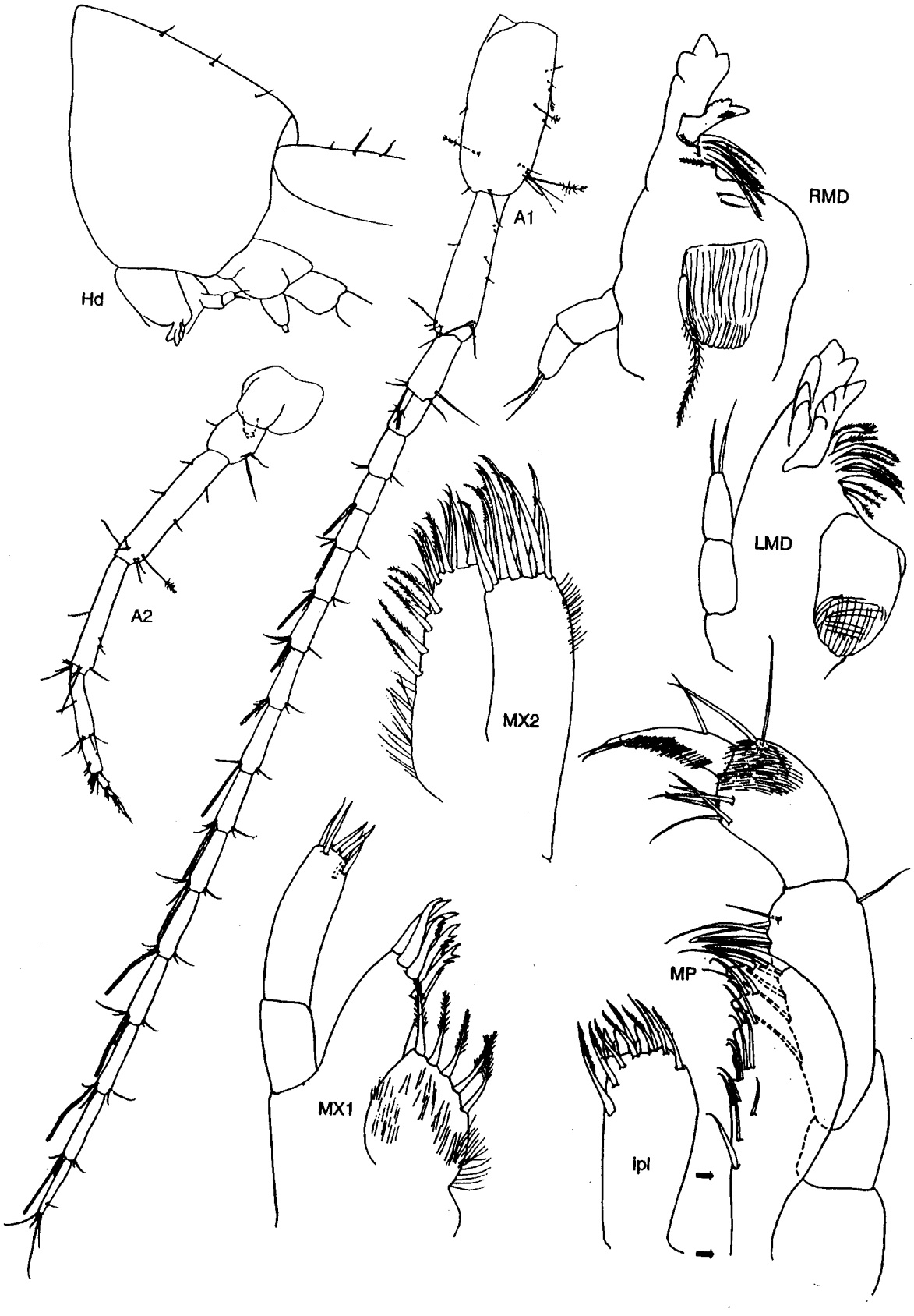

Fig. 4.31. *Nedsia chevronia* n. sp. Holotype, male 'a' 4mm. Head, antennae, mandible, maxillae and maxilliped.

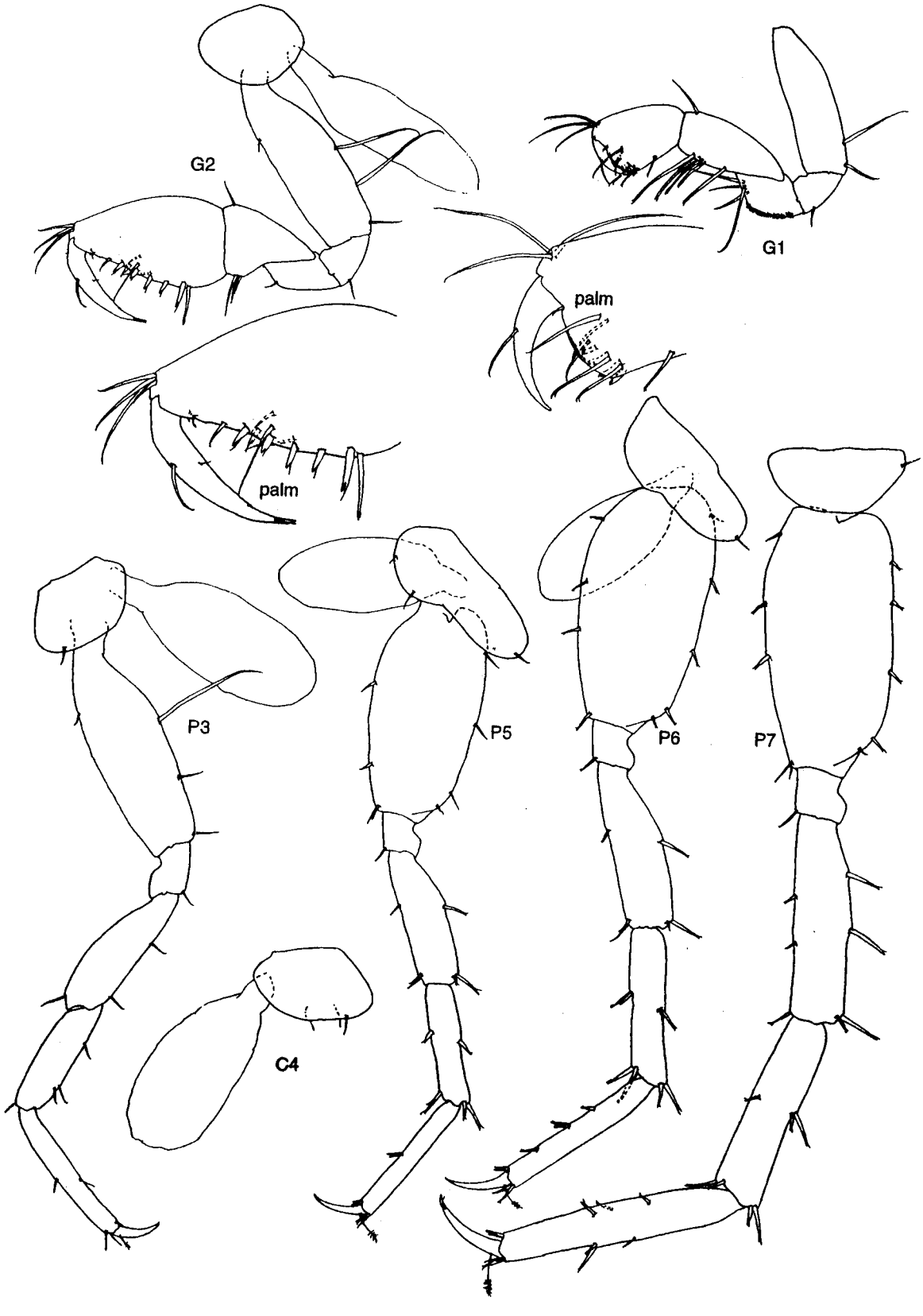

Fig. 4.32. *Nedsia chevronia* n. sp. Holotype, male 'a' 4mm. Gnathopods, gnathopodal palms, pereopods3, 5-7.

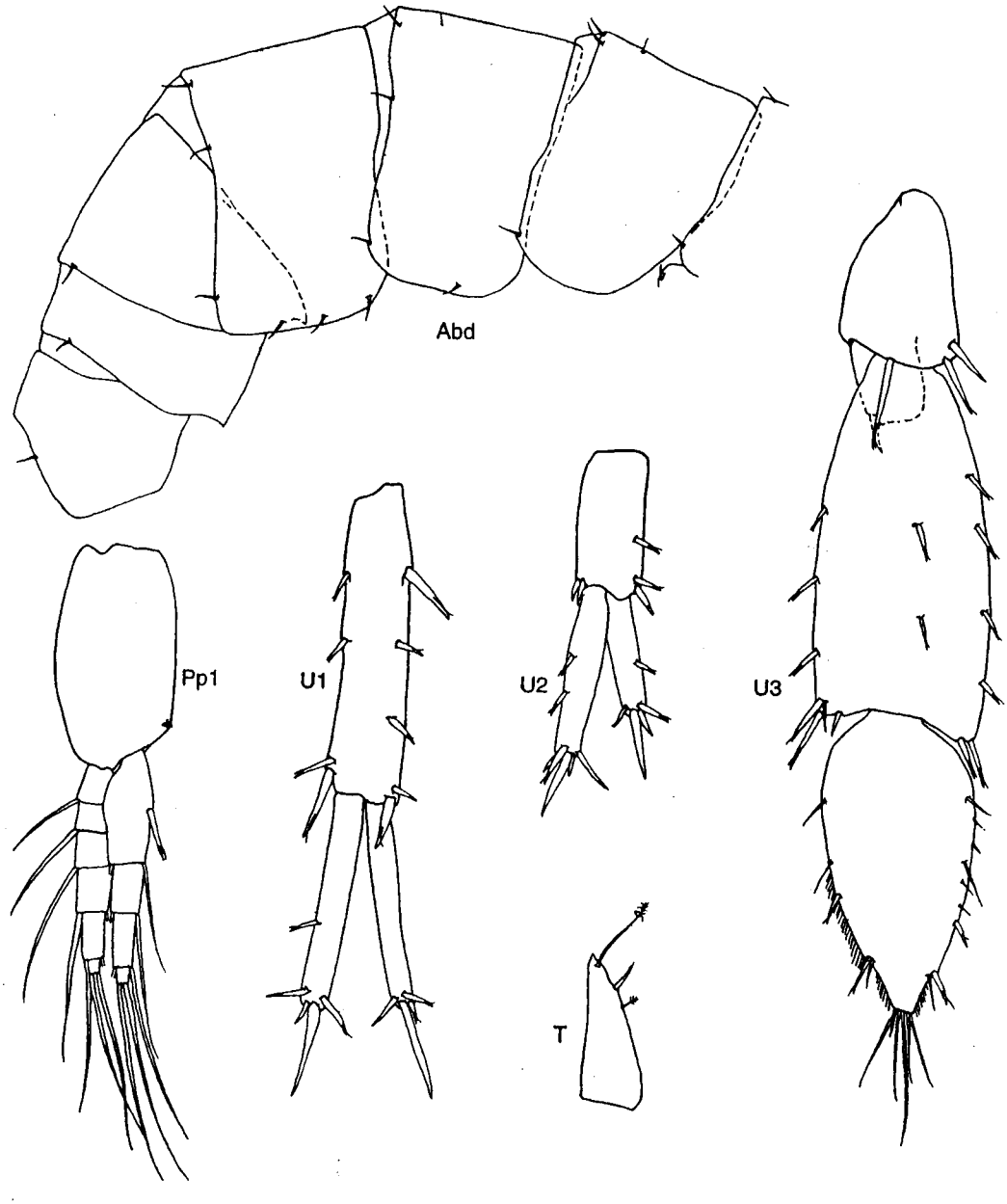

Fig. 4.33. *Nedsia chevronia* n. sp. All illustrations holotype, male 'a' 4mm., except where indicated. Abdomen, pleopod 1, uropods and telson. Female allotype 'b' 4mm. telson.

in pairs. *First gnathopod*: (coxal plate without anterior setae, naked posteriorly); article 4 slightly bulbous posteriorly, bearing short, fine setae; carpus elongate, not lobate; propodus trapezoidal, expanding slightly apically, longer than wide, the posterior edge naked, corner of palm rounded, bearing 2 long, naked lateral setae, and a row of 4 stout bifid setae medially as well as a long slender naked seta, palm slightly convex, dactyl reaching to the palmar corner. *Second gnathopod*: coxa bearing no setae, carpus subtriangular, short; propodus ovate, elongate, naked dorsally, the palmar corner with no medial and 2 lateral setae – one long, slender, apically bifid, the other robust and apically bifid; marginally 4 other stout trigger setae, a single slender seta and small seta basal to the dactyl as well as a long naked slender submarginal seta along the lateral palm; medial palm bearing a single robust trigger seta, 2 submarginal long slender setae and small seta basal to the dactyl. *Pereopods*: coxa 3 with a single anterior seta; coxa 4 bearing single anterior and posterior setae; P3-(4) longer than G2; P3-5 approximately equal, articles 4,5 sparsely setose posteriorly, propodi of P3-4 bearing single locking setae; P6-7 longer; P5-7 similar but consecutively elongate, each with 2 locking setae; P7 anterior setae of article 6 displaced inward by keel-like expansion of the segment; coxae 5-7 bearing 1,1,1 setae on posterior lobes and 2,0,0 anterior setae; article 2 weakly expanded, greatest on P6, of P7 longest, none lobate, but extended posteriorly, bearing few setae; dactyls of P3-7 simple, naked except for an anterior basal penicillate setule, with the addition of an outer terminal seta accessory to the nail on P7. *Gills*: coxae 2-6 with flask shaped gills, gill of C3 largest, of C5-6 slightly reduced. *Pleopods*: retinaculae 2 per pleopod, no accessory retinaculae; peduncles without apico-lateral setae; rami extending equally, the inner with 5:5:4 articles, the outer with 6:6:6; a single bifid seta on the inner basal articles. *Epimera*: epimera 1-2 post-ventrally rounded, of E3 subquadrate; posterior margin of E1 sinuous, of E2 straight, of E3 barely convex, all smooth, with no setae except a single seta each marking the postventral corner; E2-3 with 1 and 3 ventral setae, lacking lateral oblique ridge. *Pleon* 3): pleonites 1-6 with few dorso-lateral posterior setae; pleonite 6 with 1 dorso-lateral seta, but without any disto-ventral spinule. *Uropods*: uropod lengths relative to U1 are U2=0.6x , U3=1.6x; U1 peduncle length 1.5x inner ramus, the outer margin bearing a pair of apico-distal setae and reduced row of 2 mid-dorsal setae, the medial apex bearing 2 setae, the medial margin with 2 setae; rami of sub-equal length, both naked except for a single

medial mid-dorsal seta on the inner ramus; both rami with 4 terminal setae; U2 peduncle length 0.9x inner ramus, bearing 2 apico-lateral and apico-medial setae; inner ramus length 1.5x outer, the medial margin bearing 2 setae only, 5 terminal setae; outer ramus shorter, bearing a single mid-lateral seta and 4 apical setae; U3 strongly extended beyond uropods 1-2 in entire animal; peduncle length 0.5x outer ramus, shorter than urosomite 3, bearing single mid-dorsal and paired latero-distal marginal setae; outer ramus proximal article with few marginal setae, 4 apico-medial setae, 2 apico-lateral setae and 2 dorsal setae; article 2 shorter (0.9x), similarly armed but bearing fine short setules medially and laterally distally, terminating in a cluster of 6 slender setae; inner ramus scale like, sub-quadrate, length 0.14x outer, bearing a single apico-medial seta. *Telson*: length 1.3x width, widest at base, sub-equal in length to urosomite 3, cleft 100%; apices slightly notched laterally; sub-apices with a long plumose seta, 1 sub-distal medial seta and 1 lateral seta at M0.8, no other dorsal setae except for single penicillate setules on both lobes laterally at M0.6.

Description of other material

Specimen 'b', male: length 3.5mm. *Pleonite* 6 with a single dorso-lateral seta posteriorly. *First antenna*: flagellum of 11 articles, aesthetascs present on articles 5,7,9,10. *Mandibles*: setae of terminal article = 2E; interraker plumose setae present between accessory blades. *Maxilliped*: palp article 3 with 6 slender setae basal to dactyl; nail of dactyl moderately long, bearing 2 slender accessory nails extending slightly beyond the nail. *Coxae* 1-3 bearing single apical and facial posterior setae; coxa 4 without anterior seta, with facial posterior seta, coxa 5 with single anterior and posterior setae, coxae 6-7 bearing single posterior setae only. *Pleopods*: accessory setae absent; inner rami of 4:4:4 articles, outer rami of 5:4:4 articles. *Uropod*: lengths relative to U1; U2 0.6x , U3 1.6x; peduncle of U1 1.1x length of inner ramus, of U2 0.7x; U2 inner ramus 2x outer; peduncle of U3 0.28x length of outer ramus, second article of outer ramus equal in length to first; inner ramus 0.1x outer. Telson: bearing single slender plumose setae subapically.

Distribution

Underground water, MW15/SB36 (field collection number BES3424), bore adjacent the tank farm, Barrow Island oilfields, altitude 9.0m AHD, on coastal flats, 65m from coastal cliffs, depth to water surface 9.0m, the limestone cavernous immediately above and below the water table. Barrow Island, Western Australia,

20°46'58"S, 115°27'53"E. Sympatric with *N. hurlberti*: WAM; BES3395, 22 October 1998.

Relationships

This species differs from all others of the genus in: the flagellum of the first antenna is of 15 articles; propodus of the first gnathopod bears 2 long , apically bifid slender setae adjacent the corner and 1 short seta basal to the dactyl laterally, and 4 stout robust apically bifid setae from the palmar corner to the mid palm laterally; the propodus of the second gnathopod bears 1 long slender apically bifid and 1 stout robust trigger seta adjacent the palmar corner as well as a row of 4 robust trigger setae and 3 slender setae along the palm laterally, without medial setae adjacent the palmar corner, but 2 long slender and 1 short robust trigger setae midway along the palm as well as a short slender seta basal to the dactyl. The second coxal plate lacks anterior setae; articles 5-6 of the seventh pereopod without a keel like expansion thus anterior setae not displaced inward; rami of pleopods 1-3 of 5,5,4 medial and 6,6,6 lateral articles.

The species also differs from others of the genus by: first antenna peduncle article 1 longest, unlike *N. macrosculptilis* and *N. sculptilis*, and aesthetascs are present on the flagellum whereas in *N. humphreysi* and *N. urifimbriata* they are absent; article 4 of the peduncle of the second antenna is longer than article 5, thus differing from all species except *N. fragilis* and the flagellum is 4 articles long, unlike *N. urifimbriata*, *N. macrosculptilis* and *N. sculptilis*. The second article of the mandibular palp lacks D setae, unlike *N. straskraba*; the incisor bears 5 teeth unlike *N. hurlberti* and the left lacinia bears 5 denticles unlike *N. straskraba*, *N. hurlberti* and *N. humphreysi*; the mandible bears 4 setose accessory blades, differing from *N. halletti*, *N. straskraba*, *N. humphreysi*, *N. fragilis*, *N. macrosculptilis* and *N. sculptilis* and, unlike *N. sculptilis* and *N. fragilis*, bears no other pubescence. The palp of the first maxilla bears 6 slender setae apically similar only to *N. urifimbriata*, *N. hurlberti* and *N. sculptilis*, and the inner plate bears 5 distomedial plumose setae, unlike all but *N. halletti*; the outer plate of the second maxilla pubescent, unlike *N. stefanus*, *N. straskraba*, *N. humphreysi* and *N. fragilis*. Coxa 2 without posterior setae, unlike *N. straskraba*, *N. fragilis* and *N. macrosculptilis*; coxa 3 with 2 anterior setae, differing from *N. halletti*, *N. stefanus*, *N. hurlberti* and *N. macrosculptilis*, and no posterior setae, unlike *N. straskraba*, *N. humphreysi*

and *N. fragilis*; coxa 4 bears 1 anterior seta and no posterior setae, thus differing from *N. macrosculptilis*, *N. sculptilis*, *N. hurlberti*, *N. humphreysi* and *N. urifimbriata*; Pereopods 5-7 coxae with 1 posterior seta, differing from *N. stefanus* and *N. straskraba*, articles 2 weakly expand progressively, unlike *N. chevronus*, and propodi bear paired locking setae, unlike *N. straskraba*. Pleopods without accessory retinaculae, unlike *N. straskraba*; epimera postventrally rounded, differing from *N. sculptilis*, *N. straskraba*, *N. hurlberti*, *N. urifimbriata*, *N. fragilis* and *N. macrosculptilis*. First and second uropod rami with 4 apical setae unlike *N. halletti*, *N. stefanus*, *N. straskraba*, *N. fragilis*, *N. hurlberti* and *N. humphreysi*; third uropod peduncle relatively longer than in *N. fragilis* and *N. macrosculptilis*, and bearing a single mid dorsal seta unlike *N. halletti*, and 2 laterodistal marginal setae and 1 sub apical lateral seta unlike *N. straskraba* and *N. urifimbriata*; the outer ramus proximal article bearing 4 apicomedial and 2 apicolateral setae and the second article terminates in a cluster of 6 setae, unlike *N. halletti*, *N. straskraba*, *N. urifimbriata* and *N. macrosculptilis*; inner ramus bearing a single apicomedial seta, differing from *N. halletti*, *N. urifimbriata* and *N. macrosculptilis*. The telson relatively longer than all but *N. sculptilis*; cleft 100% unlike *N. sculptilis*; the lobes without submarginal medial setae, unlike *N. sculptilis*, *N. straskraba*, *N. hurlberti*, *N. urifimbriata* and *N. macrosculptilis*; bearing single lateral penicillate setae at M0.5, more basal than in *N. halletti* and *N. urifimbriata*.

4.3.9 *Nedsia stefania* n. sp. Figs. 4.34 - 4.36 .

Etymology

Named for Stefan Fritz, who facilitated collecting visits to Barrow Island.

Type locality

Underground water in L32J old water well, Barrow Island, Western Australia, 20°48'34S", 115°22'42"E

Material examined

Holotype: male 'a' 4mm (WAMC 28343) Western Australian Museum collection number BES 3441, L32J, old water well, 20°48'34S", 115°22'42"E, 24 October 1998, W. F. Humphreys and S. M. Eberhard. Paratypes: male 'b' 2 mm., 2 other, incomplete specimens (WAMC 28344). Same data as holotype

Diagnosis

Pleonites with few dorsal setae. *Head*: rostrum obsolescent; lateral cephalic lobes moderately to strongly projecting, very broad; no antennal sinus present; eyes absent. *First antenna*: longer than A2; ratio of peduncular articles 2.5:2.5:1. *Second antenna*: short. *Upper lip*: symmetrical; not excavate below. *Mandible*: 3 accessory blades with interraker plumose setae between each main raker; palp 2 articulate, length ratio of articles 1:1, terminal article tapered, setae 2 E. *Maxillae*: moderately setose medially; inner plate of maxilla 1 with 2 (3) medial setae; inner plate of maxilla 2 with row of medial setae extending onto face apically, other medial setae few. *Maxilliped*: inner plate very long with distal row of 2 plumose setae and 3 blunt naked setae outer plate large, with 3 distal setae, without a blunt naked tooth seta; medial margin carved into sinuosities, spineless; sub-marginal face with pairs of setae; palp articles 2-3 weakly setose laterally, article 2 moderately setose medially, article 3 with setae or comb rows of setae near the base of the dactyl, apex not produced, dactyl unguiform, with moderate length nail. *Gnathopods* 1-2 diverse: first gnathopod some setae simple, some bearing trigger hairs and thus asymmetrically bifid, some apically dentate; setae at corner of palm = lateral 1 long trigger, medial 2 robust bifid and 2 slender simple; setae along palm sparse and simple; second gnathopod defining corner with 2 setae. *Coxae* 1-7: with few posterior setae. *Pleopods*: similar; rami extending sub-equally, basomedial setae of inner rami bifid; retinaculae 2, no accessory retinaculum present. *Epimera*: postero-ventral tooth of epimera 1-3 absent; posterior margins smooth and sparsely setulose; some bearing facial setae near ventral margin. *Pleon*: ventro-distal seta on urosomite 1 at base of uropod 1 absent. *Uropods*: apico-lateral corner of peduncles on uropods 1-2 with 2 and 1 setae, dorsal margins with few setae; medial margin of uropod 1 with 2 apical setae; rami of uropods 1 and 2 extending sub-equally; uropod 1 with basofacial seta; rami of uropods 1-2 with few setae. *Telson*: longer than broad; cleft 100%; lobes weakly convex laterally, with sub-apical plumose setation; lateral setae present.

Description of holotype (male 'a')

Body: 4 mm. *Urosome*: poorly armed dorsally. *Head*: bearing few dorsal setules, rostrum obsolescent; eyes absent. *First antenna*: length 0.4x body, 1.7x A2; flagellum longer than peduncle; peduncular article 3 shortest, article 1 longest, ratio of lengths = 2.3:2:1, setae sparse; aesthetascs present on articles 5-7; calceoli

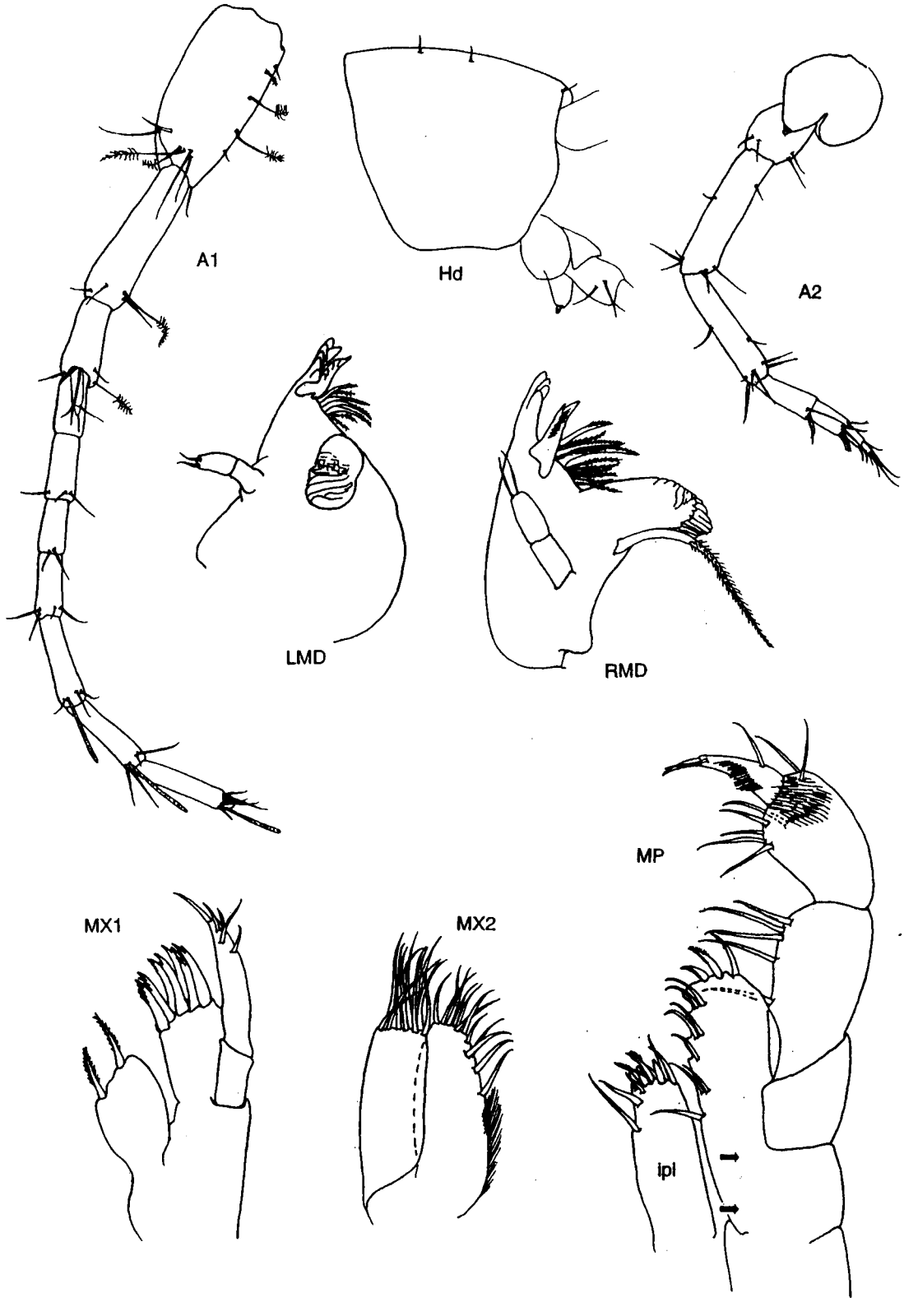

Fig. 4.34. *Nedsia stefania* n. sp. Holotype, male 4mm. Head, antennae, mandibles, maxillae and maxilliped.

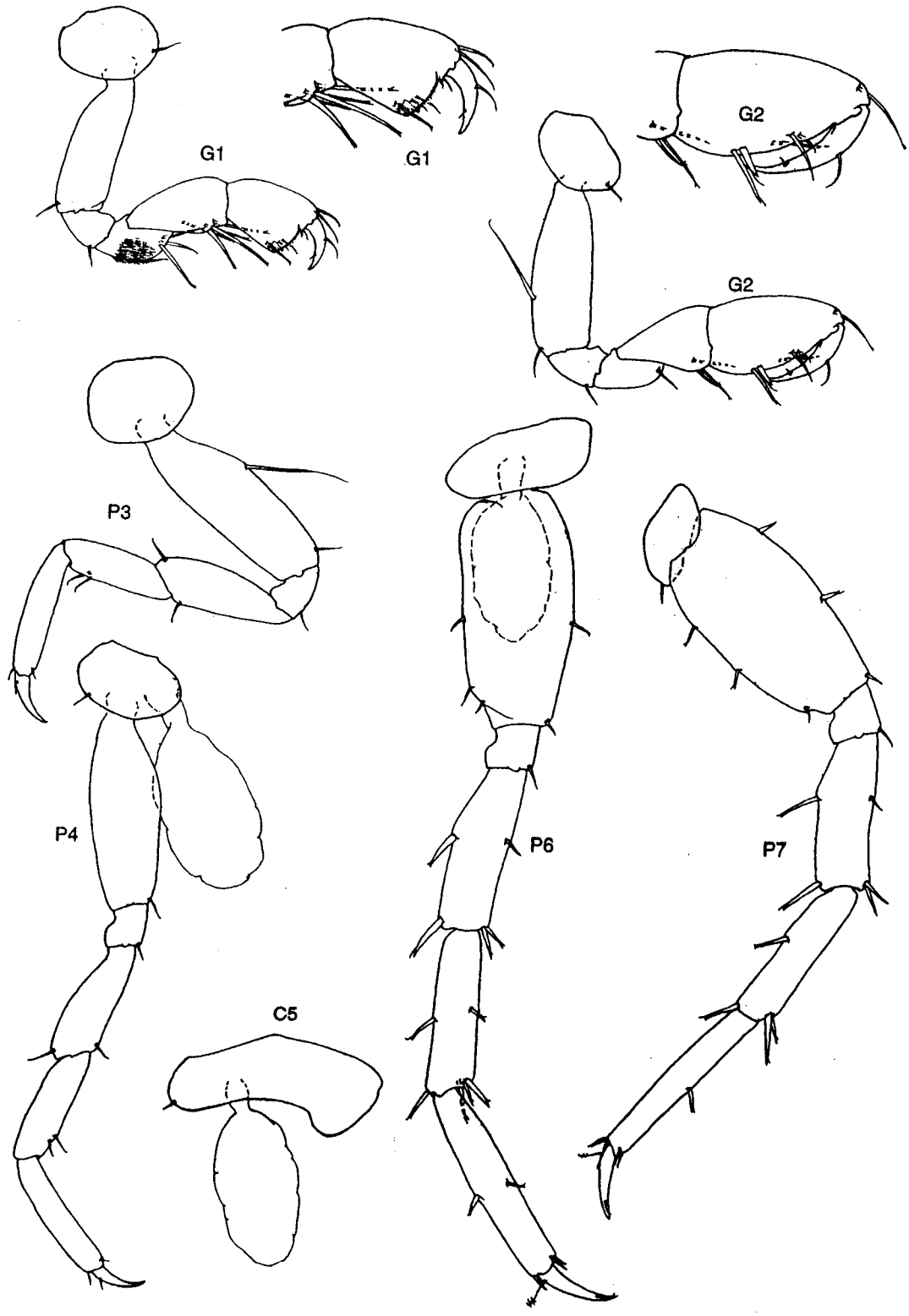

Fig. 4.35. *Nedsia stefania* n. sp. Holotype, male 4mm. Gnathopods, gnathopodal palms, coxa 4, pereopods 3, 5-7.

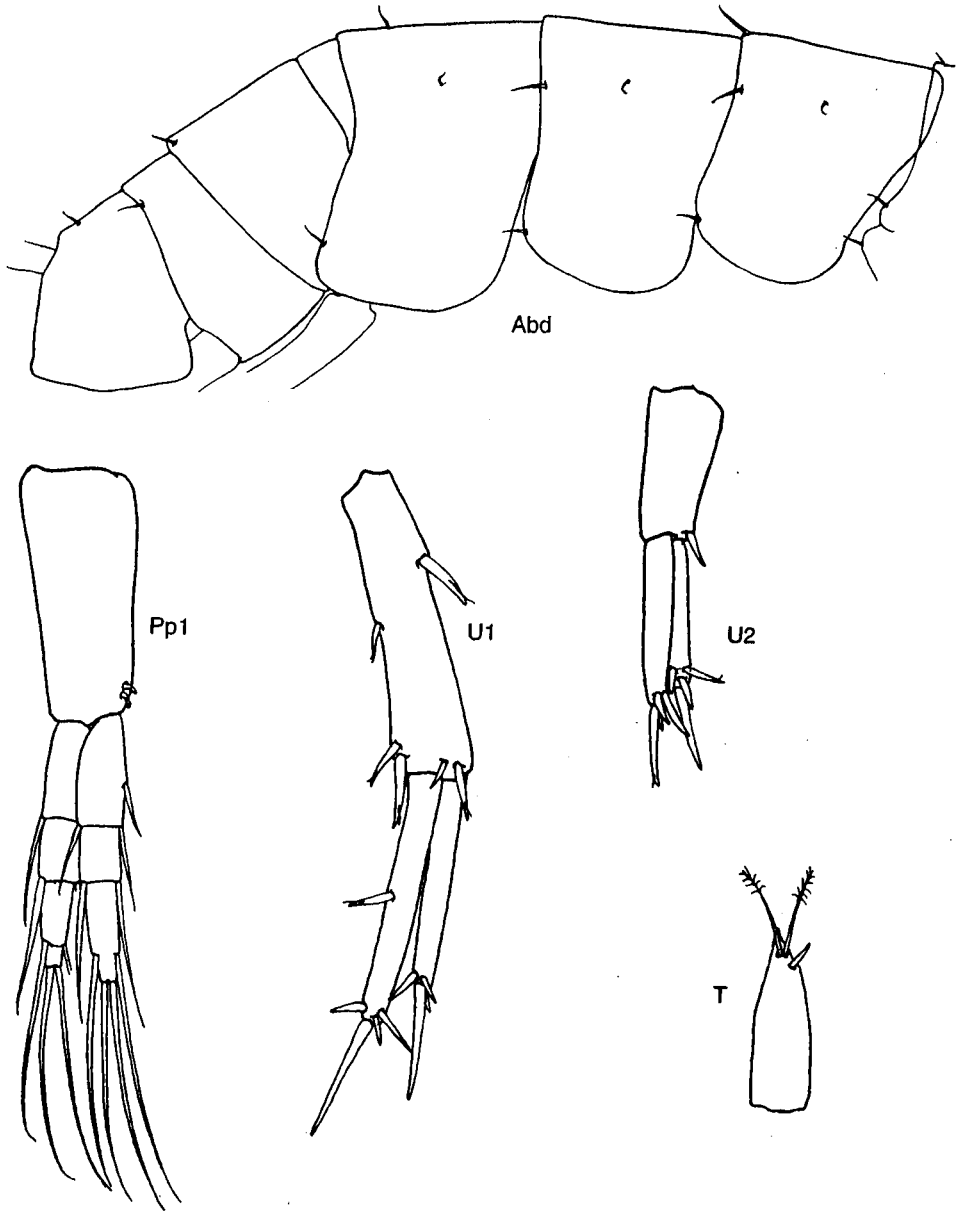

Fig. 4.36. *Nedsia stefania* n. sp. Holotype, male 4mm. Abdomen, pleopod 1, uropods and telson.

absent; flagellum of 8 articles; accessory flagellum 2 articulate, reaching M0.7 of article 1 of primary flagellum, article 2 tiny; articles of primary flagellum not uniform, sparsely setulate. *Second antenna*: length 0.2x body; peduncle much longer than flagellum, article 5 longest, 3-5 with weak ventral setation; flagellum 4 articulate, without calceoli. *Upper lip*: margin not excavate. *Mandibles*: left mandibular palp reduced, 2 articulate, articles sub-equal in length, article 2 with 2 long apical E setae; incisor 6 toothed; lacinia mobilis with 5 denticles; 4 setose accessory blades and inter-raker plumose setae; molar without distal pappose seta, triturative; no other pubescence; right mandibular incisor 4 toothed; lacinia mobilis bifid, broad, finely denticulate; accessory blades of 3 plumose setae and plumose inter-raker setae; palp 2 articulate, molar triturative, bearing a long distal pappose seta. *First maxilla*: palp article 2 with 5 thin apical setae, all naked; outer plate with 7 denticulate setae; inner plate bearing 2 apicomedial plumose setae, medial margin naked. *Second maxilla*: outer plate devoid of pubescence; inner plate pubescent on baso-medial margin. *Maxilliped*: nail of palp moderately long, medial margin of article 3 with 5 distal thin setae basal to the dactyl, none proximal; inner plate with a row of 3 medial marginal to facial setae, three naked tooth setae and 5 rastellate or naked setae apically; outer plate medial margin3 deep and one shallow indentations, a single mid marginal seta and a row of 7 mainly paired long naked apically hooked setae adjacent the indentations. *First gnathopod*: coxal plate with a single short seta apically and none post-ventrally; article 4 slightly bulbous and setate posteriorly; carpus not lobate, longer than wide; propodus trapezoidal, expanding slightly apically, longer than wide, the posterior edge naked, corner of palm rounded, 1 long, naked apically bifid lateral seta, 2 stout bifid setae and one 1 slender seta medially, palm slightly convex, dactyl reaching slightly beyond the palmar corner. *Second gnathopod*: coxa bearing a single apical seta; propodus ovate, palmar angle acute, palmar corner bearing 2 lateral setae – one long, slender and apically bifid, the other a robust trigger seta -, the mid palm bearing a single slender seta and short seta basal to the dactyl laterally, and medially a slender and a short robust setae. *Pereopods*: coxa 3 without setae, as long as wide, coxa 4 bearing an anterior seta; P3-4 longer than G2; P3-(5) approximately equal, all articles sparsely setose, propodus with only one locking seta; P(5)-7 similar but consecutively elongate, with (2),2,2 locking setae; P6 anterior seta of articles 5 and 6 displaced inward by keel-like expansion of the segment; coxae 5-7 bearing 1,0,1 setae on posterior

lobes, P6-7 articles 2 weakly expanded, subequally, not lobate; dactyls of P3-7 simple, naked except for an anterior basal penicillate setule, with the addition of an outer terminal setule on P6-7. *Gills*: coxae 2-6 with flask shaped gills. *Pleopods*: retinaculae 2 per pleopod, no accessory retinaculae; peduncles without other setae; rami extending sub-equally, the inner with 4:4:4 articles, the outer with 4:4:4articles; no bifid setae on basal articles. *Epimera*: epimera post-ventrally rounded; posterior margins scarcely convex on 1-2, slightly concave on E3, all smooth, with few or no setae; ventral setae lacking, each with a single, slender posteroventral seta marking the posterior corner. *Pleon*: pleonites 1, 3 and 6 bearing dorsal setae, 1, 2, 4 and 5 with dorso-lateral posterior setae. *Uropods*: length of U2 relative to U1 = 0.6x; U1 peduncle length 1.2x inner ramus, the outer margin bearing two apico-distal setae and no mid-dorsal setae, the medial apex bearing 2 setae, the medial margin bearing a single short robust seta; rami of sub-equal length (inner : outer = 62:52), both naked except for a single mid-dorsal seta on the inner ramus; both rami with 4 terminal setae; U2 peduncle length 0.8x inner ramus, bearing a single apico-lateral seta only; inner ramus length 1.2x outer, the medial margin without setae, 4 terminal setae; outer ramus shorter, also devoid of any but 4 terminal setae; (U3 strongly extended beyond uropods 1-2 in entire animal; inner ramus scale like, sub-quadrate). *Telson*: length 1.5x width, widest at base, sub-equal in length to urosomite 3, cleft 100%; apices slightly notched laterally; sub-apices with 2 long plumose setae, 1 sub-marginal distomedial seta.

Description of other material

Specimen 'b', male: length 2 mm. *Pleonite* 6: without a dorso-lateral seta. *First antenna*: flagellum (broken), aesthetascs present on articles 3,5. *Mandibles*: ratio of length of palp articles 1-2 = 5:4; setae of terminal article = 2E; interraker plumose setae present between accessory blades. *Maxilliped*: palp article 3 with rows of setae basal to dactyl; nail of dactyl short. *First gnathopod*: coxal plate with single anterior seta and facial posterior seta. *Pleopods*: accessory setae absent. *Uropods*: lengths relative to U1; U2 0.6x, peduncle of U1 1.3x length of inner ramus, of U2 0.8x inner ramus; U2 inner ramus 1.3x outer. Telson bearing a single subapical setae on either lobe.

Distribution

Underground water in L32J old water well (collection BES3441); disused, steel cased water bore at altitude 50m above AHD, in the central heights, Barrow Island,

ground-water 2m deep at about sea level. Barrow Island, Western Australia, 20°48'34S", 115°22'42"E

Relationships

This species differs from all others in that: the flagellum of the first antenna is of 8 articles; right mandible bears 3 accessory blades; the first maxilla inner plate bears 2 setae medially. The first gnathopod propodus palm bears a single long lateral trigger seta at the corner and only one other lateral seta basal to the dactyl; the medial corner of the palm bears 2 robust apically bifid and 2 slender simple setae and the palm only one other seta basal to the dactyl. The second gnathopod propodus lateral corner marked by a long slender trigger seta, and the lateral palm bears 1 mid-marginal slender seta and a small seta basal to the dactyl; medial palm bearing 2 slender simple setae mid way along the palm. Pereopod 2 coxa without an anterior seta. Telson lacking lateral penicillate setules. Other differences: lacking serration of the pleon and the first article of the first antennal peduncle the longest, unlike *N. macrosculptilis* and *N. sculptilis*; first antenna bearing aesthetascs, unlike *N. humphreysi* and *N. urifimbriata*; the first two articles of the flagellum of the first antenna not fused as in *N. sculptilis* and *N. macrosculptilis*; the second antenna flagellum of 4 articles, unlike *N. urifimbriata*, *N. macrosculptilis* and *N. sculptilis*; mandibular palp without D setae as in *N. straskraba*, the incisor bearing 5 teeth unlike *N. hurlberti* and *N. macrosculptilis* and the mandible bearing 4 setose accessory blades, similar only to *N. urifimbriata*, *N. douglasi* and *N. hurlberti*, the mandible lacking other pubescence, unlike *N. sculptilis* and *N. fragilis*; the palp of the first maxilla bearing 5 slender apical setae, unlike *N. sculptilis*, *N. macrosculptilis* and *N. hurlberti*; the outer plate of the second maxilla devoid of pubescence, differing from *N. hurlberti*, *N. urifimbriata*, *N. macrosculptilis*, *N. sculptilis* and *N. halletti*. First gnathopod coxa bearing 2 anterior and no posterior setae, similar only to *N. halletti*, *N. chevronus* and *N. humphreysi*; coxa of the second gnathopod bearing 2 anterior and no posterior setae, unlike *N. straskraba*, *N. hurlberti*, *N. fragilis*, *N. macrosculptilis* and *N. douglasi*. Pereopods 3-4 subequal in length unlike *N. sculptilis*; pereopods 5 and 7 with paired locking setae, not single as in *N. straskraba*, and coxae 5-7 bearing 1,0,1 posterior setae unlike *N. halletti* and *N. straskraba*, the second articles weakly expanding progressively posteriorly unlike *N. halletti* and not extending posteriorly unlike *N. straskraba*. Pleopods without accessory retinaculae, differing from *N. humphreysi*

and *N. straskraba*; both rami of 4,4,4 articles, unlike all except *N. halletti* and *N. fragilis*. Uropod 1 peduncle bearing a reduced row of mid dorsal seta and the medial apex bearing 2 setae, differing from all other species; the rami subequal in length unlike *N. fragilis* and *N. sculptilis*; bearing a single mid dorsal seta medially unlike *N. hurlberti* and *N. urifimbriata*; both rami bearing 4 apical setae, differing from all but *N. halletti*, *N. chevronus*, *N. fragilis* and *N. humphreysi*. The second uropod peduncle approximately equal in length to the inner ramus, unlike *N. halletti*, *N. chevronus*, *N. urifimbriata*, *N. fragilis* and *N. macrosculptilis*; bearing a single apicolateral seta unlike *N. sculptilis* and *N. hurlberti*; the inner ramus medial margin naked unlike *N. halletti*, *N. chevronus*, *N. sculptilis*, *N. straskraba*, *N. hurlberti* and *N. urifimbriata*; both rami bearing 4 apical setae, unlike *N. chevronus*, *N. straskraba* and *N. hurlberti*. The telson shorter than *N. halletti*, *N. macrosculptilis* and *N. humphreysi*; cleft 100%, unlike *N. sculptilis*; and lacking submarginal medial setae, differing from *N. sculptilis*, *N. straskraba*, *N. hurlberti*, *N. urifimbriata* and *N. macrosculptilis*.

4.3.10 *Nedsia halletti* n. sp. Figs. 4.37 - 4.40.

Etymology

Named for Keith Hallett who generously imparted of his knowledge of the ground water environment of Barrow Island.

Type locality

Underground water in L32J old water well, Barrow Island, Western Australia, 20°48'34S", 115°22'42"E.

Material examined

Holotype: male 'a' 4mm (WAMC 28345) Western Australian Museum collection number BES 3462, L32J, old water well, 20°48'34S", 115°22'42"E, 25 October 1998, W. F. Humphreys and S. M. Eberhard. Allotype: female 'b', 4mm. (WAMC 28346). Same data as holotype. Paratype: male 'c', 3mm. (WAMC 28347). Same data as holotype

Diagnosis

Pleonites: with few dorsal setae. *Head*: rostrum weak; lateral cephalic lobes moderately projecting, very broad; no antennal sinus present; eyes absent. *First antenna*: elongate, longer than A2; ratio of peduncular articles 6:5:2; accessory

flagellum 2 articulate. *Second antenna*: very short; flagellum much shorter than peduncle; calceoli absent. *Upper lip*: symmetrical. *Lower lip*: with inner lobes. *Mandibles*: accessory blades (rakers) very few (6) on right with interraker plumose setae between each main raker; both mandibles with no additional serrations beyond rakers; mandibular palp reduced, 2 articulate; ratio of articles 1:1, article 1 not setose, terminal article linear, sub-truncate, apical setae 2 E. *Maxillae*: well setose medially; inner plates of maxillae 1-2 poorly covered with pubescence; inner plate of maxilla 1 ovate with 5 medial setae, outer plate with denticulate setae, palps symmetric, with thin apical setae; both plates of second maxilla with apical setae of medium length; inner plate with row of medial setae extending onto face apically, other medial setae absent, medial and lateral margins poorly covered with pubescence. *Maxilliped*: inner plate very long with distal row of several setae and 3 blunt naked setae, and short medial row of plumose setae; outer plate large, with few distal plumose setae, continuous without a blunt naked tooth seta; medial margin carved into sinuosities, spineless; sub-marginal face with pairs of setae; palp articles 2-3 weakly setose laterally, article 2 moderately setose medially, article 3 with setae or comb rows of setae near the base of the dactyl, apex weakly produced, dactyl unguiform, with moderate length nail. *Coxae* 1-7: short, broader than long, with few posterior setae; coxa 1 not expanded below; coxa 4 not excavate posteriorly; coxa 5 as long as 4. *Pereopods*: 3-4 of proportions similar to pereopods 5-7; posterior seta sets on article 6 of pereopods 3-4 unevenly spaced. *Pleopods*: similar; peduncles with few setae each; rami extending equally, basomedial setae of inner rami bifid; retinaculae 2 , no accessory retinaculum present. *Gnathopods*: 1-2 diverse; dactyls lacking inner tooth seta, lacking nail. *First gnathopod*: small, feeble, without rastellate seta of article 4; carpus longer than propodus, not lobate; merus lacking hyaline lobe; palm transverse, setae simple, some bearing trigger hairs and thus asymmetrically bifid, some apically dentate; setae at corner of palm = lateral 2 long apically bifid, medial 2-5 short, robust, apically bifid; setae along palm sparse and simple. *Second gnathopod*: weakly enlarged, carpus short and lobate, propodus of medium enlargement and ovate; palm oblique, irregularly spinose and sparsely setose, defining corner with 1 lateral long apically bifid seta. 1 medial robust apically bifid seta. *Pereopods* 5-7: moderately elongate; article 2 moderately expanded, ovato-rectangular, postero-ventrally extended but not lobate; dactyls of pereopods 3-7 lacking accessory spinules. *Gills*: coxae 2-6 each with

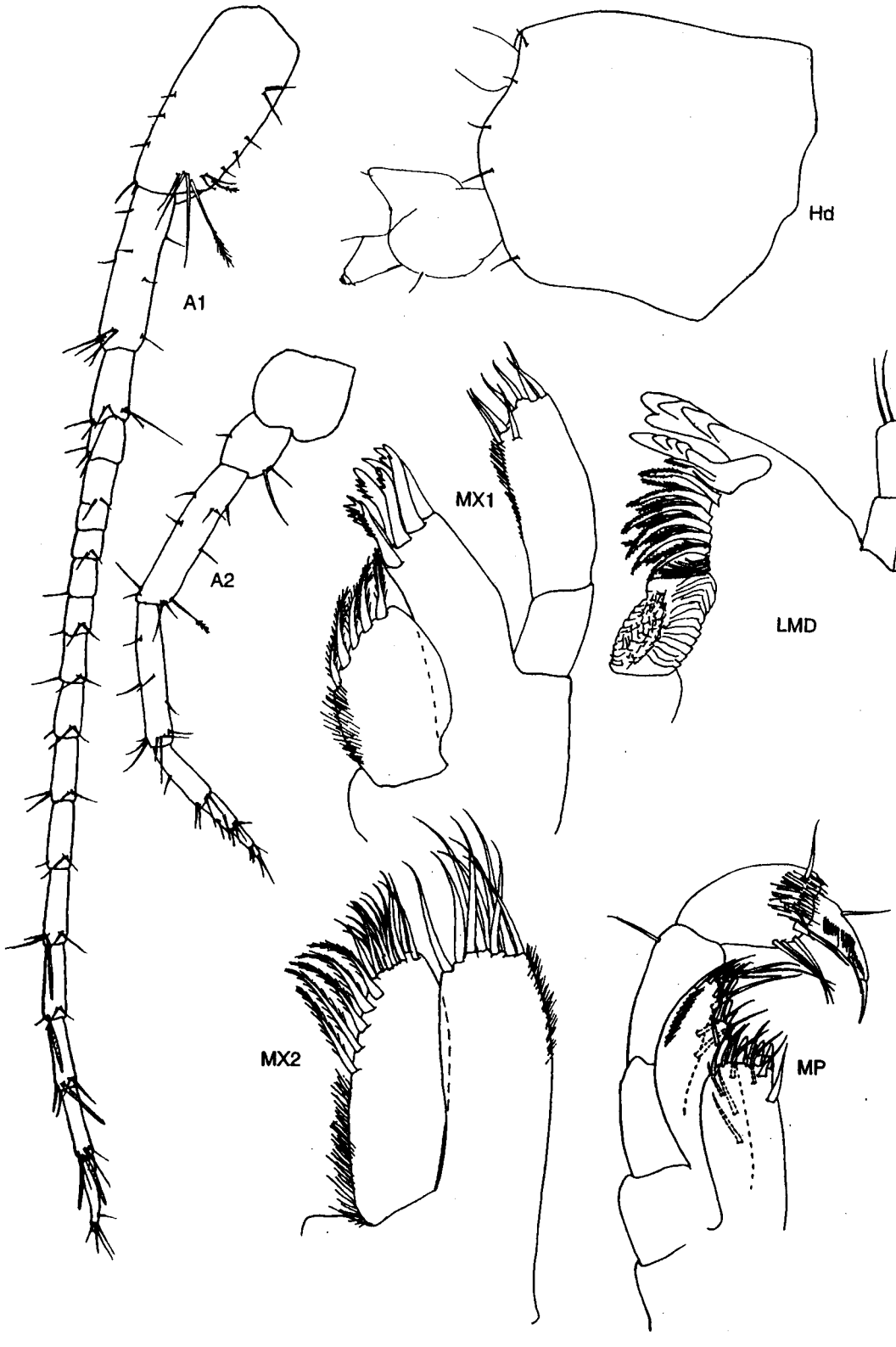

Fig. 4.37. *Nedsia halletti* n. sp. Holotype, male 4mm. Head, antennae, mandibles, maxillae and maxilliped.

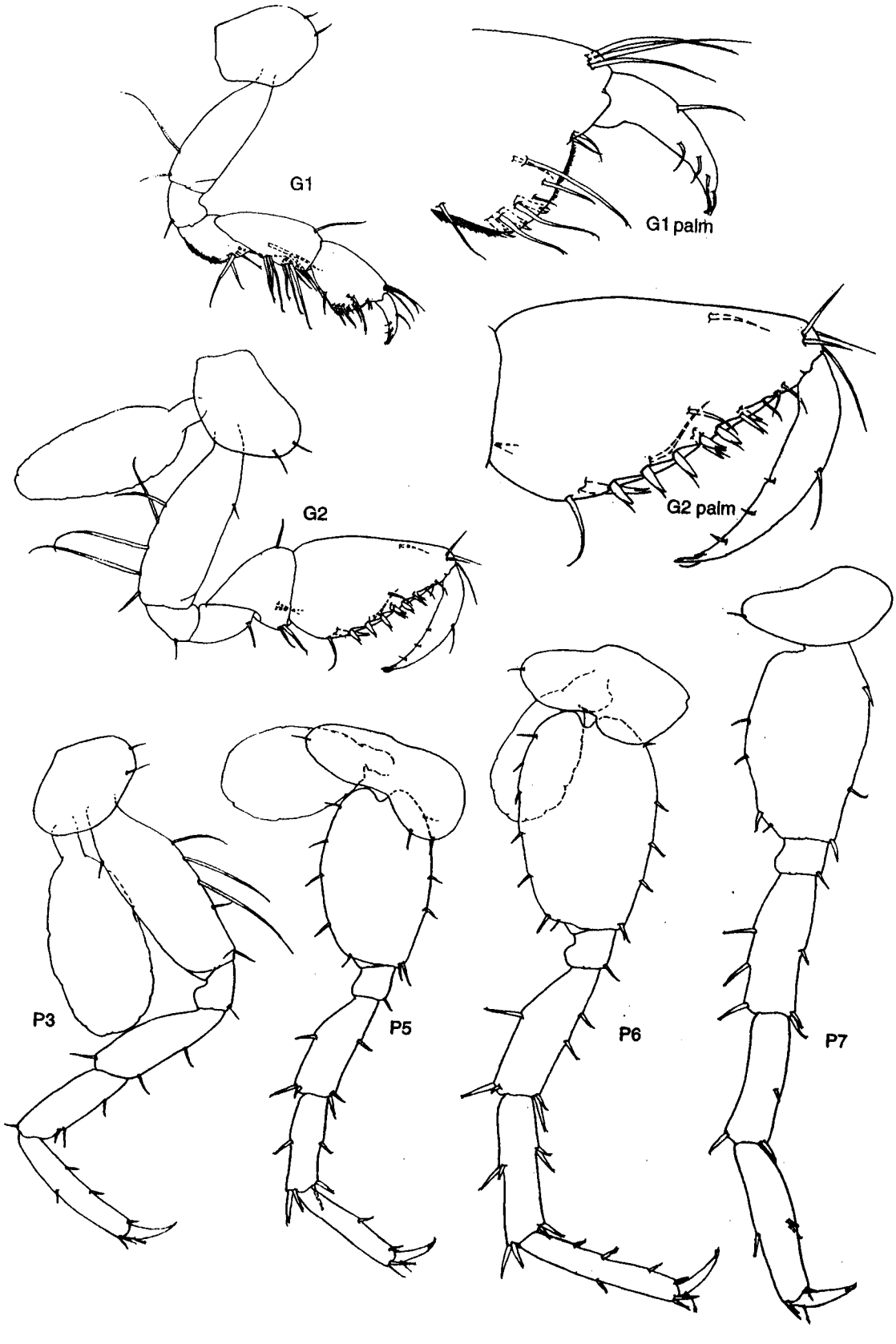

Fig. 4.38. *Nedsia halletti* n. sp. Holotype, male 4mm. Gnathopods, gnathopodal palms, coxa 5, pereopods 3,4,6,7.

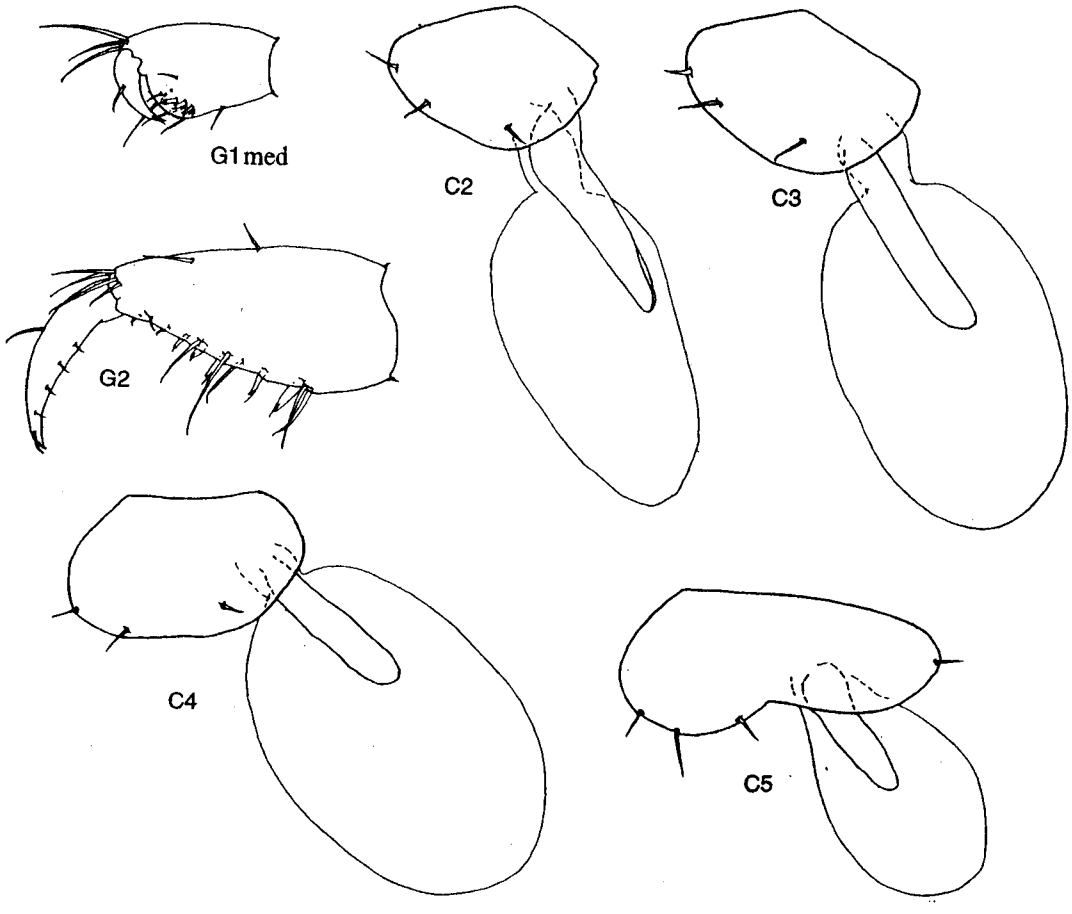

Fig. 4.39. *Nedsia halletti* n. sp. Allotype, female 'b' 4mm. Gnathopodal propodi, coxae 2-5 showing coxal gills and oostegites.

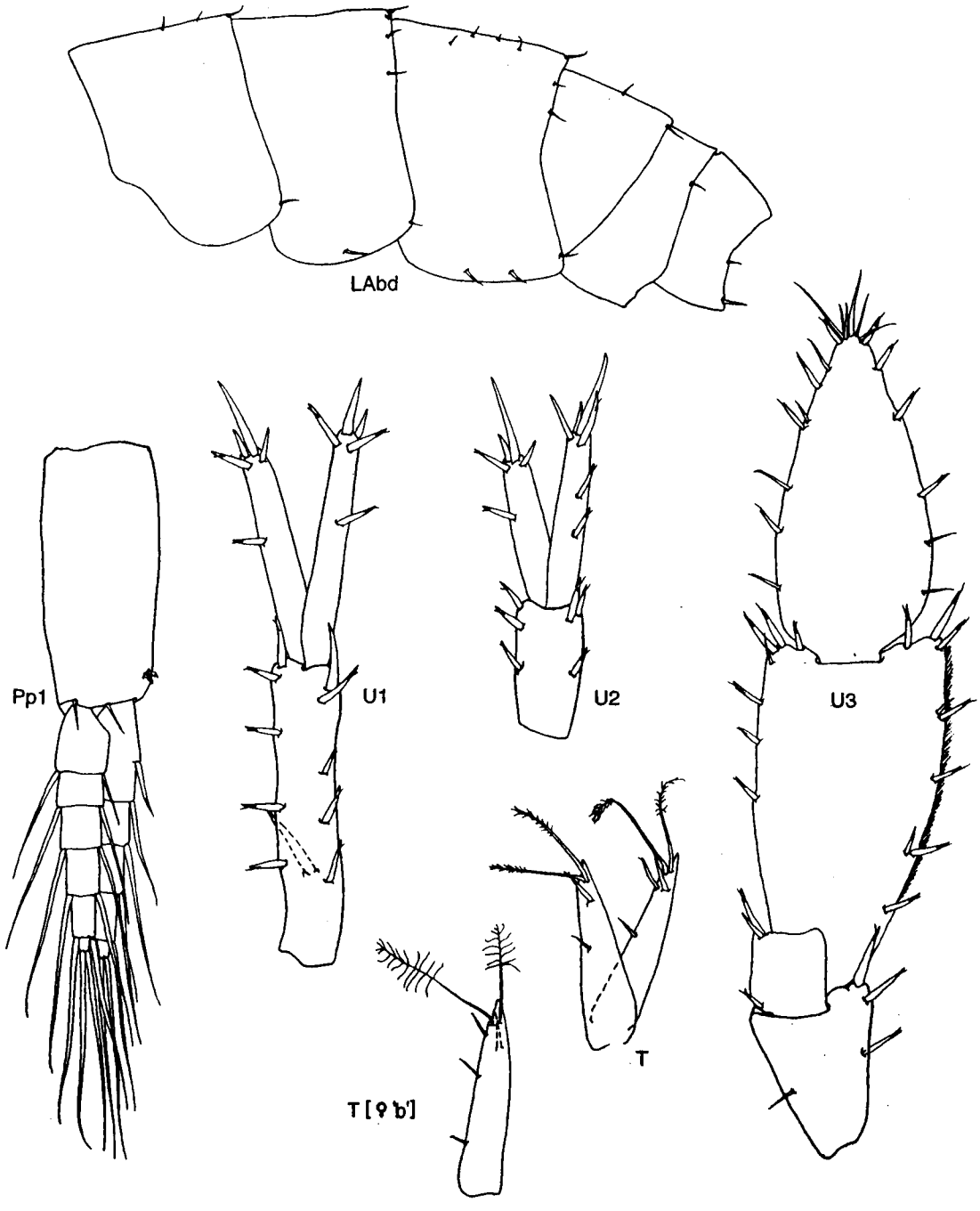

Fig. 4.40. *Nedsia halletti* n. sp. Holotype, male 4mm. Abdomen, pleopod 1, uropods 1-2 and telson.

flask-shaped gill; coxal gill 6 not reduced. *Epimera*: postero-ventral tooth of epimera 1-3 absent; posterior margins smooth, and sparsely setulose; E2-3 bearing facial setae near ventral margin. *Urosome*: ventro-distal seta on urosomite 1 at base of uropod 1 absent. *Uropods*: apico-lateral corner of peduncles on uropods 1-2 with 2 and 2 setae; dorsal margins with setae; medial margin of uropod 1 with 2 apical setae, rami extending sub-equally; outer ramus of uropod 2 shortened; uropod 1 with basofacial seta; most rami of uropods 1-2 with single seta rows; medial setae of outer ramus of uropod 3 sparse, without sub-distal peduncular setae; uropod 3 strongly extended, parviramous, peduncle short, outer ramus 2 articulate, huge; inner ramus scale like, reaching to M0.25 on article 1 of outer ramus. *Telson*: longer than broad; cleft 90-100%; lobes weakly convex laterally, with sub-apical setation; setae, where present, lateral; single lateral penicillate setules at M0.6 to M0.7 on each side.

Description of holotype (male "a")

Body: 4. mm. *Urosome*: poorly armed dorsally. *Head*: rostrum obsolescent; antennal sinus absent; eyes absent. *First antenna*: length 0.4x body, 1.5x A2; flagellum longer than peduncle (1.8x); peduncular article 3 shortest, article 1 longest, ratio of lengths = 62:48:20; setae sparse; flagellum of 16 articles; aesthetascs present on articles 11-14; calceoli absent; accessory flagellum 2 articulate, reaching M0.9 of article 1 of primary flagellum, article 2 tiny; articles of primary flagellum not uniform, but progressively longer, sparsely setulate. *Second antenna*: length 0.25X body; peduncle much longer than flagellum, articles 4-5 equally long (45:42), articles 3-5 with weak ventral setation, lacking robust setae; flagellum short (0.4x peduncle), 4 articulate, no calceoli. *Upper lip*: margin not excavate. *Mandibles*: left mandibular palp 2 articulate, articles sub-equal in length, article 2 with 2 long apical setae (E2) only; incisor 5 toothed; lacinia mobilis with 5 denticles, bearing a postero-facial rugose seta; 6 setose accessory blades; molar without distal plumose seta, triturative; cluster of fine setae between accessory blades and base of molar; (right mandibular incisor 5 toothed; lacinia mobilis bifid, broad, finely denticulate; accessory blades of 6 plumose spines; palp 2 articulate). *Lower lip*: bearing distinct inner lobes. *First maxilla*: palp article 2 with 6 thin apical and one distofacial setae, all naked; outer plate bearing 7 denticulate setae; inner plate ovate, bearing 5 apicomedial plumose setae, baso-medial margin pubescent. *Second maxilla*: outer plate bearing pubescence apicolaterally; inner

plate pubescent on baso-medial margin, bearing a row of 5 medial marginal tending distofacial plumose setae. *Maxilliped*: nail of palp moderately long (0.3 of dactyl), palp article 3 with few thin setae at dactylar base, none proximal, apex slightly extended and facially pubescent; outer plate medial margin bearing 4 scallop like indentations distally, a medio facial row of strong naked setae, 3 apicolateral naked setae and distofacial pubescence laterally: inner plate without ventro-facial seta or short spur, with a pair of sub-marginal medial plumose setae apicofacially, three naked tooth setae apically and 4 thin naked apical long setae. *First gnathopod*: coxal plate with two short setae apically and none post-ventrally; article 4 pubescent and slightly bulbous posteriorly; carpus not lobate, longer than wide; propodus trapezoidal, expanding slightly apically, longer than wide, the posterior edge bearing a single slender seta at M0.6; corner of palm rounded, bearing 2 long, naked, apically bifid setae laterally and 3 stout bifid setae medially, palm slightly convex, bearing few long slender setae; dactyl reaching to the palmar corner. *Second gnathopod*: coxa bearing 2 anterior setae only; palmar corner marked laterally by a single long slender seta, medially by 1 long, robust trigger seta; palm bearing 5 robust and one slender trigger setae and 2 short slender simple setae adjacent the dactylar base laterally, a single mid-palmar robust trigger seta, 2 sub marginal slender setae and 1 small seta basal to the dactyl medially; dactyl bearing 3 small submarginal setae distally. *Pereopods*: coxa 3 with 2 anterior setae, similar to coxa 1, P3 longer than G2; P3-5 approximately equal, articles 4,5 sparsely setose posteriorly, with only one locking seta; P5-7 similar but consecutively elongate, each with paired locking setae distal on article 6; P7 anterior setae of articles 5 and 6 displaced inward by keel-like expansion of the segment; coxae 5-7 bearing 1,1,1 setae on posterior lobes, 2,0,0 anterior setae, article 2 weakly expanded, most on P7, not lobate, but extended posteriorly and bearing few setae; dactyls of P3-7 simple, naked except for an anterior basal penicillate setule, with the addition of an outer terminal setule on P5-7. *Gills*: coxae 2-6 with flask shaped gills, gill of C3 largest. *Pleopods*: retinaculae 2 per pleopod, no accessory retinaculae; peduncles each bearing 2 apical setae; rami extending equally, the inner with 5:5:5 articles, the outer with 7:6:6; no bifid setae on basal articles. *Epimera*: E1-2 post-ventrally rounded, E3 subquadrate; posterior margins scarcely convex on 1-2, straight on E3, all smooth, with no setae except a single seta marking the posterior corner; E2-3 with 1 and 2 weak submarginal ventral setae, lacking lateral oblique ridge. *Pleon*:

pleonites 2-5 with dorso-lateral posterior setae; pleonite 6 with 1 lateral and 1 disto-ventral setae. *Uropods*: uropod lengths relative to U1 are U2=0.6X , U3=1.5X; basal face of U1 bearing a robust seta; peduncle length 1.4X inner ramus, the outer margin bearing 2 apico-distal setae and a row of 3 mid-dorsal setae, the medial apex bearing 2 setae and the medial margin bearing 3 setae; rami of sub-equal length (inner : outer = 92:85), both naked except for a single mid-dorsal seta medial on the inner ramus and lateral on the outer ramus; both rami with 5 terminal setae; U2 peduncle length 0.8X inner ramus, bearing a single apico-lateral seta and 2 marginal setae; inner ramus length 1.2X outer, the medial margin bearing 2 setae only, with 4 terminal setae; outer ramus shorter, bearing a single marginal seta and 4 terminal setae; U3 strongly extended beyond uropods 1-2 in entire animal; peduncle length 0.3X outer ramus, shorter than urosomite 3, bearing paired latero-distal marginal setae and 1 lateral seta, 1 apicomedial seta, and 1 small mid-medial sub-marginal, facial seta; outer ramus proximal article with few marginal setae, some paired, laterally pubescent, and 2 apicolateral setae; medially 3 apical setae, 3 marginal setae; 2 apical setae basal to the second article; article two equal in length to the first, similarly armed, lacking pubescence, terminating in a cluster of 8 mixed robust and slender setae; inner ramus scale like, sub-quadrate, length 0.13x outer ramus, bearing paired apico-medial setae. *Telson*: length 1.8x width, widest at the base, sub-equal in length to urosomite 3, cleft 100%; apices slightly notched laterally; sub-apices with 2 long plumose setae, 1 right and 2 left sub-marginal medial setae at M0.7 and 1 lateral seta at M0.5; no other dorsal setae.

Description of allotype (female 'b')

Body: length 4mm. *Pleonite* 6 bearing single dorso-lateral and dorsolateral setae. *First antenna*: aesthetascs absent. *Second antenna*: length of peduncle 4 = 0.9x peduncle 5; flagellum length less (0.7x) than peduncle. *First gnathopod*: propodus small, trapezoidal, expanding apically, 0.6x G2, bearing three long slender lateral setae, and 3 robust apically bifid setae medially, with few other setae; coxal plate bearing two anterior and one facial post-ventral setae. *Second gnathopod*: propodus large, ovate, palm acute, marked at corner by an elongate slender seta laterally and one long, slender and one robust apically bifid setae medially; palm bearing additionally two long slender and one short setae laterally, and four robust apically bifid, one long slender and two short setae medially; coxal plate similar to G1. Coxae of pereopods G2 to P6 each bearing a single flask shaped gill, and coxae 2-5

additionally bearing a narrow, strap like, naked oostegite. *Pleopods*: bearing 2 retinaculae, without accessory retinaculae; pleopodal inner rami of 6,6,5 articles, outer rami of 7,6,6 articles. *Uropod*: first uropod length relative to U2 = 1.7x; peduncle of U1 1.3X length of inner ramus, of U2 0.8x length of inner ramus;. *Telson*:: longer than wide; ventral face with a single seta medial submarginal at M0.77; length 2.2x width; lateral margin bearing three setae at M0.3, M0.6, M0.8; dorsal subapices bearing a pair of elongate penicillate setae.

Description of paratype (male 'c')

Body: length 3mm. *First antenna*: length 0.5x body, much longer thanA2; peduncle shorter than flagellum, flagellum of 16 articles, bearing aesthetascs on articles 10-15. *Second antenna*: peduncle article 4 shorter than article 5 (0.8x), longer than flagellum (3x); flagellum of 4 articles. *Mandible*: palp short, two articulate, articles subequal in length. *Gnathopods* and *Pereopods*: similar to type (male 'a'). *Pleopods*: peduncles each bearing 2 retinaculae and no accessory retinaculae; inner rami of 5,5,4 articles, outer rami of 6,6,5 articles. *Epimera*: epimera 1-2 postventral corners rounded, the posterior margins slightly convex; epimeron 3 postventrally subquadrate posterior margin straight; each posteroventral corner marked by a small seta, each posterior margin naked; epimeron 1 without ventrofacial setae, epimera 2-3 bearing 2 and 4 ventrofacial setae, respectively. *Pleon*: pleonites 1-3 each bearing 2 distal setae dorsally and 1 distolateral seta; pleonite 4 bearing 2 small dorsodistal setae, pleonite 5 single small dorsolateral setae and pleonite 6 single dorsolateral and distoventral setae. *Uropods*: uropod 1 length relative to uropod 2 = 1.8x. *Uropod 1*:peduncle bearing a strong basofacial seta, peduncle length 1.2x inner ramus, bearing 2 dorsomedial and dorsolateral setae as well as 2 apicomedial and apicolateral setae; inner ramus bearing only 4 apical setae; outer ramus bearing a single dorsolateral seta and 4 apical setae . *Uropod 2*: peduncle 0.75x length of inner ramus, bearing 1 dorsomedial and 4 apical setae; inner ramus longer than outer ramus (1.2x), bearing a single dorsomedial seta and 4 apical setae; outer ramus bearing 2 dorsolateral setae and 5 apical setae. *Telson*: similar to the holotype (male 'a').

Distribution. Underground water in L32J old water well (collection BES3441); disused, steel cased water bore at altitude 50m above AHD, in the central heights, Barrow Island, ground-water 2m deep at about sea level. Barrow Island, Western Australia, 20°48'34S", 115°22'42"E.

Relationships

N. halletti differs from all other described species of the genus *Nedsia* in: primary flagellum of the first antenna of 16 articles; mandibles bear 7 setose accessory blades; the palm of the first gnathopod bears 2 long naked lateral setae adjacent the corner and 3 other long setae along the palm, and 3 stout bifid setae medially as well as a single slender seta basal to the dactyl; the second gnathopodal corner is marked by a single slender seta laterally and a long robust trigger seta medially, the palm bearing 5 robust and 1 slender trigger setae as well as 2 slender setae basal to the dactyl laterally and single robust and slender trigger setae as well as 3 other slender setae medially; the uropodal rami bear 5:5:5 medial articles and 7:6:6 lateral articles; the second article of the outer ramus of the third uropod is as long as the first, and bears 7 terminal setae.

As well as the above universal differences, *N. halletti* differs from *N. macrosculptilis* and *N. sculptilis* in lacking posterior serration of the pleon, in the elongate first rather than the second article of the first antennal peduncle, and the non-fused first two articles of the primary flagellum; *N. halletti* differs from *N. macrosculptilis*, *N. sculptilis*, *N. urifimbriata* and *N. douglasi* in that the primary flagellum of the first antenna bears aesthetascs; the second antenna flagellum is 4 articulate rather than 5; the mandibular palp is of 2 equally short articles unlike *N. straskraba*, *N. hurlberti*, *N. urifimbriata*, *N. fragilis* and *N. douglasi* in which the first article is shorter than the second; the second article of the mandibular palp bears 2 only E setae unlike *N. straskraba* which also bears 2 D setae; the incisor is 5 toothed compared with 4 in *N. hurlberti*, and the left *lacinia mobilis* bears 5 denticles and the mandible pubescent, unlike *N. hurlberti*, *N. straskraba* and *N. humphreysi* which each have 4 denticles and also, along with *N. urifimbriata*, lack mandibular pubescence. The palp of the first maxilla bears 7 apical setae, unlike all other *Nedsia* spp. except *N. hurlberti*; the outer plate of the second maxilla is pubescent, thus differing from *N. straskraba*, *N. humphreysi*, *N. fragilis* and *N. stefanus*, as well as on the inner plate, unlike *N. humphreysi* and *N. fragilis*. The first coxal plate bears 2 apical setae, unlike *N. hurlberti*, *N. humphreysi* and *N. fragilis* and *N. douglasi*, and is without posterior setae whereas *N. straskraba*, *N. urifimbriata* and *N. fragilis* each bear 1, and *N. douglasi* two; the second coxa is similar to the first and different from *N. straskraba*, *N. fragilis*, *N. macrosculptilis*

and *N. douglasi*, although *N. hurlberti* bears no posterior setae on the second coxa; coxa 3 differs from all except *N. sculptilis*. The lengths of pereopods 3-4 are approximately equal, unlike *N. sculptilis*; P5-7 bear paired locking setae, not single on P5 and P7 as in *N. straskraba* and the second articles are approximately equal, not progressively expanded, as in *N. straskraba*, *N. hurlberti* and *N. humphreysi*. Pleopods bear no accessory retinaculae as do *N. straskraba* and *N. douglasi*; the first epimeron is without ventrofacial setae unlike *N. douglasi*, which bears 1; the second epimeron bears a single ventral seta, unlike all other species except *N. chevronus*, and the third epimeron 2 ventral setae, similar only to *N. straskraba*; pleonites 4-5 bear single dorsolateral posterior setae, differing from all but *N. urifimbriata*, *N. stefanus* and *N. chevronus*; the peduncle of the first uropod bears 1 apicodistal, 4 mid-dorsal and 1 apicomedial setae similar only to *N. hurlberti*, rami are sub-equal in length, unlike *N. sculptilis* and *N. fragilis*, naked except for a single mid-dorsal seta on the inner ramus rather than paired setae as in *N. hurlberti* and *N. urifimbriata*, and bearing 4 apical setae similar only to *N. stefanus*, *N. chevronus*, *N. fragilis* and *N. humphreysi*, all others bearing 5 apical setae; likewise, the second uropod differs from all other species. The peduncle of the third uropod is proportionally longer than in other species excepting *N. chevronus*, bears paired distolateral marginal setae rather than single setae as in *N. straskraba* and *N. urifimbriata*, no sub-apical seta, compared with 3 in *N. urifimbriata* and 1 in *N. straskraba*; the first article of the outer ramus differs, in numbers of marginal setae from *N. douglasi*, in numbers of apical setae from *N. macrosculptilis*, *N. chevronus*, *N. straskraba* and *N. urifimbriata*; and the second article is equal to, not shorter than, the first, unlike all other species, bears 7 terminal setae, more than any other species, and the inner ramus bears paired apicomedial setae, thus differing from *N. straskraba*. Telsonic lobes are more slender than all but *N. humphreysi* and *N. macrosculptilis*, are without dorsal setae as in *N. douglasi*, cleft 100%, unlike *N. straskraba* (85%), and bear single lateral penicillate setules on either lobe at M0.5, more basal than other species excepting *N. urifimbriata*.

4.4 Discussion: family Melitidae.

Melitids appear to be marine strandings and/or invaders from periods of inundation during the Cretaceous, between 120 and 100 million years ago (Bradbury & Williams 1997; Paine 1990). These once marine regimens encompass much of inland Australia, as well as many coastal regions, and considerable numbers of new species might reasonably be expected among collections yet to be analysed; fourteen species have been described to date (Barnard and Williams 1995; Bradbury and Williams 1996a; Bradbury and Eberhard 2000; Bradbury 2002). All such melitids are hypogean and have well developed stygobiont characteristics, including blindness, lack of pigmentation, fragility and attenuation of the appendages (Holsinger 1994a, b), and in some regions display considerable endemism. Following Barnard and Williams (1995), these species have been placed within the Melitidae, although the affinities within the Melitid-Hadziid group are not clearly defined.

4.5 Distribution of Australian freshwater Melitidae

The distribution of described Australian Melitids is shown in Fig. 4.41.

4.6 Composition: Australian freshwater Melitidae

Brachina invasa Barnard and Williams 1995. Flinders Range, S.A.

Nedsia douglasi Barnard and Williams 1995. North. West Cape, W. A.

Nedsia straskraba Bradbury and Williams 1996. Barrow Island W. A.

Nedsia fragilis Bradbury and Williams 1996. Barrow Island W. A.

Nedsia humphreysi Bradbury and Williams 1996. Barrow Island W. A.

Nedsia hurlberti Bradbury and Williams 1996. Barrow Island W. A.

Nedsia urifimbriata Bradbury and Williams 1996. Barrow Island W. A.

Nedsia macrosculptilis Bradbury and Williams 1996. Barrow Island W. A.

Nedsia sculptilis Bradbury and Williams 1996. Barrow Island W. A.

Nedsia stefania Bradbury 2002. Barrow Island Western Australia

Nedsia halletti Bradbury 2002. Barrow Island Western Australia

Norcapensis mandibulis Bradbury and Williams 1997. N. West Cape, W. A.

Nurina poulteri Bradbury and Eberhard 2000. Roe Plain, Nullarbor Pl.,W.A.

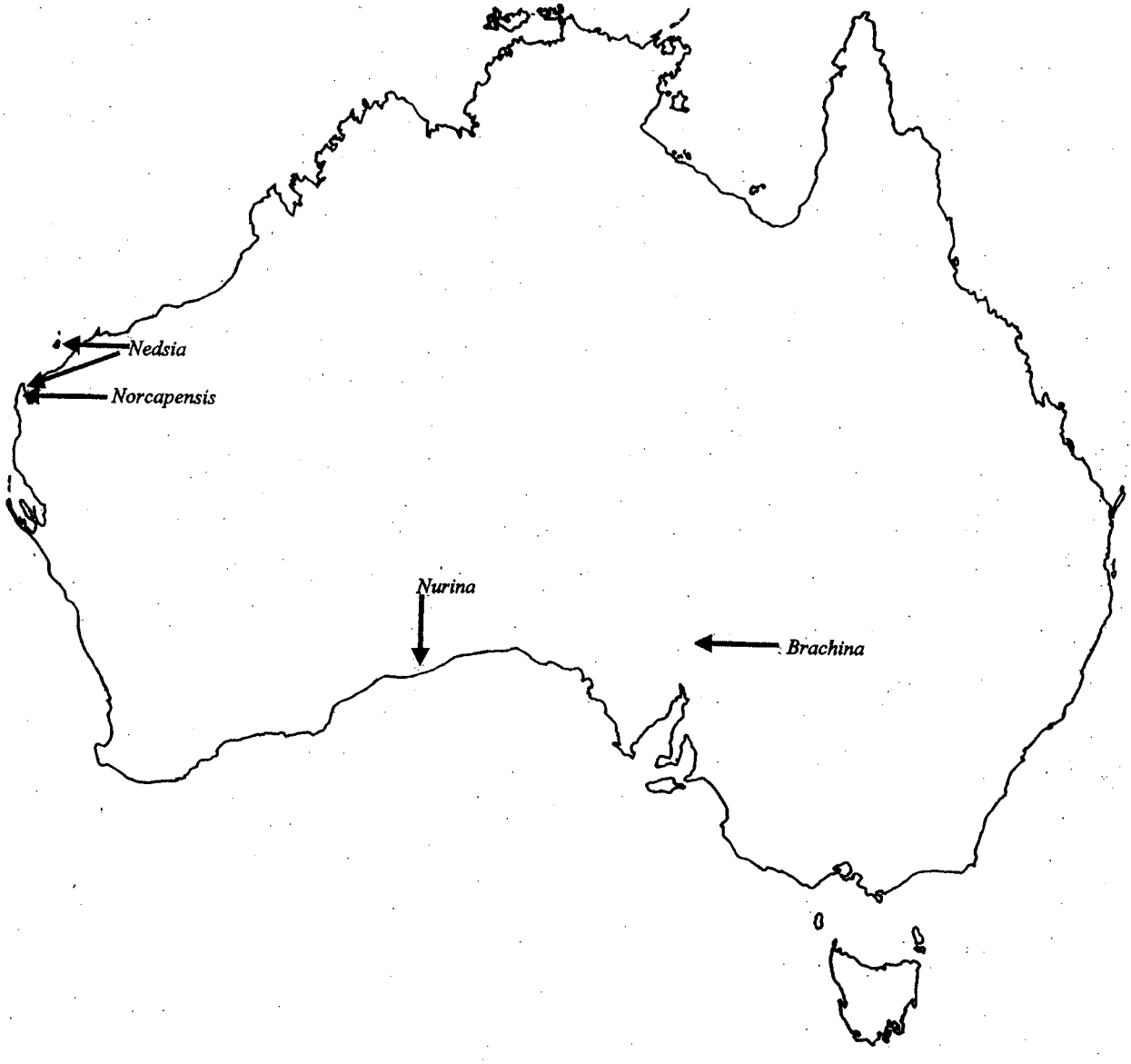

Fig. 4.41. Distribution of Australian freshwater genera of the family Melitidae.

Chapter 5

Stygobiotic Amphipoda

Introduction

Troglobitic animals have long been recognised (Belles 1992) and the term *stygobites* has been coined to refer specifically to aquatic troglobites. Relatively recently, though, the nature, phylogenetic relationships and origins of underground aquatic fauna, in particular Amphipoda, have been investigated (Bousfield 1982a; Holsinger 1986b, 1994a, b; Williams 1986; Stock 1986; Notenboom 1986).

Observations of aquatic cave organisms in southern Europe led to a realisation the distributions of many such organisms, especially crustaceans, were closely correlated with regions inundated by Late Mesozoic or Tertiary seas (Notenboom 1986). Furthermore, many of these inhabitants of groundwater habitats were often related to typically marine groups. These observations led Stock (1980) to suggest a mechanism of evolution of stygobionts based on fluctuations in sea levels: that during sea level regressions marine littoral species may be stranded as levels fell, and become adapted to mixohaline conditions, eventually leading to speciation through isolation in underground fresh waters. This concept has become known as the "regression model". An alternative explanation for the origin of stygofauna is the "active migration" or "dispersion" model (Danielopol 1980) - the 'occupation of a free niche situated within the species range', and related to transition zones between epigean and hypogean or marine and freshwater environments. The dual origin of groundwater fauna (stygofauna) is thus from either marine ancestors by regression or invasion, or from migration or dispersion of epigean freshwater ancestors (Notenboom 1986). Typical of stygobitic amphipods derived from marine origins are the Hadzioidea which is composed of the marine Melitidae (plus

the monospecific Mediterranean Carangoliopsidae) and the exclusively stygobiont Hadziidae. Melitidae are shallow littoral and estuarine taxa, and Hadziidae are found in sublittoral and littoral marine sediments, anchialine[1] caves and pools. Stygobiont Crangonyctoidea have a freshwater origin, having no marine relatives nor display current distributions associated with past marine inundation.

Unlike many other areas of the world (Holsinger 1994a, b) gammarid amphipods have not often been reported as components of Australian subterranean freshwater faunas, and diversity of Australian stygobiont amphipods has been considered to be relatively low. Williams (1986) regarded as subterranean only four or possibly five species, although, in a separate footnote to Williams (1986: 556), Knott foreshadowed greater diversity and noted that a range of undescribed subterranean amphipods occurred in Western Australia (comments supporting this note were separately published (Knott 1983, 1985), but without description of taxa). Descriptions of several subterranean species (Stock and Iliffe 1991; Williams and Barnard 1988; Barnard and Williams 1995) however, provided substantive confirmation that a diversity of forms occurs, a phenomenon which includes - as elsewhere - both stygobitic and stygophilic forms (i.e. obligate and facultative sub-surface forms). Bradbury and Williams (1997a) discussed and drew attention to this diversity, listed all described sub-surface forms, and noted the occurrence of several further undescribed taxa.

The prolific diversity of subterranean fauna, both terrestrial and aquatic, of Australia, and in particular north western Australia, has now been revealed; a diversity probably not exceeded in any comparable region (Humphreys 1993a, b, c; Watts and Humphreys 1999, 2000). This fauna has a significant and diverse amphipod component dominated by the family Melitidae and the super family Crangonyctoidea (Bradbury and Williams 1995, 1996a, b, 1997a, b, Bradbury 2000, 2002, Bradbury and Eberhard 2000).

[1] anchialine: with no surface connection with the sea, containing salt or brackish water, which fluctuates with the tides (Holthuis, 1973); also referring to land-locked pools or cave lakes in limestone, coral or basalt with subterranean connections to the sea (Holsinger and Yager 1985).

Data

Aquatic stygofauna have been recorded in increasing numbers from widespread regions of Australia, but most particularly from Western Australia (Humphreys and Adams 1991; Humphreys 1993a, b, c, 1995, 1999, 2000; Knott 1993). The significance of the amphipod component among aquatic stygofauna is revealed in the number of reports of recent years from Western Australia (Williams and Barnard 1988; Barnard and Williams 1995; Bradbury and Williams 1995, 1996a, b, 1997a, b; Bradbury 2000, 2002; Bradbury and Eberhard 2000; Jasinska *et al* 1996), Tasmania (Horwitz 1988; Eberhard 2001; Eberhard *et al* 1991), New South Wales (Bradbury and Williams 1997b; Eberhard and Spate 1991), Queensland (Barnard and Williams 1995) and South Australia (Stock and Iliffe 1991). Moreover, this diversity appears to extend over the coastally located underground waters (e.g. anchialine caves; Bradbury and Williams, 1996b).

Australian stygobitic and stygophilic amphipods are listed in Table 5.1, including all described species recorded thus far from either underground waters (caves, bore-holes) or springs near their source. It lists two principal sorts of taxa: those which have been recorded from underground waters (including springs) and nowhere else (obligate stygobionts (stygobites) *sensu* Barr and Holsinger (1985)); and those recorded from both underground and surface waters (facultative-stygobionts or stygophiles). In total, the table lists over 60 species of which three quarters can be regarded as stygobites and the remainder stygophiles. All are endemic. On the basis of described species, therefore, approximately 50 per cent of the total amphipod diversity of Australian inland waters can be found in subsurface waters. This figure is far higher than the global figure of 13 per cent given by Holsinger (1993) for the approximate fraction of all described amphipod species that are stygobionts. Furthermore, the actual number of known taxa (both stygobite and epigean) is much greater as many are in the process of description or held in collections pending taxonomic treatment. The majority of stygobites is associated with ground waters in carbonate rocks which have been karstified.

TAXON	DISTRIBUTION	HABIT	No.
Melitidae			
Nedsia douglasi Barnard & Williams, 1995	N. West Cape W.A.	stygobiont	01
N. straškraba Bradbury & Williams, 1996	Barrow Island W.A.	stygobiont	02
N. fragilis Bradbury & Williams, 1996	Barrow Island W.A.	stygobiont	03
N. humphreysi Bradbury & Williams, 1996	Barrow Island W.A.	stygobiont	04
N. hurlberti Bradbury & Williams, 1996	Barrow Island W.A.	stygobiont	04
N. macrosculptilis Bradbury & Williams, 1996	Barrow Island W.A.	stygobion	06
N. sculptilis Bradbury & Williams, 1996	Barrow Island W.A.	stygobiont	07
N. urifimbriata Bradbury & Williams, 1996	Barrow Island W.A.	stygobiont	08
N. chevronia Bradbury, 2002	Barrow Island W.A.	stygobiont	09
N. stefania Bradbury, 2002	Barrow Island W.A.	stygobiont	10
N. halletti Bradbury, 2002	Barrow Island W.A.	stygobiont	11
Brachina invasa Barnard & Williams, 1995	Flinders Ranges. S.A.	hyporheic interstit.	12
Norcapensis mandibulis Bradbury & Williams 1997	North West Cape W.A.	stygobiont	13
Nurina poulteri Bradbury and Eberhard, 2002	Nullarbor Plain W.A.	stygobiont	14
Bogidiellidae			
Bogidomma australis Bradbury & Williams 1996	Barrow Island W.A.	stygobiont	15
Paramelitidae			
Hurleya kalamundae Straškraba, 1966	South-west W.A.	stygobiont	16
Protocrangonyx fontinalis Nicholls, 1926	Darling Range. W.A.	stygophile	17
Uroctena westralis (Chilton), 1925	nr Perth W.A.	stygophile	18
Totgammarus eximius Bradbury & Williams, 1995	South-west W.A.	stygophile	19
Chillagoe thea Barnard & Williams, 1995	North Queensland	stygobiont	20
Giniphargus pulchellus (Sayce), 1899	Gippsland Victoria	stygobiont	21
Austrogammarus sp.	Tasmania	stygophile	22
Austrogammarus smithi Williams & Barnard, 1988	Tasmania	stygophile	23
Antipodeus antipodeus (G.W.Smith), 1909	Tasmania	stygophile	24
Antipodeus wellingtoni (G.W.Smith), 1909	Tasmania	stygophile	25
Antipodeus franklini Williams & Barnard, 1988	Tasmania	stygophile	26
Uronyctus longicaudus Stock & Iliffe, 1990	South-east S.A.	stygobiont	27
Pilbarus millsi Bradbury & Williams, 1997	Pilbara Springs W.A..	stygophile	28
Chydaekata acuminatum Bradbury, 2000	Newman area, W.A.	stygobiont	29
C. nudulum Bradbury, 2000	Newman area, W.A.	stygobiont	30
C. dolichodactylus Bradbury, 2000	Newman area, W.A.	stygobion	31
C. breviclavus Bradbury, 2000	Newman area, W.A.	stygobiont	32
C. transversi Bradbury, 2000	Newman area, W.A.	stygobiont	33
C. diagonalis Bradbury, 2000	Newman area, W.A.	stygobiont	34
C. carscuticum Bradbury, 2000	Newman area, W.A.	stygobiont	35
C. gyraspis Bradbury, 2000	Newman area, W.A.	stygobiont	36
C. simulatum Bradbury, 2000	Newman area, W.A.	stygobiont	37
C. tetraspis Bradbury, 2000	Newman area, W.A.	stygobiont	38
C. ovatosetosus Bradbury, 2000	Newman area, W.A.	stygobiont	39
C. anophelma Bradbury, 2000	Newman area, W.A.	stygobiont	40
C. scopula Bradbury, 2000	Newman area, W.A.	stygobiont	41
C. scuticari Bradbury, 2000	Newman area, W.A.	stygobiont	42
C. brachybasis Bradbury, 2000	Newman area, W.A.	stygobiont	43
Molina pleobranchon Bradbury, 2000	Millstream area, W.A.	stygobiont	44
Perthiidae			
Perthia acutitelson Straškraba, 1964	South-west W.A.	stygophile	45

Table 5.1 Continued next page.

Neoniphargidae			
Neoniphargus obrieni Nicholls, 1926	Mt Buffalo Victoria	possible stygophile	46
Neoniphargus spp.	Tasmania	stygophile	47
N. coolemanensis Bradbury & Williams, 1997	Kosci. Nat. Park N.S.W.	stygophile	48
N. secus Bradbury & Williams, 1997	Wombeyan N.S.W.	stygobiont	49
N. richardi Bradbury & Williams, 1997	Wombeyan N.S.W.	stygobiont	50
Neocrypta primaris Bradbury & Williams, 1997	Wellington N.S.W.	stygobiont	51
N. robinae Bradbury & Williams, 1997	Canomodine N.S.W.	stygobiont	52
N. moniae Bradbury & Williams, 1997	Bowan Park N.S.W.	stygobiont	53
N. georginae Bradbury & Williams, 1997	Abercrombie N.S.W.	stygobiont	54
N. annae Bradbury & Williams, 1997	Bowan Park N.S.W.	stygobiont	55
N. simoni Bradbury & Williams, 1997	Jenolan N.S.W.	stygobiont	56
Jasptorus solepti Bradbury & Williams, 1997	Wee Jasper N.S.W.	stygobiont	57
Wesniphargus nichollsi Straškraba, 1964	South-west W.A.	stygophile	58
W. yanchepensis Bradbury & Williams, 1997	Yanchep W.A.	stygobiont	59
Wombeyanus botulosus Bradbury & Williams 1997	Wombeyan N.S.W.	stygobiont	60
Ceinidae			
Phreatochiltonia anopthalma Zeidler, 1991	Mound spring S.A.	possible stygobiont	61
Austrochiltonia australis (Sayce), 1901	southern Australia	stygophile	62
Eusiridae			
Pseudomoera fontana (Sayce), 1902	south-east Australia	stygophile	63
(Hadziidae)			
Liagoceradocus branchialis Bradbury & Williams	North West Cape, W.A.	anchialine stygo.	64
L. subthalassicus Bradbury & Williams, 1996	Barrow Island, W.A.	anchialine stygo.	65

Table 5.1. Systematic position and geographic distribution of Australian subterranean amphipoda.

The geographical distribution of the species listed in Table 5.1 is indicated in Fig. 5.1. An obvious point to emerge from this figure is the large number of stygobite species recorded from Western Australia.

A less obvious point shown by Fig. 5.1 is that the distributions of hypogean amphipods extend more to the north in Australia than do those of any surface aquatic amphipod. Thus, those from Barrow Island in Western Australia and *Chillagoe thea* in Queensland lie many hundreds of kilometres north of areas where surface amphipods occur. It is not difficult to provide an explanation of this; freshwater amphipods are not common in subtropical and tropical waters and only subterranean waters in these regions provide the consistent and relatively lower temperatures and more stable environmental conditions required to support amphipod populations. It may be noted that not all northern and apparently suitable subtropical subsurface waters in Australia contain amphipods: the Cutta Cutta caves near Katherine, Northern Territory, for example, do not appear to be inhabited by

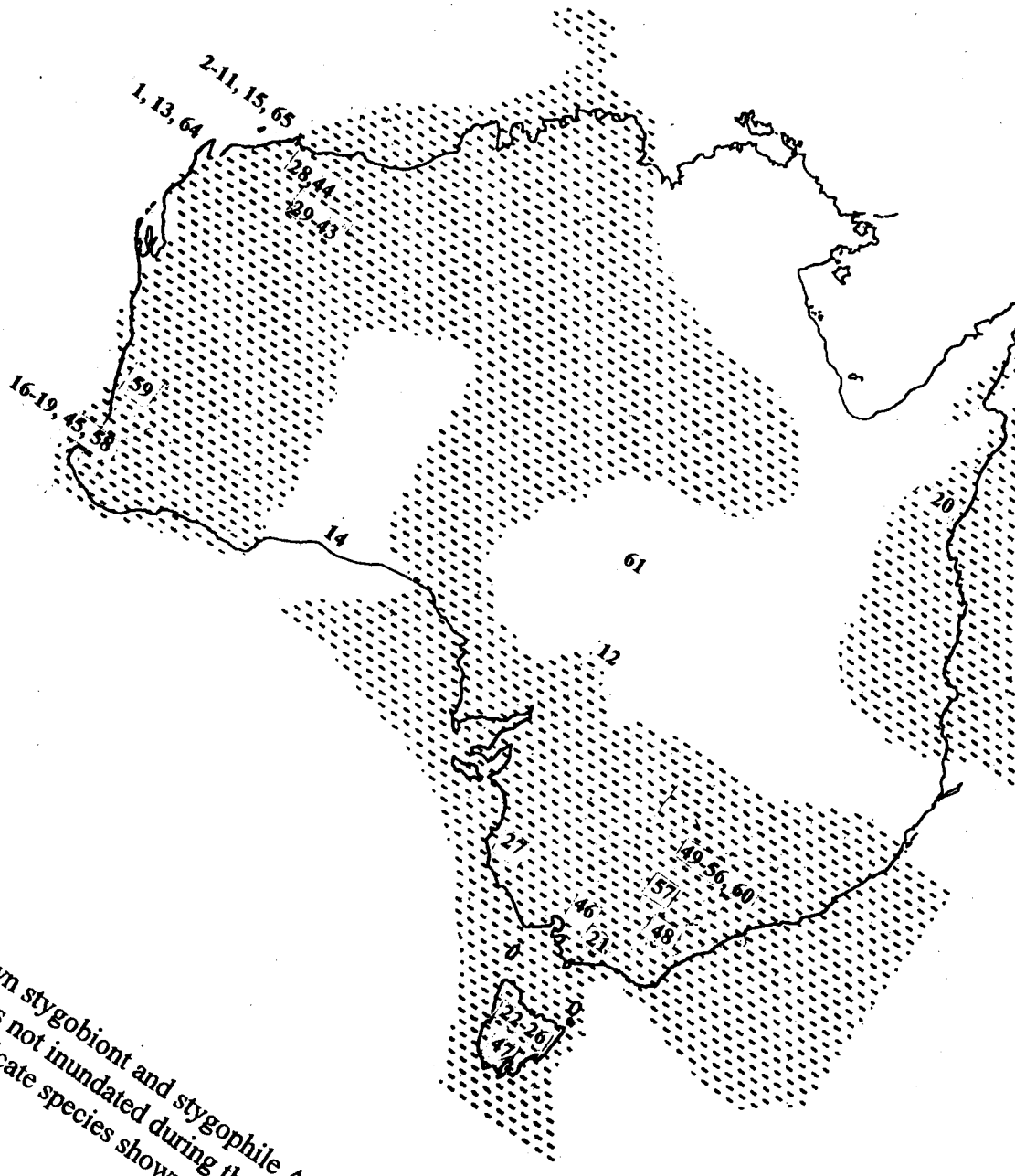

Fig. 5.1. Distribution of known stygobiont and stygophile Australian amphipoda. Stippled area indicates landmass not inundated during the Cretaceous (119-114 illion years ago). Numbers indicate species shown in Table 5.1. Species 62 and not shown.

amphipods (Williams, pers. com.). Perhaps the water in this cave system is too warm, or there was no available ancestral surface form. No amphipods, likewise, have been collected from caves in the Kimberly region of Western Australia (Humphreys 1995).

The ecological nature of subsurface waters inhabited by species here considered as stygobites covers a considerable range in type. Avoiding the plethora of technical terms that have been applied to subsurface waters, descriptions include freshwater streams and lakes in inland caves in calcareous karst, coastal anchialine caves containing marine or brackish water, springs, mud or plant detritus on the bottom of surface waters which are in obvious continuity with the water table in unconsolidated substrata, and interstitial (hyporheic) water associated with streams (Eberhard *et al* 1991; Eberhard and Spate 1995; Humphreys 1995, 1999). The majority of stygobiotic amphipods is associated with ground-waters in carbonate rocks which have been karstified.

Typically, cosmopolitan characteristics of stygobite amphipods and adaptations to a stygal environment can include loss or reduction of eyes, loss of pigmentation, and attenuation and/or lengthening of the body and appendages, reduction of the coxal plates, and reduction of the pleopodal rami (Holsinger 1994b; Camachoo *et al* 1992).

With regard to the systematic positions of the species listed in the table, it is immediately obvious that most belong to two of the three groups identified by Holsinger (1993, 1994a) as those of most importance so far as hypogean amphipod diversity is concerned worldwide, namely, the crangonyctoids, and the melitoids (hadzioids)[2]. Holsinger's third important group, the bogidiellids is also represented, although few have as yet been described (Humphreys, pers. com.; Bradbury, unpublished).

[2] As discussed previously, considerable confusion exists regarding the exact relationships among the melitid/hadziods. I have followed Barnard and Williams (1995) in placing these taxa with the Melitidae.

Species of Melitidae are distributed widely over the continent. Melitids appear to be marine strandings from invasion during periods of marine inundation during the Cretaceous, between 120 and 100 million years ago (Paine 1990). All are hypogean and have well developed stygobite characteristics, including blindness, lack of pigmentation, fragility and attenuation of the appendages, and in some regions display considerable endemism. Melitids are restricted to cave systems, ground-waters or underground streams in areas of past marine inundation, which are now within relatively dry and warm regions of the continent where little or no permanent surface water exists (Bradbury and Williams 1997a, b). The majority of described Melitidae, of the genus *Nedsia* (10), are known from Barrow Island, an isolated extension of North West Cape, while from the Cape itself single species of *Nedsia* and of the genus *Norcapensis* have been described. Two other melitids have been described: *Nurina poulteri* from the Roe Plain, Western Australia, and *Brachina invasa* from the Flinders Ranges in South Australia. Additionally, specimens of *Nedsia* are known from the lower Fortescue River and some of its tributaries, and from the Ashburton River system, both in Western Australia (Western Australian Museum collections, Bradbury unpublished). Further species close to *Brachina* have been collected from wells east of the Flinders Ranges, South Australia (South Australian Museum collections, Zeidler pers. com.).

Australian crangonyctoid (Williams and Barnard 1988) Amphipoda are ancient animals, probably pre-dating the break up of Pangea (Barnard and Barnard 1983). This group, the most ubiquitous of Australian freshwater Amphipoda whose major distribution has hitherto, with few exceptions, been regarded as confined by the cool fresh waters of the south east and south west of the continent and Tasmania (Williams and Barnard 1988; Barnard and Williams 1995), is bound to regions not inundated by the sea since the Cretaceous, and is restricted to permanent fresh waters (Bradbury 1999). An association with continental regions not inundated by the sea since the Paleozoic is a common feature of all crangonyctoids, although some, non Australian, lowland or near-coastal species do occur in regions of Cretaceous or Tertiary marine embayment, having dispersed from nearby freshwater since the most recent inundation (Holsinger 1994a). Among the stygobite crangonyctoid amphipods described here, loss of eyes and pigmentation is

universal, attenuation or elongation of the body is not marked in all taxa, reduction of the coxal plates is present but not extreme, and the pleopods are not reduced in any species, although pereopods 5-7 are attenuated and lengthened in every case. Crangonyctoid stygobite taxa are especially diverse in the Pilbara, with three genera and 17 species described, but the superfamily is also represented in other regions. Interestingly, Tasmanian stygobite species are entirely the locally endemic *Antipodeus* (Paramelitidae) which is also distributed in epiglacial streams and is highly specious. Stygophile Neoniphargidae do occur in a few Tasmanian locations and in Victoria, but not stygobites, whereas caves in New South Wales are inhabited by stygobite Neoniphargidae.

Discussion

Significant diversity of the ground-dwelling amphipod fauna of Australia in both Hadzioidea and Crangonyctoidea is affirmed through description of 46 new species of stygobites. The geographical distribution of these new species falls clearly within areas of Cretaceous marine transgression (Melitidae), or areas not inundated during the Cretaceous (Paramelitidae and Neoniphargidae).

This observed diversity amongst subsurface forms is not, however, surprising given both the paucity of previous studies and, more importantly, the fact that amphipods are known worldwide to be amongst the most widespread, abundant and diverse of subsurface aquatic invertebrates (Holsinger 1993).

Of interest are those factors responsible for the high diversity. In this connection it is instructive to determine those features held in common by the two regions of greatest stygobiont amphipod diversity, the central-southern European- circum Mediterranean region and the eastern and southern North American-West Indian region (Holsinger 1993). In both regions, the following features are both held in common and regarded as significant in promoting the development of high diversity (Holsinger 1994a): a former proximity to the Tethys Sea, the lack of extensive glaciation during the Pleistocene, large areas of karst, and widespread marine transgressions in the late Mesozoic and Cainozoic. To a considerable degree, these

features also characterise large parts of the Australian continent. Over much of the Mesozoic the Tethys Sea lay west of Australia. Apart from the highlands of Tasmania, and small areas of the highest mountains in the south-east of the mainland, the Australian continent was free of ice during the Pleistocene. Marine transgressions covered large areas of the Australian continent during the early Cretaceous. The only difference, and one of degree not kind, is the extent of karst in Australia. Karst does occur widely in Australia (Jennings 1985; Mathews 1985), but continuously extensive areas are confined to the Nullabor Plain and the lower Murray Valley, with only relatively minor occurrences elsewhere (included here is the Fitzroy Basin of Western Australia, the Cooleman Plain, Jenolan and Wee Jasper areas of New South Wales, the Buchan caves area of Victoria, the Mole Creek area of northern Tasmania, and the Barkly Basin of Queensland).

The evolution of stygobionts does not depend entirely upon the presence of karst, but there is little doubt that it does promote their evolution and the development of diversity. In any event, the features listed above, including the occurrence of karst - albeit it to an extent more limited than in the southern Europe-Mediterranean and North American-West Indian regions - have been important in producing the observed diversity of the Australian stygobiont amphipod fauna. Numbers of crangonyctoid and melitoid species have been collected and described from limestone caves in New South Wales (*Neocrypta* spp., *Wombeyanus botulosus*, *Jasptorus solepti*, *Neoniphargus* spp.) and Queensland (*Chillagoe thea*), and from caves and calcretes in Western Australia (*Chydaekata* spp., *Wesniphargus yanchepensis*). However, not all regions of karst in Australia have been host to diversification of stygobiont amphipoda. The Nullarbor Plain, a 200 000 km^2 region of tertiary limestone, includes extensive areas of caves which intersect the water table forming underground lakes, although few appear to contain aquatic macroinvertebrates. Richards (1971) recorded no aquatic fauna from a comprehensive survey of many caves, suggesting that low effective precipitation, general absence of permanent surface streams, and phreatic origin of the caves with no evidence of marine inundation, precluded colonisation either by marine or freshwater species. Richards (1971) found indications of sea-levels as high as 30m above the present level. The Roe Plain, however, is an eroded area of coastal lowland in the central Nullarbor, formed from uplifted sea bed, adjacent to the

Southern Ocean in the Great Australian Bight along the southern edge, with a maximum altitude of 30 m above sea level at its northernmost margin. In Roe Plains caves, therefore, marine intrusive species, or relict marine species might well be expected, and have been found (*Nurina poulteri*). This has been the case in other regions of similar geological history such as North West Cape and Barrow Island (*Nedsia* spp., *Norcapensis mandibulis* (Humphreys and Adams 1991; Knott 1983; Barnard and Williams 1995; Bradbury and Williams 1996, 1997b; Bradbury 2002), the Ashburton River (*Nedsia* spp. Bradbury, unpublished) and lower Fortescue River (*Nedsia* spp., Bradbury, unpublished) areas in northern Western Australia, and in the Flinders Ranges of South Australia (*Brachina invasa*) (Barnard and Williams 1995).

Also important in the evolution of amphipod stygofauna has been both (1) *continental drift* during which Australia first broke free from Gondwana and then passed through a series of quite distinct climatic zones during the Cainozoic, and (2) *palaeoclimatic fluctuations* including periods of aridity which, in conjunction with allied sea-level changes for coastal populations, would have served to isolate surface and subsurface populations of a species and have led to the development of discrete drainage basins (Paine 1990; Williams and Barnard 1988). A succession of favourable (wetter and colder) and unfavourable (drier and warmer) climates could easily have provided mechanisms promoting stygobiont speciation as epigean populations were driven to seek subterranean refugia. It may also be that some stygomorphic forms lacking eyes and [illegible] now found in surface waters, for example *Totgammarus eximius*, actually represent the return to epigean conditions of hypogean forms in the absence of surface competitors; the latter having become extinct during former unfavourable conditions.

Regarding causes of diversity, it may be presumed that the evolutionary routes followed by stygobiont amphipods in Australia are similar to those followed elsewhere by such organisms. Thus, all originated from surface forms by regressive evolution - irrespective of whether selection, the accumulation of neutral mutations, or genetic drift was the more important in this process (Culver 1982). Isolation from surface forms then occurred following sea-level change, the onset of climatic aridity, or a given geomorphological event. A number of evolutionary steps have

been proposed through which populations pass as stygobiont species evolve. As a general rule, three broad steps can be recognized to accommodate the evolution of stygobionts from both inland and marine ancestors (Notenboom 1986; Holsinger 1988, 1994a). The first is inclusive of stygophiles with few if any stygomorphic features. *Pilbarus millsi* provides an example. The second also includes stygophiles but these do exhibit some stygomorphic features. Various species of *Antipodeus* (Bradbury, unpublished) provide examples. The third step includes stygobites with clear stygomorphy. *Hurleya kalamundae, Nedsia* species, and *Protocrangonyx fontinalis* are some examples.

As for geographical patterns, three are obvious and accord with the broad biogeographical patterns postulated by Holsinger (1994a) for all subterranean amphipods and perhaps other malacostracans. These patterns are: (1) that shown by stygobionts derived from old freshwater ancestors (limnostygobionts), (2) that shown by stygobionts derived from marine ancestors, and (3) that shown by stygobionts inhabiting coastal waters with marine affinities and clearly derived from closely allied marine ancestors (thalassostygobionts or 'crawl-outs') (Bradbury and Williams 1996b, 1997b). The process involved in pattern (3) is often referred to as 'stranding' (Notenboom 1986; Holsinger 1994a). Crangonyctoid species clearly exhibit pattern (1), Melitid species, pattern (2), and *Liagoceradocus* and *Bogidomma* species, pattern (3). Other Australian stygobionts are less easily assigned to a particular pattern, but *Pseudomoera fontana* at least, given its marine taxonomic affinities and despite its entirely freshwater distribution, would appear to exhibit pattern (3). Correlation between distribution of stygobiont amphipods derived from hadziid (melitid) ancestors with areas of marine transgression and, conversely, of those with crangonyctoid ancestors and areas not inundated before or during the Cretaceous, is remarkably distinct, but parallel distributional patterns elsewhere (Notenboom 1986; Holsinger 1986).

Conspicuous among Australian crangonyctoids are many true stygobionts and it is noteworthy that more than half of all described species display stygobiont characteristics, including blindness and the attenuation of limbs, suggesting a past, if not present, hypogean association. It is postulated these species may be either hypogean species living as epigeans only in the vicinity of emergent springs

(Barnard & Williams 1995), or as fully epigean species, having re-emerged following moderation of climate or of competition (Bradbury & Williams 1997a). These characteristics of the group support the concept of Australian Amphipoda being a cool water obligate taxon harried by environmental oscillations, their current distribution evidence of a survival progressively limited by availability of suitable waters with consequent extinctions and little resurgence. Considering their relative lack of abundance, inability to withstand desiccation, and the absence of a radiation to warm permanent streams, this also suggests a conservatism now manifested in their restricted distribution.

On the basis of described taxa alone (Table 5.1), it obvious that significant diversity exists amongst amphipods found in subsurface waters in Australia. How much more diverse will this fauna prove to be when further investigations have taken place? There is reason to believe that the answer is that it will prove to be substantially more diverse. Although the species described herein significantly increase the already considerable known diversity of subterranean Australian amphipods, still further new taxa await description. Material is available (Bradbury, unpublished) which points to the likelihood of new stygobiont taxa from Queensland (*Chillagoe* sp.), New South Wales (Neoniphargidae), South Australia (north-western, east-central, and south-eastern), Tasmania (Paramelitidae - see also Eberhard *et al* 1991), and Western Australia (Ashburton River, Pilbara region, Yilgarn region). That the number of species of hypogean amphipods in Australia will ever reach the numbers found in the two most diverse regions of the world in so far as this group is concerned, that is, the central-southern European - Mediterranean region and the eastern and southern North American - West Indian region is unlikely. Even so, it is already clear the increased knowledge of the diversity of hypogean amphipods in Australia confirms Holsinger's (1993) view that southern Australia is a region of significant diversity for this group. However, description of Paramelitidae from the Pilbara region of Western Australia contradicts findings elsewhere which predict "only in subtropical areas where freshwater stygobionts have been derived from marine ancestors by stranding ..... have significant stygobiont amphipod faunas evolved in limnic waters" (Holsinger 1993). Calcrete deposits have developed extensively in the Pilbara craton, a tectonically stable region which has been emergent above the sea since the

Precambrian. Many of these ground waters have remained fresh (Humphreys 1999), remnants of extensive palaeo channels from extinct river systems.

Much remains for investigation with regard to the stygobiont amphipods of Australia, not least in respect of their evolution and the adaptive and selective processes involved in this. Many areas of karst (for example, eastern Victoria, south-east South Australia, Nullarbor Plain, Camooweal caves in western Queensland, and many caves in Tasmania), as well as other caves (for example, the lava tubes at Undara in Queensland) have yet to be thoroughly examined or their fauna described. Several of these sites are known to contain populations of stygobiont amphipods (Eberhard *et al* 1991; Eberhard and Spate 1995; Bradbury, unpublished).

Conservation of underground waters and their associated faunas has become increasingly topical. Anthropogenic influences are impacting on the quality and quantity of ground waters in the Pilbara and in other regions of interest to mining processors. These underground streams, flowing through calcretes, and their associated faunas, are subject to degradation and collapse when water extraction reaches critical levels (Humphreys 1999, 2000). Australian speleologists have long recognized the need for caves to be conserved and their fauna protected on the basis of both biological and geomorphological criteria (Eberhard 2001; Hamilton-Smith, 2001; James et al 1991). Governments have generally acted sympathetically to this need for cave protection and conservation (Clarke 1997; Eberhard and Spate 1995).

Chapter 6

Phylogeny of Australian Crangonyctoidea

6.1 Introduction

The Australian freshwater amphipod fauna is comprised of eight families and twenty three genera (Chap 1.3). Nine new genera of the family Melitidae and of the superfamily Crangonyctoidea are described in this work (Chaps. 3 and 4), bringing the total to thirty two genera. The major component of Australian freshwater Amphipoda is the Crangonyctoidea which, with new taxa described here, includes twenty two genera and seventy two species of the families Paramelitidae, Perthiidae and Neoniphargidae.

Considerations of phylogenetic relationships among Australian amphipods have been few, and piecemeal. Early investigators (Thompson 1893, Stebbing 1899, Smith 1909a, b) saw affinities between Australian and European taxa, consequently assigning species to the Niphargidae and Gammaridae (neither of which groups lie within the Crangonyctoidea), although Stebbing (1906) differentiated between the genus *Niphargus* and characters of the Tasmanian "*Niphargus montanus*", and erected the new genus *Neoniphargus*, which is now included among the Crangonyctoidea. Sayce (1902), Smith (1909a, b), Chilton (1916, 1925), Nicholls (1924, 1926a-d), Straskraba (1964, 1966), Barnard (1980), Barnard and Karaman (1983) all contributed to knowledge of the Australian amphipod fauna.

The superfamily Crangonyctoidea was established by Bousfield (1977, 1978), although in concept it was much earlier suggested by Schellenberg (1937 a, b), and has been the subject of some debate (Holsinger 1977; Barnard and Barnard 1983; Barnard and Karaman 1983). The Crangonyctoidea was most recently reviewed and redefined by Williams and Barnard (1988). By their definition the superfamily included the non-Australian taxa *Phreatogammarus*, the Crangonyctidae

(*Crangonyx*, *Stygobromus*, *Bactrurus*), *Paramelita*, *Allocrangonyx*, *Austroniphargus*, *Sandro*, *Pseudocrangonyx*, *Procrangonyx*, and *Sternophysinx*, and possibly *Falklandella*. The Australian taxa they included in the Crangonyctoidea consisted of the members of three families, the Paramelitidae Bousfield, the Neoniphargidae Bousfield, and the Perthiidae Williams and Barnard . With this synthesis Barnard and Williams (1988) established a new *status quo* for Australian Crangonyctoidea: three families and twelve genera. In 1995 Barnard and Williams added a further two new genera to the family Paramelitidae. The composition of the Australian crangonyctoids is summarised in Table 6.1 .

Superfamily	Families	Genera
Crangonyctoidea Bousfield 1977	Paramelitidae Bousfield, 1977	*Austrogammarus* Barnard and Karaman, 1983
		Austrocrangonyx Barnard and Karaman, 1983
		Giniphargus Karaman and Barnard, 1979
		Hurleya Straskraba, 1966
		Uroctena Nicholls, 1926
		Protocrangonyx Nicholls, 1926
		Antipodeus Williams and Barnard, 1988
		Chillagoe Barnard and Williams, 1995
		Toulrabia Barnard and Williams, 1995
		Paramelita Schellenberg, 1926
	Neoniphargidae Bousfield, 1977	*Neoniphargus* Stebbing, 1899
		Tasniphargus Williams and Barnard, 1988
		Yulia Williams and Barnard, 1988
		Wesniphargus Williams and Barnard, 1988
	Perthiidae Williams and Barnard, 1988	*Perthia* Straskraba, 1964
	Unplaced	*Uronyctus* Stock and Iliffe, 1990

Table 6.1 Classification of Families and Genera of the Australian Crangonyctoidea (*sensu* Williams and Barnard 1988, 1995).

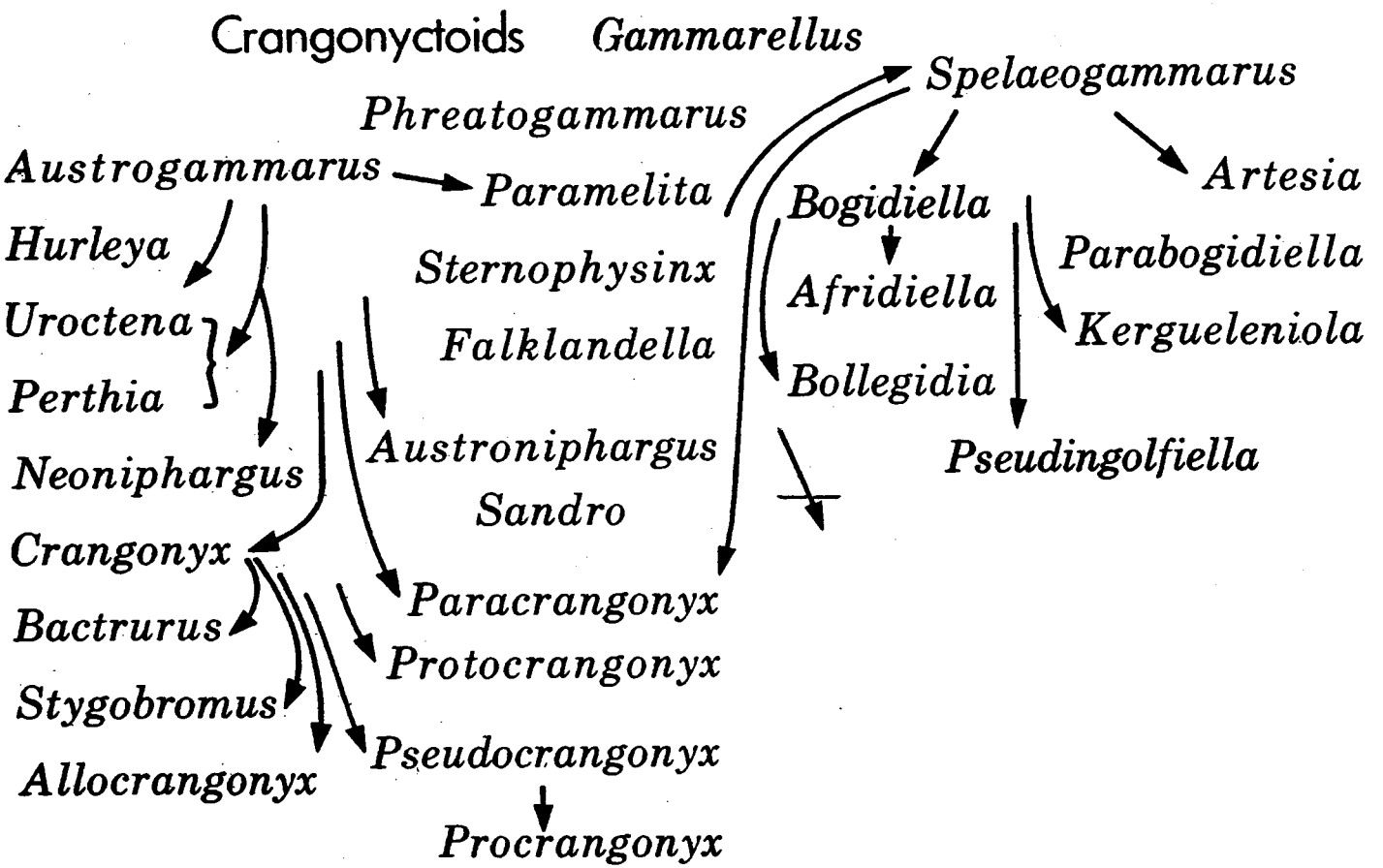

Figure 6.1. Evolutionary pattern of genera in the Crangonyctoid groups. From Barnard and Barnard, 1983 p. 255.

The phylogenetic position of crangonyctoids has been regarded as plesiomorphic and close to Pangean roots of extant Amphipoda (Barnard and Barnard 1983; Barnard and Karaman 1983). However, Barnard and Barnard (1983 p. 255) were not exactly explicit in their definition of evolutionary pathways among the Crangonyctoidea, but placed *Austrogammarus* close to *Phreatogammarus* and *Paramelita* as ancestors to the group (Fig. 6.1). Williams and Barnard (1988) as well as Barnard and Karaman (1983) proposed that the freshwater Crangonyctoidea are plesiomorphic, and proposed a hypothesis for amphipod evolution from morphologically complex to morphologically simplified. The Australian amphipod fauna they considered as relict, being the "*strongly constrained* (through geographic isolation) *descendants of a fauna common to much of (pre-Jurassic) Pangea*" (Barnard and Karaman 1983).

The fauna of Australia was assumed to have been much more diverse at a time when the climate was wetter and colder (Williams and Barnard 1988). Williams and Barnard (1988) elaborated a hypothesis that considerable extinction occurred among the epigean freshwater crangonyctoid amphipod fauna of Australia during periods of climatic oscillation and this resulted in contemporary amphipod fauna consisting of few representative species of a relatively large number of genera. This, of course, ignores the issue of whether genera actually represent units of diversity or not. They suggested that since the distribution of amphipod species, both marine and freshwater, is largely non-tropical, amphipods are apparently biased to cool waters and cool climates (Barnard and Karaman 1983; Williams and Barnard 1988). They argue, then, that extinction has occurred in warmer, more northerly areas with most Australian crangonyctoids being mainly in Tasmania and the south east and south west coastal regions, and in cooler mountain regions further north.

However, recent discoveries have revealed the presence of crangonyctoid amphipods in much warmer climes, although these occurrences are not of epigean animals, rather stygobiotic (ie. aquatic troglobiotic) species, living underground where the surface climate is harsh, and surface water is rarely permanent (Barnard and Williams 1995; Bradbury 2000).

Williams and Barnard (1988) foresaw future "familial emendation", particularly among the Paramelitidae, the largest and most diverse family of Australian Crangonyctoidea. Their analysis, which reviewed established taxa, with the introduction of few new taxa, they considered "*should be regarded as essentially one which emends Bousfield's original and subsequent family diagnosis in order to expedite and accommodate our (re)description of Australian paramelitids*". Indeed, at the time of their study, they were aware of new, unpublished records, many of which have since been reported (Bradbury 2000, 2002; Bradbury and Eberhard 2000; Bradbury and Williams 1995, 1996a, 1997b).

In this study cladistic analyses of morphological data are used to explore phylogenetic relationships among Australian crangonyctoid genera and families. This is in contrast to the methods previously adopted by Williams and Barnard (1988); the establishment of the family Paramelitidae as the most primitive Australian taxa was explicitly based on primitive features (plesiomorphies), and discrimination of the families Neoniphargidae and Perthiidae on the basis of apparent apomorphies. Furthermore, the opportunity arises to examine associations between characters linked to stygobiotic lifestyle, such as absence of eyes and attenuation of appendages. These have been suggested possible trade-off mechanisms of adaptation to stygobiotic existence (Culver *et al* 1995; Fong 1989) and these are assessed here.

6.2 Material And Methods

Terminal Taxa

This analysis is based on morphological characters. Terminals used are genera, with no attempt being made here to assess their monophyly. The scoring for terminal taxa is derived largely from the literature, although where necessary, and possible, type material was examined. Where it was not possible to score characters from the types, scoring was based on a synthesis of information from a number of nominal species in a given genus, although this was done on a minimum of occasions. About half the taxa are monotypic, including; *Totgammarus*, *Toulrabia*,

Hurleya, *Protocrangonyx*, *Chillagoe*, *Giniphargus*, *Pilbarus*, *Molina*, *Perthia*, *Tasniphargus*, *Uronyctus*, *Yulia*, *Wombeyanus* and *Jasptorus*. Others are represented by only a few species: *Austrocrangonyx* (2), *Wesniphargus* (2). Where both epigean and stygobiotic taxa occur within a genus, these groups were scored as separate terminals within the character matrix. Where polymorphism occurred, information from the types was used. Not all characters could be scored for all taxa, in which cases the data are represented in the matrix by a question mark (?) for unknown scores. A dash (-) is used for inappropriate characters for given terminals.

Outgroup

The lack of cladistic analysis of Amphipoda or even Gammaridea means that choosing an outgroup to root any analysis of Crangonycoidea is problematic. Traditionally, Crangonyctoidea has been regarded as a plesiomorphic group of Gammaridea (Barnard and Barnard 1983; Williams and Barnard 1988).

For the purposes of this study a range of Crangonyctoidea were chosen as outgroups. The cladograms were rooted using *Gammarellus*, regarded as primitive by Barnard and Barnard (1983), admittedly an arbitrary choice, but unlikely to be problematic given the main question here concerns Australian taxa. Other taxa included here as outgroups were *Phreatogammarus* (both epigean and stygobiont), *Crangonyx*, and *Sternophysinx*. The New Zealand genus *Phreatogammarus* which Barnard and Barnard (1983) regarded close to both *Gammarellus* and *Austrogammarus* bears many supposed primitive characters (Barnard and Karaman 1983); it is a freshwater taxon, with both epigean and stygobiotic members, presumably isolated since the Eocene (Smith and Briden 1976) when the two island masses drifted apart. *Crangonyx* is a predominantly Nearctic taxon of more than 20 species, also present in the Palearctic, and with both epigean and stygobiotic representatives. The characters of the epigean Nearctic type *C. anomalus* Hubricht were used. *Sternophysinx* is a stygobiotic southern African crangonyctoid which Barnard and Barnard (1983) show as apomorphic to *Paramelita* (Fig. 6.1), but noted that it shares characteristics with *Falklandella* and is probably derived from the same ancestral 'pool' (Barnard and Barnard 1983). In a more recent review of *Sternophysinx*, including the description of two new species, Holsinger (1992)

concluded the sternophysingids sufficiently different from other crangonyctoid groups to warrant recognition as a separate family, and suggested the group possibly closer to the Pseudocrangonyctidae than to other groups of crangonyctoids, including the paramelitids and neoniphargids.

The outgroup taxa apart from *Gammarellus* were in fact free to vary in that they could possibly go with various Paramelitidae, Neoniphargidae and Perthiidae ingroup taxa. This provided an assessment of the monophyly of the nominated ingroup, though further study is required.

Morphological Characters

Morphological features characterising crangonyctoid amphipods have been reviewed by Williams and Barnard (1988). The comparison of many, often obscure, characters is symptomatic of amphipod diagnoses.

Morphological characters used here include those used in published diagnoses of genera (Table 6.1). However, as such diagnoses are not necessarily directly comparable, considerable recourse has been made to original descriptions and illustrations. Terminology also was variable, such as the use of 'spine' for what is actually a robust seta, or 'interantennal' lobe for lateral cephalic lobe. Some potentially significant characters could not be determined for all taxa. For example, calceoli (Lincoln and Hurley, 1981; Lincoln, 1985) are usually present on the flagellum of the second antenna of mature males, although not infrequently on the peduncle of the second antenna, and occasionally on the first antenna of mature males, but rarely on the second antenna of females. However, several taxa (*Austrocrangonyx* Barnard and Karaman; *Toulrabia* Barnard and Williams; *Chillagoe* Barnard and Williams) have been described from the female alone, or include only immature males (*Hurleya* Straskraba; *Protocrangonyx* Nicholls); thus, the described absence of calceoli could not be regarded as reliably recorded for those taxa. Also, calceoli have not always been considered a significant character, so their presence or absence is not always noted. Wherever possible, such ambiguities have been resolved by examination of specimens held in my collection. Similarly, the absence, or presence, and position of penicillate setae, or of dorsal

setae of the telson is rarely recorded, although not infrequently illustrated, so that reliable data could be derived from illustrations in many cases. Such characters as body form, or length of articles, can be subjective; care was taken to interpret these characters consistently, again with recourse to original descriptions and figures. A stygobiotic lifestyle is a frequent characteristic of the Crangonyctoidea. Holsinger (1993, 1994b) notes 13% of all gammarid species are stygobiotics, 80% of which are freshwater species, and that 80% of crangonyctoid species are stygobiotics, particularly those of eastern North America; subterranean amphipods are also significant components of the taxa of South Africa (Holsinger 1992a). Among the Australian Crangonyctoidea 50% of species are represented in groundwaters (see Chapter 5). Habitat, as a function of epigean or stygobiotic lifestyle, is therefore included in the character matrix. Stygobiotic existance is often expressed in morphological traits, such as attenuation of the limbs, absence of pigmentation and rudimentation or absence of eyes (Holsinger, 1994b). The expressions of these characters have been included in the character matrix table (Table 6.2).

The primary homology arguments and character formulations are set out below.

Habitat (1).

Epigean (0) or surface dwelling Amphipoda were once thought the principal fauna among Australian species (Williams 1986). However, recent work (Bradbury and Williams 1996, 1997, Bradbury, 2000) indicates stygobiotic (1) taxa are as diverse as their epigean counterparts. In many instances stygobiotic amphipods display morphological characteristics, similar to those of stygobiotic amphipods found in North America or Europe (Holsinger 1994a, b). Among the Australian fauna the majority of epigean amphipods are distributed about the south east of the mainland and Tasmania and the south west of Western Australia; cooler regions with reliable annual rainfall. Nevertheless stygobiotic taxa occur both in those regions and in underground waters of much more arid and warmer zones further inland and further north.

Body (2) (Fig. 7.1).

The normal body form (0) of Crangonyctoidea is robust, the coxae much deeper than long, pereopods not elongate or weak, with few setae of moderate length; e.g.

Gammarellus, *Crangonyx* and *Phreatogammarus-a*. Stygobiotic forms, such as *Sternophysinx* and *Phreatogammarus-b* typically are less robust and slightly attenuated (1), while other stygobiotic taxa show appendages that are strongly attenuated, the body and legs elongate, the coxae short (2), e.g. *Giniphargus*.

Pleonite setation (**3**) (Figs. 7.1, 7.5).

Setation of the pleonites varies from completely naked to a moderately dense posterior band with additional lateral robust setae: 4 states were scored. *Gammarellus* and *Crangonyx* are relatively smooth, with few processes and little setation (0), whereas *Phreatogammarus-a&b* bear some setae as a distal transverse dorsal band (1), *Austrocrangonyx* less so (2), and *Sternophysinx* is moderately setate (4). *Hurleya* bears scattered setae, but not as a postdorsal band (3) (Williams and Barnard 1988).

Head (Fig. 7.1).

The distal mid dorsal projection of the head forms a rostrum, which is not prominent among Australian Crangonyctoidea, being usually small to absent. A rostrum (**4**) is absent in *Phreatogammarus-b* (0), obsolescent (vestigial) (1) in *Crangonyx* and *Sternophysinx*, small (2) in *Gammarellus* and *Phreatogammarus-a*. Lateral cephalic lobes (**5**) were recognised as being of taxonomic value by Barnard (1969). They project forward at the side of the head between first and second antennae, their differentiation recognised as being of taxonomic value (Barnard 1969). Projection of the lobes is weak (0) in *Austrogammarus*, moderate (1) in *Crangonyx*, *Sternophysinx* and *Phreatogammarus*, and strong (2) in *Gammarellus*. The antennal sinus (**6**), from which region the peduncle of the second antenna projects is another variable character of the head. Four states, from strongly formed to absent, are recognised. The sinus is absent (0) in *Crangonyx* and *Phreatogammarus*, weak (1) in *Sternophysinx*, moderate (2) in *Gammarellus*, and strong (3) in some other taxa.

The absence of eyes is often associated with a stygobiotic lifestyle. Barnard (1969), Barnard and Barnard (1983), Williams and Barnard (1988), recognised not only the presence or absence of eyes as taxonomic characters, but also that size, density of pigmentation, and shape are relevant characters. Eyes (**7**) are absent (0) in most

stygobiotic forms, such as *Sternophysinx* and *Phreatogammarus-b*, they are present (1) in *Gammarellus*, *Crangonyx* and *Phreatogammarus-a*. Eye size and form (**8**) is variable, being large, pigmented and reniform (0) in *Gammarellus*, *Crangonyx* and *Phreatogammarus-a*, moderate size, round or ovate (1) in *Antipodeus*, or very small and round (2) in *Uroctena-a*. The head bears two pairs of antennae (Figs. 7.1, 7.2), and an accessory appendage arises from the end of the third peduncle segment of the first antenna, along with the primary flagellum, which reflects the biramous derivation of the appendage; it may be relatively elongate or of few articles, but not less than two (Williams and Barnard 1988). The length of the first antenna has been shown to be relative to body length (*Gammarus* - Sutcliffe and Carrick 1981, Gammaridae - Barnard 1969; *Stygobromus* - Wang and Holsinger 2001). Other characteristics of the second antenna are the presence of calceoli, and tumidity, or pediformity, of the peduncle (Williams and Barnard, 1988). As antennal length (**9**) appears to be a continuous variable, three states have been chosen arbitrarily: long (0), in which the antenna is half the body length or more; moderate (1), length 30-50% of body length; short (2), length <30% of body length. Antenna one length, relative to body length is long in *Crangonyx*, moderate in *Sternophysinx* and *Phreatogammarus*, and variable in *Gammarellus*. The dominant peduncular article (**10**) may be the first (0) as in *Gammarellus*, *Sternophysinx* and *Phreatogammarus-a&b*, or the second (1) as in *Crangonyx*, or third (2). The number of articles of the accessory flagellum (**11**) varies between 2 (0) in *Crangonyx* and *Sternophysinx*, 3-4 (1) in *Pilbarus* and *Austrocragonyx*, 5-6 (2) in several genera, and 7 or more (3) in *Phreatogammarus-a&b*. The second antenna (**12**), normally slender (0), is pediform (1) (short, peduncles enlarged) in *Uroctena-a&b* and *Paramelita*. The length of the second antenna relative to the first antenna (**13**) can be much less (0) as in *Crangonyx*, *Phreatogammarus* and *Sternophysinx*, slightly less (1), or about equal (2) as in *Gammarellus*. The flagellum length of the second antenna (**14**) can be greater than the peduncle (0) as in *Gammarellus*, equal to the peduncle (1) as in *Phreatogammarus-a&b*, or less than the peduncle (2) as in *Crangonyx* and *Sternophysinx*. The second antenna (**15**) may be without (0) calceoli, or with (1) calceoli as in *Gammarellus*, *Crangonyx*, *Sternophysinx* and *Phreatogammarus-a*.

Mandibles (Figs. 7.2, 7.5).

Numbers of articles, shape and setation of the palp third article are all characters of taxonomic importance (Barnard, 1969). The Australian Crangonyctoidea, as well as outgroup taxa, all bear three article mandibular palps. Medial setae on the mandibular palp second article (**16**) are few (1) as in the outgroup genera, or absent (0). However, the presence of rastellate setae (Oshel and Steele, 1988) distally on the second article of the mandibular palp is a character of some Australian taxa; the second article bears an oblique distofacial row of rastellate setae (**17**) absent (0) in the outgroup taxa, but present (1) in e.g. *Hurleya*. The third mandibular palp article is characterised by the presence (1) or absence (0) of variable numbers of five types of setae apically (Karaman, 1969; Barnard and Barnard, 1983; Wang and Holsinger, 2001), designated 'A' (**18**) present in all outgroup taxa, 'B' (**19**) absent in *Crangonyx*, 'C' (**20**) present in *Crangonyx*, 'D' (**21**) and 'E' (**22**) both of which are present in all taxa in the analysis. The form of the third article (**23**) is normally bent - 'falcate' (Williams and Barnard, 1988) - (0), or, less commonly, relatively straight - linear (1) as found in *Phreatogammarus-a*. Adjacent to the mandibular incisor is a row of 'raker' setae (Williams and Barnard, 1988; Barnard and Karaman, 1991), between which plumose setae (**24**) are frequently present (1) although absent (0) among the outgroup taxa. Between the rakers and molar further plumose (**25**) setae may be absent (0) or present (1), and ragged setae (**26**) which may be absent (0) or present (1), but among the outgroup only the former are found in *Crangonyx* and *Phreatogammarus-b*. The normal gammaridean lower lip bears inner lobes (**27**) (Barnard, 1969), which in the Australian Crangonyctoidea are frequently absent (0) although present (1) on the lower lip in *Crangonyx* and *Sternophysinx*.

Maxillae (Fig. 7.2).

The setae present, and the form of the inner and outer plates of maxillae, as well as form of the first maxilla palps, are recorded by Koenemann and Holsinger (1999) (Bogidiellidae), Barnard (1969) (Gammaridae), Williams and Barnard (1988) (Crangonyctoidea). Both maxillae may (1) or may not (0) bear medial setae (**28**), and at varying densities (**29**): in *Sternophysinx* and *Phreatogammarus-a* they are few (0), while in *Gammarellus* and *Crangonyx* moderate numbers are present (1), while many such setae (2) can be present in other taxa. The form of the inner plate of the first maxilla (**30**) varies (Williams and Barnard 1988) from triangular (0), to

ovate (1), ovato-triangular (2), quadrate (3), sub-rectangular (4), linear (5), and ovato-linear (6) - the states represented in the outgroup are: *Gammarellus* (0), *Sternophysinx* (1), *Phreatogammarus-a* & b (2), and *Crangonyx* (4). Extent of medial setation of the inner plate of the first maxilla (**31**) (Barnard 1969; Williams and Barnard 1988) is recorded as one of four states: in *Gammarellus*, *Sternophysinx*, and *Phreatogammarus-b* the medial margin is fully setose (0), in *Crangonyx* only the apical half is setose (1), some taxa have very few medial setae (2), whereas *Phreatogammarus-a* is devoid of medial setae (3). The outer plate of the first maxilla (Barnard 1969; Williams and Barnard 1988; Barnard and Karaman 1991) bears a number of spine setae (**32**), which can be toothed or naked. Three states were arbitrarily chosen for the numbers of spine setae: ≥10 (0) as in *Phreatogammarus-b*, 8-9 (1) *Gammarellus*, *Crangonyx*, *Sternophysinx* and *Phreatogammarus-a*, ≤7 (2) as in some *Neoniphargus*. Palps of maxilla 1 (**33**) can be asymmetrical (0) or not (1). Williams and Barnard (1988) describe the left asymmetrical palp as bearing thin apical (spines) setae, whereas the right bears tooth like thick apical (spines) setae sometimes fused to the segment. In *Gammarellus*, *Crangonyx*, and *Sternophysinx*, asymmetry (1) occurs, whereas in *Phreatogammarus-a&b* palps are symmetrical and each bear thin apical setae (0). Fine setation or pubescence occurs in some taxa on the inner plate of both maxillae (Williams and Barnard 1988), either absent, sparse, moderate, or dense, and often accompanied on the second maxilla by an oblique facial row of setae (Barnard and Williams 1995; Wang and Holsinger 2001). Pubescent setae of the first maxilla inner plate (**34**) are absent (0) in *Crangonyx* and *Phreatogammarus-b*, present (1) in *Sternophysinx* and *Phreatogammarus-a*, numbers present (**37**) are sparse in *Sternophysinx* (0), moderate in *Phreatogammarus-a* (1), and dense (2) in some other taxa. Pubescent setae of the second maxilla inner plate (**35**) are absent (0) in *Crangonyx*, present (1) in *Sternophysinx*, and the numbers of setae (**36**) sparse (0) in *Sternophysinx*, and *Phreatogammarus-a&b*., moderate (1) in *Austrocrangonyx* and dense (2) in *Austrogammarus*. An oblique facial setal row (**38**) on the inner plate of the second maxilla is absent (0) in *Austrocrangonyx* and present (1) in all the outgroup taxa. Williams and Barnard (1988) distinguish between number, position and form of setae on the maxillipedal palp, and extension of the third article. The apex of the third article of the maxillipedal palp (**39**) is not produced in *Crangonyx* (0), weakly produced (1) in *Phreatogammarus-a*, strongly produced (2) in

Giniphargus. Second and third articles of the maxillipedal palp (**40**) can be without lateral setae (0) as in *Phreatogammarus-b*, or bear setae (1) in numbers (**41**) between sparse (0) as in *Crangonyx*, *Sternophysinx*, and *Phreatogammarus-a*, moderate (1) or dense (2). A robust 'scythe' basal seta (**42**) (Williams and Barnard, 1988) is absent (0) among outgroup taxa, but borne (1) by some taxa on the base of the third palp article.

Coxae (Fig. 7.3).

Configurations of the coxal plates, particularly relative lengths and presence or absence of setae are recognised as characters of taxonomic value by Koenemann and Holsinger (1999), Barnard 1969, Williams and Barnard (1988), and Wang and Holsinger (2001). These include absence (0 - only in *Gammarellus*) or presence (1) of ventral setae (**43**) on coxae 1-4. The numbers (**44**) of ventral setae show three states: moderate (0) in *Crangonyx*, few (1) in *Sternophysinx* and many (2) in *Austrogammarus*. The coxal lengths (**45**) may be long/elongate (0) in *Gammarellus* and *Crangonyx*, short (1) in *Sternophysinx*, and moderate (2) in *Phreatogammarus-a*. Absent (0) from all outgroup taxa are posterior robust setae of coxae 1-3 (**46**) but they occur (1) frequently in *Austrogammarus* (Williams and Barnard 1988). The ventral shape of coxa 1 (**47**), normally sub-quadrate and not tapering (0), as in outgroup taxa, can be rounded or tapered (1) (Williams and Barnard 1988). Posterior excavation (emargination) (**48**) of coxa 4 (Barnard 1969; Williams and Barnard 1988) is normally present (1), as in all outgroup taxa, and the extent of emargination (**49**) of coxa 4 (Barnard 1969, Williams and Barnard 1988) varies from weak (0) as in *Crangonyx* and *Phreatogammarus-b*, to moderate (1) as in *Gammarellus* and *Phreatogammarus-a*, to strong (2) *Sternophysinx*. All outgroup taxa have normal coxae 4-5 (**50**) in which coxa 4 is longer than 5 (0). However, in a few taxa the lengths of these coxae are equal (1), or coxa 4 is shorter than coxa 5 (2) (Williams and Barnard 1988).

Gnathopods (Figs. 7.3, 7.5).

Among some taxa sexual dimorphism in gnathopod size is evident, the male organs being the larger. Female gnathopod size (**51**) can be large (0), medium (1), small (2), or mixed sizes (3). Relative sizes of gnathopods 1 and 2 are recorded in character (**52**), the four states being: equal (0), first gnathopod very much smaller

than the second (1), first gnathopod smaller than the second (2), and the first gnathopod larger than the second (dominant) (3). Male gnathopod size (**53**) and relative size (**54**) are each recorded in one of the same four states as females. First and second gnathopods frequently differ in size, and although among Australian Crangonyctoidea the first is never dominant, sizes may be close to equal (Barnard and Barnard 1983; Notenboom 1988; Williams and Barnard 1988). Gnathopods 1 and 2 are large (0) in both female (**51**) and male (**53**) *Sternophysinx* and *Phreatogammarus-a*, medium(1) in *Gammarellus* and *Crangonyx*, but of mixed size (3) in *Phreatogammarus-b*, small (2) gnathopods occur in *Neoniphargus*. Gnathopod 1 is dominant (3) in both female (**52**) and male (**54**) *Crangonyx* and *Sternophysinx*, equal in size (0) to gnathopod 2 in *Gammarellus* and smaller (2) than gnathopod 2 in *Phreatogammarus-a&b*, very small first gnathopods (1) occur in *Uroctena-a&b*. Williams and Barnard (1988) record a number of dichotomous characters of gnathopods of Australian Crangonyctoidea. The merus may bear (1) a long scythe 'spine' (seta) (**55**), absent (0) in outgroup taxa, and posterior hyaline lobe (**56**), also absent (0) in outgroup taxa, or bear a simple, non-hyaline lobe (**61**), mostly absent (0) among Crangonyctoids, but present (1) in *Phreatogammarus-b* in outgroup taxa. The carpus (**57**) can also bear posterior lobes, which among outgroup taxa are present (1) on only the carpus of *Crangonyx*, *Sternophysinx* and *Phreatogammarus-a*. Similar lobes may be present (1) on the propodus in other taxa (**59**). These posterior lobes of the gnathopodal carpus (**58**) and propodus (**60**) bear (1) rugose setae in some taxa, but not (0) among the outgroup taxa (Barnard 1969; Barnard and Barnard 1983; Williams and Barnard 1988; Barnard and Karaman 1991, Bradbury *et al* 1998). The form of the propodus (**62**) can be ovate (0), commonly subquadrate (1), as in *Gammarellus*, *Sternophysinx* and *Phreatogammarus-a&b*, robust (2), or small and hammer shape (3) as in *Crangonyx*, or cantilevered (4) (ie. not synaxially attached to the carpus) as in *Perthia*. Other characters of the gnathopodal propodus recognised by Barnard (1969), Barnard and Barnard (1983), Barnard and Karaman (1991), Williams and Barnard (1988), Bradbury *et al* (1998) are variation of the palmar angle, the first gnathopod propodus palmar angle (**63**) being strongly oblique (0) in *Gammarellus*, *Sternophysinx* and *Phreatogammarus-b*, oblique (1) in *Crangonyx* and *Phreatogammarus-a*; weakly oblique (2) and transverse (3) palmar angles occur among other taxa. The second gnathopod palmar angle (**64**) was strongly oblique

(0) in all outgroup taxa and oblique (1), weakly oblique (2) or transverse (3) among other taxa. Posterior corners of the propodus are rugose (1) (**65**) in some taxa, eg. *Neoniphargus*, but not (0) among any of outgroup taxa, although similar structures do occur in some taxa (2). Palmar setae (**66**) are simple or bifid among Crangonyctoidea, some bearing triggers. Australian taxa of the superfamily bear simple setae (0), simple setae with triggers (1), and notched setae (2). Bifid setae (3) occur in *Gammarellus* and *Crangonyx*, although *Sternophysinx* and *Phreatogammarus-a&b* bear simple setae (0) only. Numbers of setae present on gnathopodal propodus palmar margins (**67**) are dense (0) in *Sternophysinx*, *Crangonyx* and *Phreatogammarus-a&b*, sparse (2) in *Gammarellus*, and in other taxa moderate (1). The gnathopodal dactyl (**68**) may be naked (0) as in all outgroup taxa, or bear a recumbent inner tooth spine (1) (Williams and Barnard, 1988)

Pereopods (Fig. 7.3).

Pereopods 5-7 (**69**) can be elongate, especially among stygobiotic amphipods in which attenuation of the appendages is evident (Holsinger 1994 a, b). Long pereopods (0) occur on *Gammarellus*, *Sternophysinx* and *Phreatogammarus-b*, whereas legs 5-7 of *Phreatogammarus-a* and *Crangonyx* are short to moderate (1) in length. The second article of pereopods 5-7, the basis, is often post-laterally expanded (**70**) (Barnard 1969; Williams and Barnard 1988), although not expanded (0) in the stygobiotic *Phreatogammarus-b*, slightly (1) in *Sternophysinx*, moderately (2) in *Gammarellus* and *Phreatogammarus-a*, and strongly expanded (3) in *Crangonyx*. The basis of pereopods 5-7 also bears a posteroventral lobe (**71**) in some taxa (Barnard 1969; Williams and Barnard 1988), absent (0) in *Sternophysinx* and *Phreatogammarus-b*, small (1) in other outgroup genera, but moderately (2) or strongly expanded (3) in other taxa. Pereopods 3-7 normally bear a single dactylar setule on the inner margin. However, some taxa also bear additional spinules on the inner dactylar margin, a condition termed 'multispinous' (**72**) (Barnard and Barnard 1983; Williams and Barnard 1988). Pereopodal dactyls of *Gammarellus* and *Phreatogammarus-a* bear only the normal single inner margin setule (0), while multispinous dactyls (1) occur in *Crangonyx*, *Phreatogammarus*-b and in some species of *Sternophysinx*. A further condition of the pereopods, in which the dactyl is strongly bent midway along its length to form a hook (**73**) occurs (1) in *Giniphargus* alone (Williams and Barnard 1988). Three states of relative lengths of

pereopods 6-7 (**74**) (Barnard 1969; Barnard and Barnard 1983; Williams and Barnard, 1988) are coded; pereopod seven is longer than 6 (0) in some taxa, pereopods 6-7 are equal in length (1) in *Gammarellus*, *Sternophysinx* and *Phreatogammarus-b*, whereas in *Crangonyx* and *Phreatogammarus-a* pereod 6 is longer than (2) pereopod 7.

Gills (Figs. 7.3, 7.4).

Coxal gills, ovate, sac like lamellae, can occur on coxae 2-7, but in some taxa gill seven is absent (**75**: 0), and in other taxa there is reduction in size of the seventh gill (**76**: 0), and, rarely, gill 6 is absent (Barnard and Barnard, 1983; Williams and Barnard 1988). Coxal gills (**77**) 2-7 are present (0) in *Gammarellus*, *Crangonyx* and *Phreatogammarus-a&b*, although gill 7 is absent (1) in *Sternophysinx*, and gill 6 also absent (2) among other taxa. Sternal gills, although characteristic of Crangonyctoidea, are not universally present (Barnard and Barnard 1983; Williams and Barnard 1988). Distribution of sternal gills is also variable, occurring from lateral to medial and anterior to posterior on sternites 2-7, 2-6, 3-6, 6-7. In this analysis location of gills on sternites has not been included as available information is incomplete. Among outgroup taxa sternal gills (**78**) are absent (0) in *Gammarellus* and *Phreatogammarus-a* and present (1) in the others, on (**79**) sternites 2-7 (0) in *Sternophysinx* and *Phreatogammarus-b* and on sternites 2-6 (1) in *Crangonyx*, on sternites 3-6 (2) in *Protocrangonyx*, and 6-7 (3) in other taxa.

Pleopods (Fig. 7.4).

The pleopods of some taxa bear specialised, bifid basomedial peduncular setae in which the branches are diverse, of different length and shape, one branch occasionally with a 'diamond' shape head. Other peduncular setae include the retinacula and their accessories. Rami can be equal or unequal in length. (Barnard, 1969; Barnard and Barnard, 1983; Williams and Barnard, 1988). Basomedial peduncular setae (**80**) are not bifid (1) in any outgroup taxa (data unknown for *Gammarellus*, *Phreatogammarus-a&b* and *Crangonyx* which were coded with a '?'). Three or more retinacula (**81**) were present (2) on the pleopods of *Sternophysinx* and *Phreatogammarus-b*, absent (0) on other outgroup taxa, and two retinacula (1) present on other taxa. Accessory retinaculae (**82**) were absent (0) on peduncles of outgroup taxa except *Phreatogammarus-b* in which 3 or more

were present (3), and other taxa bear single (1), or two (2) accessories. The relative lengths of pleopodal rami (**83**) were coded as one of 4 states: outer ramus shorter (0) as in *Sternophysinx* and *Phreatogammarus-b*, rami equal (1) in *Gammarellus*, and outer ramus longer (2) in *Crangonyx*, and in some other taxa the inner ramus is very reduced (3).

Pleonites (Figs. 7.1, 7.5).

Australian Crangonyctoidea bear few or no setae on the pleonites (**84**) (Williams and Barnard 1988). Of the outgroup, *Gammarellus*, *Crangonyx* and *Phreatogammarus-a* are without pleonal setation (0), but setae are present on *Phreatogammarus-b* and *Sternophysinx* (1).

Epimera (Fig. 7.5).

Epimeral setae occur on ventral submargins, posterior margins, and, less commonly, on the postventral corner, which may be rounded, acuminate, or spinous (Williams and Barnard 1988). Posterior marginal setae of the three epimera (**85**, E1; **86**, E2; **87**, E3) are absent (0) from *Gammarellus*, weakly present (1) in *Crangonyx* and *Phreatogammarus-a*, and moderately dense (2) in *Phreatogammarus-b*. The postventral corner of the epimera (**88**) is rounded (0) in *Gammarellus* and *Phreatogammarus-a&b*, bearing a seta (1) in *Sternophysinx* and bearing a spine (2) in *Crangonyx*.

Uropods (Fig. 7.4).

The form, setae, size, relative extension of articles and numbers of articles of the uropods are all characters of systematic value (Barnard, 1969; Barnard and Barnard, 1983; Williams and Barnard 1988; Barnard and Karaman 1991). Presence of a basofacial robust seta on the peduncle of the first uropod (**89**) is uncommon, and is only found (1) in *Chillagoe* among the taxa under examination (Barnard and Williams 1995), as well as in *Phreatogammarus-a&b* of outgroup taxa, and absent (0) in other outgroup taxa. The third uropod (**90**) normally extends beyond uropods 1-2, although in some taxa both third urosomite and uropod may be short and thus the third uropod not extend so far (Barnard 1969). In *Gammarellus* and *Crangonyx* all three uropods extend equally (2), whereas in other of the outgroup taxa the third uropod extends beyond (0) uropods 1-2 in the intact specimen, and in *Hurleya* the

third uropod does not project as far (1) as uropods 1-2. The peduncle of the third uropod (**91**) can be short (0), as in *Gammarellus*, moderate length (1) as in *Austrocrangonyx*, or long (2) as in *Phreatogammarus-a*. The length of the first article of the outer ramus of the third uropod (**92**) can be short (0) as in *Protocrangonyx*, moderate (1) as in *Antipodeus*, long (2) as in *Chillagoe* or very long (3) as in *Sternophysinx*. Presence and size of the second article of the outer ramus of the third uropod is taxonomically significant (Barnard 1969; Barnard and Barnard 1983; Williams and Barnard 1988; Barnard and Karaman 1991). The majority of Australian Crangonyctoidea possess a relatively small second article of the third uropod, but in some taxa e.g. *Giniphargus*, it is of extreme length, whereas in others e.g. *Toulrabia*, the second article is absent. The outer ramus second article of the third uropod (**93**) is absent (0) in all outgroup taxa, whereas, where the second article is present (**94**) it may be short (0), tiny (1) as in *Antipodeus*, moderately long (2) as in *Uroctena*, or extremely long (3) as in *Giniphargus*. The inner ramus of the third uropod (**95**) is present (1) in all outgroup taxa except *Phreatogammarus-a*; normally present among Australian Crangonyctoidea, the inner ramus is however absent (0) in the two taxa *Giniphargus* and *Uronyctus* (Williams and Barnard 1988; Stock and Iliffe 1986). The relative size (**96**) of the inner ramus of the third uropod is a significant marker of many Amphipoda, including Australian Crangonyctoidea, and specific terminology has been developed to describe its morphological states (Williams and Barnard 1988). The inner ramus never exceeds the outer ramus in length. 'Magniramous' (0) refers to the equal extension of both rami, and this condition is found in both *Gammarellus* and *Phreatogammarus-b*. *Crangonyx* and *Sternophysinx* have very small inner rami (1) ie. 'parviramous', while the inner ramus of other taxa are of intermediate length (2) ie. 'variramous'. Medial fine setae of the outer ramus (**97**) (Williams and Barnard 1988; Barnard and Williams 1995) are absent (0) in several taxa (as distinct from robust setae, often described as 'spines'), including *Crangonyx*, but are present (1) in all other outgroup taxa. Robust setae of the third uropod peduncle (**98**) are or present both medially and apically (0), as in *Gammarellus*, *Crangonyx* and *Phreatogammarus-a&b*, but confined to the apical region (1) in some taxa (Williams and Barnard 1988), as in *Sternophysinx*,

Telson (Fig. 7.4).

Several characteristics of the telson, including thickness, length, lateral and apical shape of the lobes, presence and depth of cleft, numbers of apical robust and penicillate setae, presence or absence of dorsal setae are taxonomically relevant characters recorded by Barnard (1969), Barnard and Karaman (1991), Williams and Barnard (1988), Barnard and Williams (1995). Australian Crangonyctoidea all bear a laminar telson, usually relatively short, basally fused, but also usually cleft about half the length. Telson length (**99**) is short (0) in *Phreatogammarus-a*, long (1) in *Gammarellus* and *Sternophysinx*, and of moderate length (2) in *Crangonyx* and *Phreatogammarus-b*, the lobes (**100**) are usually symmetrical, broader than long (0) in most taxa, including outgroup taxa except *Gammarellus* where lobes are longer than broad (1), and laterally (**101**) tumid (0) in *Sternophysinx* and *Phreatogammarus-a&b*, straight (1) in *Gammarellus* and *Crangonyx*, but the laterally tumid telsons of *Sternophysinx* and *Phreatogammarus-a* are apically (**102**) rounded (0) as in *Pilbarus*, apically truncated (1), or apically notched (2) as in *Phreatogammarus-b*, whereas the laterally straight (**103**) lobes of *Gammarellus* are apically rounded (0), and of *Crangonyx* apically truncated (1), and apically notched (2) in *Yulia*. *Gammarellus* telson (**104**) is not cleft (0), *Phreatogammarus-a&b* fully cleft 80-100% (1), *Crangonyx* and *Sternophysinx* cleft 5-40% (2), and other taxa cleft 40-80% (3) as in *Austrocrangonyx*. Dorsal setae of the telsonic lobes (**105**) are absent (0) in *Crangonyx*, *Sternophysinx* and *Phreatogammarus-b*, present (1) in *Gammarellus* and *Phreatogammarus-a*. Numbers of telson apical setae (**106**) less than 4 (0) occur in *Crangonyx* and *Phreatogammarus-a&b*, 4 or more (1) in *Gammarellus* and *Sternophysinx*. Penicillate setae of the telson (**107**) occur dorsolaterally and apically on the lobes of some taxa, their position measured as the proportion of total distance from the base of the telson (Williams and Barnard 1988). Penicillate setae are absent (0) in *Sternophysinx* and *Phreatogammarus-a*, occur at M0.4-5 in *Crangonyx* (1), and in other taxa occur at M0.6-7 (2) and M0.8-9 (3). Apical penicillate setae (**108**) are absent (0) in *Crangonyx*, paired (2) in *Sternophysinx* and *Phreatogammarus-a*, and single (1) in other taxa. Oostegites of the female coxae (**109**), usually present on coxal plates 2-5 (0) as in *Austrogammarus* are sometimes arranged differently (1) as in *Antipodeus*.

Cladistic Analysis

The problems of reliably coding simple "qualitative" data into a form suitable for phylogenetic reconstruction were addressed by Pleijel (1995) though without any satisfactory solution. In this study 'C' coding of Pleijl (1995) was adopted, whereby not only the homology of more general conditions such as absence or presence of a character such as eyes, but also subsidiary characters, such as eye shape or pigmentation, can be coded. All characters were treated as of equal weight even when linked (e.g. characters based on the pigmentation and form of the eyes are linked to the presence of eyes in the first place). Where characters become inapplicable, such as eye characters in the absence of eyes, a '-' was used meaning that the score is treated as a missing state by the programme. Possible problems inherent in adopting this missing entries method ('C') are discussed by Pleijel (1995).

Cladistic analyses were performed using PAUP* version 4.0b4a (Swofford 2000). Trees were rooted and hence characters polarised (Rouse, 2001) using *Gammarellus* (plus *Sternophysinx*, *Phreatogammarus*, *Phreatogammarus* stygobiont and *Crangonyx*) as outgroup. Unknown characters states were coded with a '?'. Zero length branches were collapsed and MULPARS was activated. Tree searches were performed using the random addition search command with 100 replicates. Analysis of character optimisations were performed using MacClade 3.07 (Maddison and Maddison 2001).

6.3 Results

The analysis generated eighteen equally parsimonious trees of length 667 (consistency index Ci = 0.2774; rescaled consistency index RC = 0.1319). Two characters (**21**), D setae of article 3 of the mandibular palp; (**22**), E setae of article 3 of the mandibular palp) were constant and thus uninformative. Three variable characters (**50**), the length of coxa 5 versus length of coxa 4; (**56**), hyaline lobe of the 1st gnathopod merus - presence or absence; (**73**), geniculate dactyls of P5-7 - presence or absence) were parsimoniously uninformative. Character (**50**) is a

multistate character displaying two independent autapomorphies, and characters (**56**) and (**73**) were autapomorphies among single taxa. While these characters were uninformative in the analysis they were included in anticipation of future studies. The number of parsimoniously informative characters examined was 104. In the analysis excluding uninformative characters, the consistency index (CI) was 0.2730.

From the consensus tree (Fig. 6.2) it can be seen there are only three areas of instability; within the outgroup, in the minor clade (*Jasptorus* - *Neoniphargus-b*), and between *Protocrangonyx*, *Hurleya* and the clade (*Chillagoe* - *Austrogammarus*). These actually only reflect three basic tree topologies, as shown in Figs. 6.3.1-3. With regard to discussing transformations, only one tree (tree 3) was chosen since for all relevant characters all the topologies show the same patterns. Unambiguous character transformations (most parsimonious reconstructions; MPRs) are shown in Fig. 6.4. The characters supporting some of the major clades are also outlined here.

The Australian Crangonyctoidea plus *Paramelita* form a clade supported by characters (**49**) (the degree of emargination of coxa four: 1→2) and (**84**) (dorsal setae of the pleonites: 0→1). The Australian Crangonyctoidea form a clade distinguished from the South African *Paramelita* by: the length of the first antennae (**9**); the presence of mandibular interraker setae (**24**); the generally small female gnathopod (**51**); presence of a posterior lobe keel on the propodus of the gnathopods (**59**); length of pereopods 5-7 (**69**); the seventh coxal gill (**75**); preponderence of taxa bearing gills on coxae 2-6 (**77**); the depth of telsonic cleft (**104**).Within this clade is nested a major clade (*Neoniphargus-a* - *Perthia*).

The clade, (*Neoniphargus-a* - *Perthia*) is supported by the following apomorphies: medial setae of the mandibular palp (**16**); ragged setae basal to the mandibular molar (**26**); absence (0) of medial setae of the maxillae (**28**); few (2) medial setae on the inner plate of the first maxilla (**31**); the presence of 7 tooth setae (2) on the outer plate of the first maxilla (**32**); absence (0) of a scythe spine on the merus of the first gnathopod (**55**); presence (1) of a posterior lobe keel on the carpus of the gnathopods (**57**); a small (1) or moderately sized (2) lobe on the basis of pereopods 5-7 (**71**); the presence (1) of medial setae on the outer ramus of the third uropod

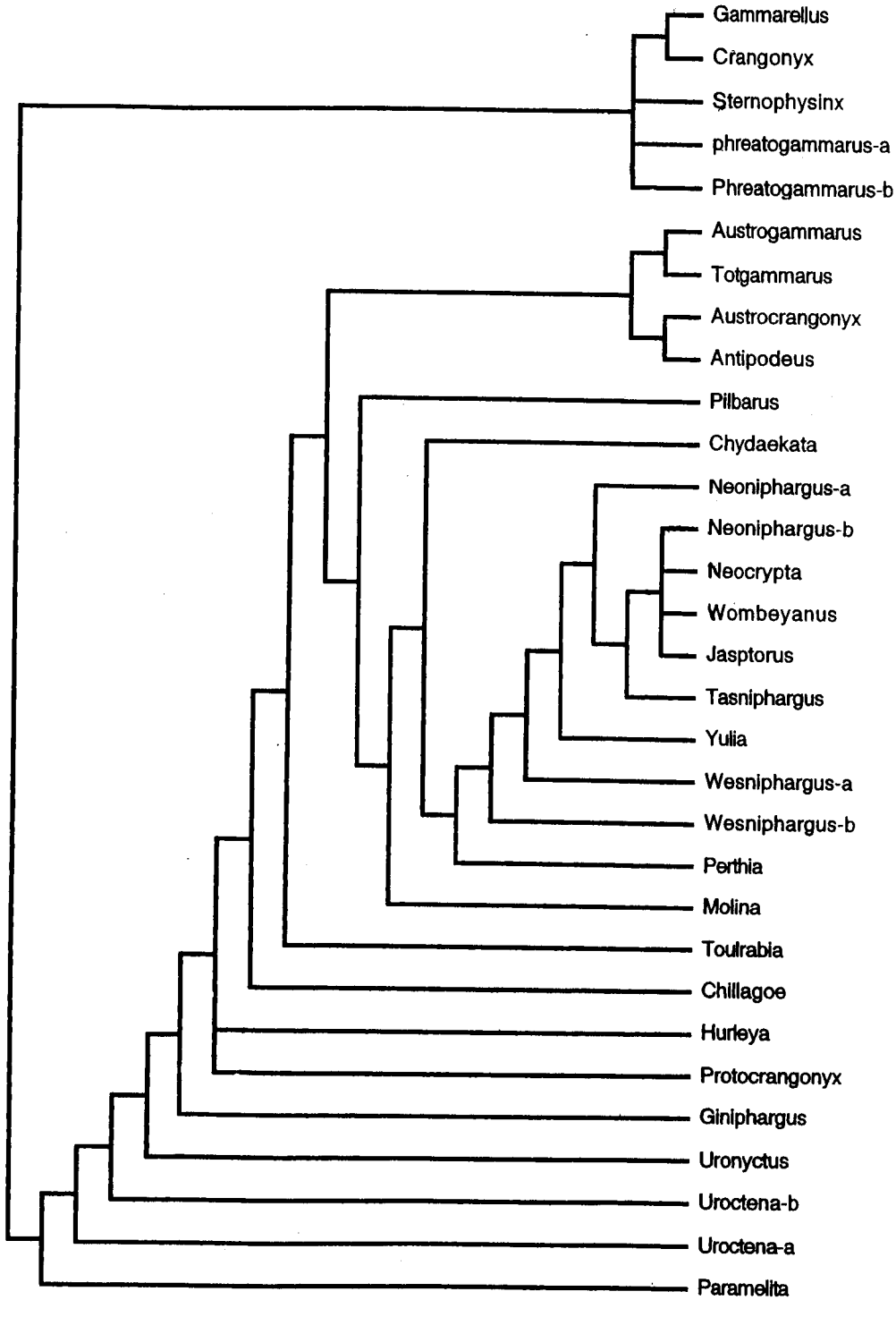

Figure 6.2. Strict consensus of 18 equally parsimonious trees generated from the data matrix.

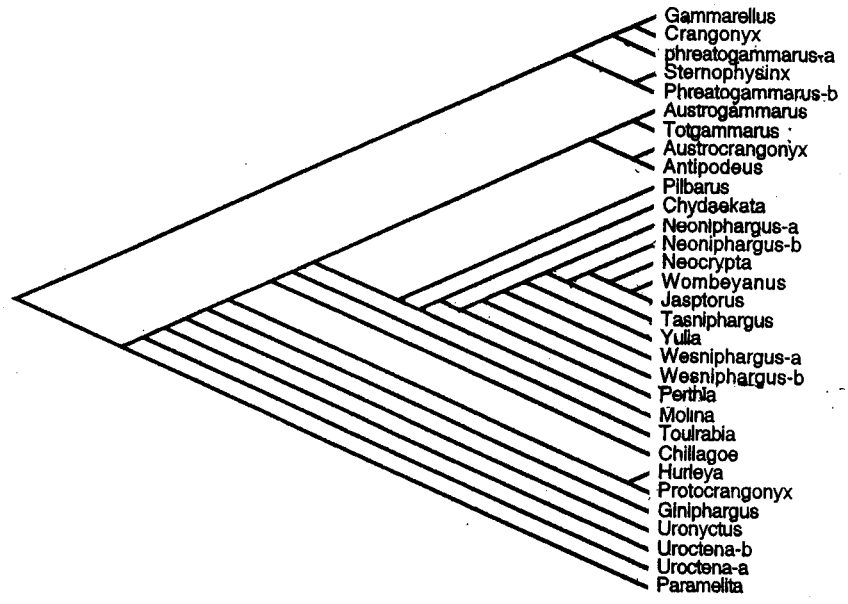

Figure 6.3.1. Tree 3 of 18 equally parsimonious trees generated from the data matrix.

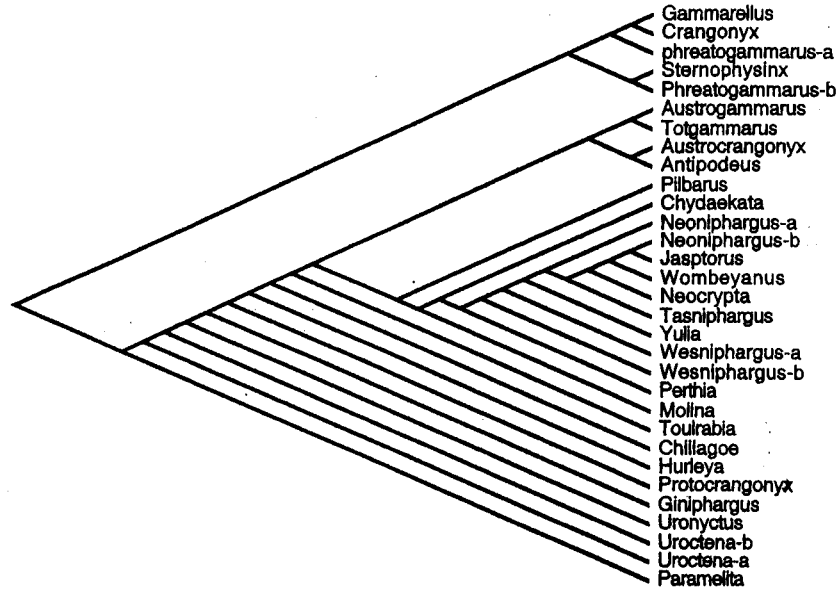

Figure 6.3.2. Tree 7 of 18 equally parsimonious trees generated from the data matrix.

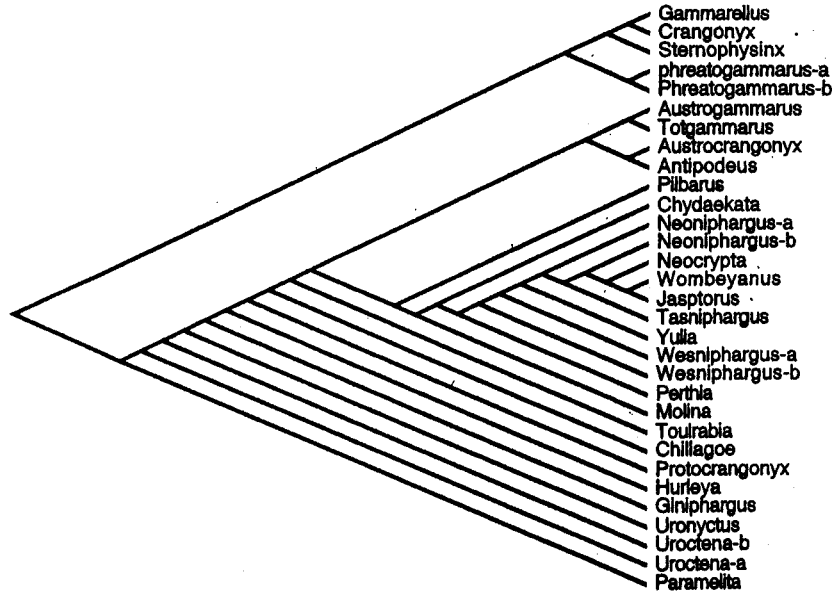

Figure 6.3.3. Tree 10 of 18 equally parsimonious trees generated from the data matrix.

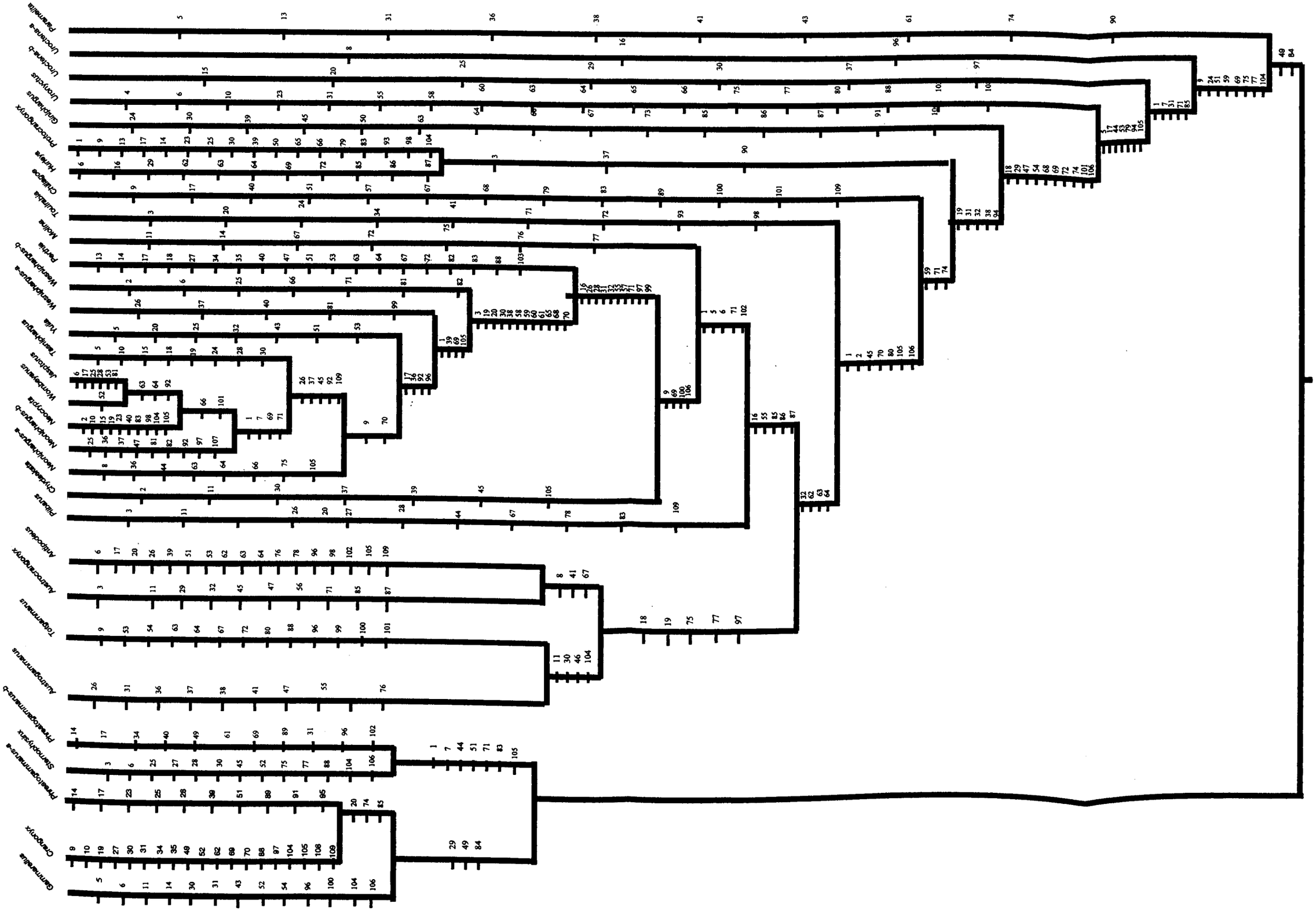

Figure 6.4. Character transformations on tree 3. Character details are in the text and listed in Table **6.5**

(**97**); the long (1) or moderately long (2) telson (**99**). *Perthia* is sister group to the clade *Neoniphargus-a - Wesniphargus-b*.

The monophyly of the clade (*Neoniphargus-a - Wesniphargus-b*) is supported by: the sparsity (3) of pleonic setation (**3**); presence (1) of B setae on the third article of the mandibular palp (**19**) and presence (1) of C setae on the third article of the mandibular palp (**20**); the non triangular shape of the inner plate of the first maxilla (**30**); absence (1) of an oblique facial setal row on the inner plate of the second maxilla (**38**); presence (1) of rugosities on carpus of both gnathopods (**58**); the presence (1) of a posterior lobe-keel on the propodi of the gnathopods (**59**); presence (1) of rugosities on propodus of both gnathopods (**60**); the posterior expansion (1) of the merus of the first gnathopod (**61**); rugosity (1) of the palmar corners (**65**); absence (0) of a recumbent inner tooth spine on dactyls of both gnathopods (**68**); posterior expansion (2, 3) of the basis of pereopods 5-7 (**70**).

Among other characters, those which relate to a stygobiotic lifestyle, including habitat (**1**), attenuation of the body (**2**) and appendages (**9**, **45**, **69**, **74**, **90**, **94**), weak eye pigmentation (**8**), and presence/absence of eyes (**7**) are worth outlining. The occupation of stygobiotic habitat (**1**) has arisen three times, but, somewhat surprisingly, with as many reversals to epigean lifestyle (Fig. 6.5). Absence of eyes (**7**) is perhaps the most commonly recognised stygobiotic condition among a number of taxa, including Amphipoda. In this study eyes were seen to be lost five times and regained twice (Fig. 6.5). In order to determine whether the loss of eyes was correlated with adoption of stygobiotic living the "Concentrated Changes Test" (Maddison 1990) in MacClade 4.03 was applied to data. This tests whether gains in one character (the dependent variable) are more concentrated than expected by chance on those branches of the clade selected that are reconstructed to have a particular state in a second variable (the independent variable). Transformations involving stygobiotic habitat and gain or loss of eyes were juxtaposed to illustrate the test (Fig 6.5). There are fourteen transformation events, three of which involve double transformations on the same branch, resulting in a total of eleven events (Table 6.2). With habitat as the independent variable there were four losses of eyes and one return to eyes on branches that were stygobiotic, the probability of

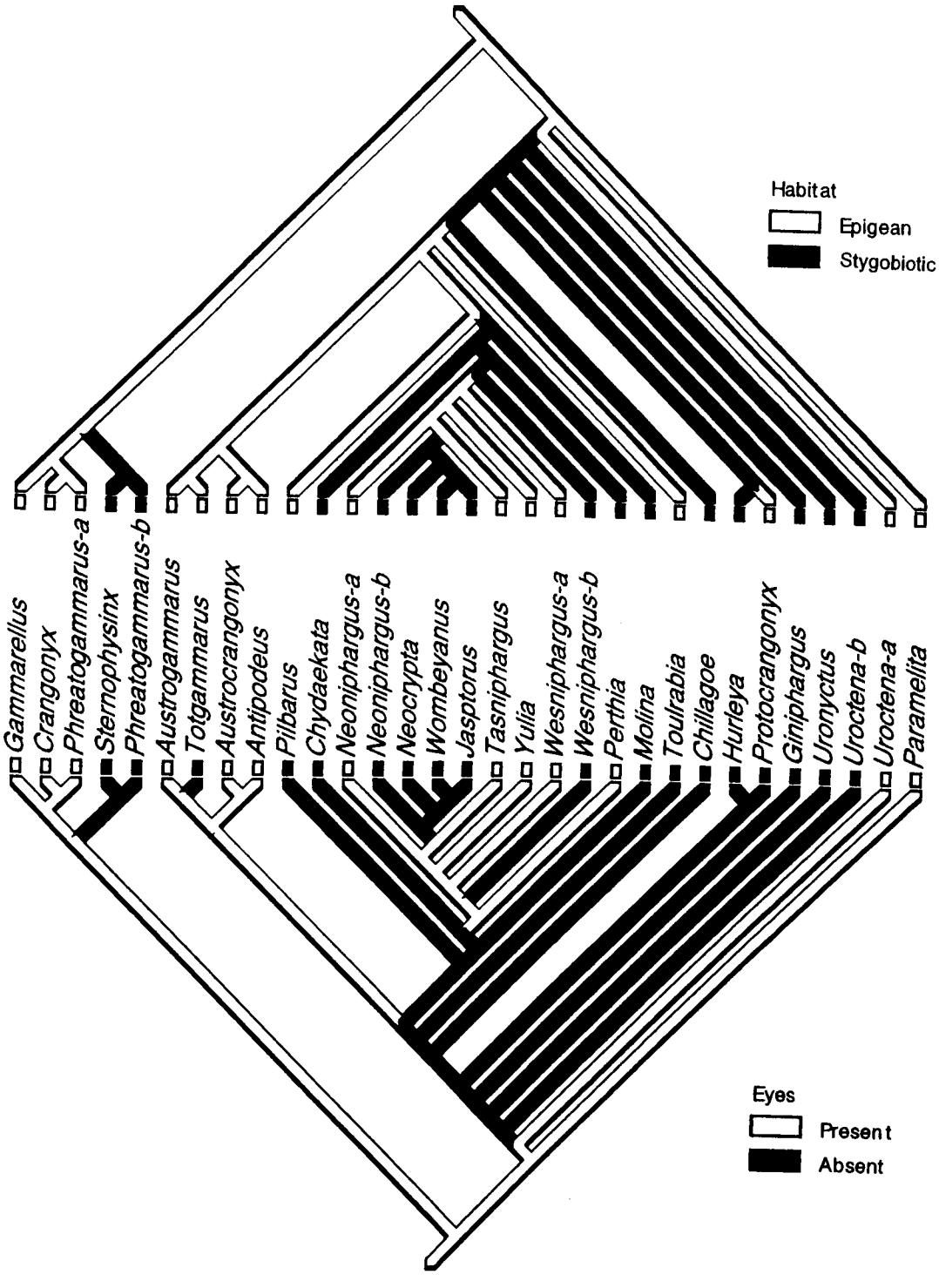

Figure 6.5. Juxtaposed transitions of the characters Epigean/Stygobiotic habitat (**1**) and Presence/Absence of eyes (**7**).

TRANSFORMATIONS	
→Stygo/EyesAbsent	**→Stygo/EyesPresent**
1	**0**
(*Molina - Chydaekata*)	
(*Uroctena-b - Austrogammarus*)	*Wesniphargus-b, Totgammarus**
→Epi/Eyesbsent	**→Epi/EyesPresent**
2	**1**
Protocrangonyx, (*Toulrabia- Austrogammarus*)	(*Wesniphargus-a - Neoniphargus-a*)
Stygo/→EyesAbsent	**Stygo/→EyesPresent**
4	**1**
Wesniphargus-b (*Sernophysinx - Phreatogammarus-b*)* (*Uroctena-b - Austrogammarus*)* (*Jasptorus - Neoniphargus-b*)	(*Perthia - Neoniphargus-a*)
Epi/→EyesAbsent	**Epi/→EyesPresent**
1	**1**
Totgammarus	(*Austrogammarus - Antipodeus*)

Table 6.2 Transformations involving stygobiont habitat and gain or loss of eyes. Data derived from the juxtaposed transitions for each character in Figure 6.5. There are a total of 14 transformation events, three of which involved double transformations on the same branch, resulting in a total of 11 events counted here. The Concentrated Changes test in MacClade 4.03 (see text for details) indicated overall there were no significant gains or losses of epigean/stygobiont habitat or eyes when the other was the independent variable (see text for details).

The clades mentioned above are used to point out the relevant node where the change occurred but note that subsequent changes may have occurred above these nodes. *These clades are scored here to represent a simultaneous transition to stygobiont existence and loss of eyes. It is assumed here that loss of eyes occurred after the occupation of the stygobiont habitat.

observing these changes by chance equalled 0.061. With eyes as the independent variable, stygobiotic habitat was adopted three times and a return to epigean habitat three times on the 'eyes absent' branches. The probability of observing these changes by chance was 0.068. Given the changes to or from the dependent variable are randomly scattered over the tree, the probability of observing the changes expected by chance alone of 0.061 and 0.068 exceed the 5% level and thus the null hypothesis cannot be rejected. There is no demonstrated link between the absence of eyes and stygobiotic habitat. Seemingly anomalous results seen in the transformations, such as the presence of eyes in the stygobiont *Perthia* and absence of eyes in the epigean taxa *Totgammarus* and *Protocrangonyx* are discussed later.

To assess the potential covariability of stygobiotic features such as loss of eyes and antennal length as outlined in the introduction the Concentrated Changes test was used. So to test whether the loss of eyes among some Australian Crangonyctoidea could be related to a 'trade-off' with the elongation of the first antenna, characters (**7**) the presence or absence of eyes was assessed against character (**9**) the length of the first antenna. Character (**9**) was converted to a binary character by amalgamation of states (1) antenna length 30-50% of body length, and (2) antenna length less than 30% of body length, and state (0) remained as antenna one length 50% or more of body length. Transformations involving length of the first antenna and gain or loss of eyes were juxtaposed as seen in Fig. 6.6. There were twelve transformation events, one of which involved double transformations on the same branch, resulting in a total of eleven events(Table 6.3).

The null hypothesis was that there was no relationship between the presence of long first antenna and loss or gain of eyes. When the first antennal length was the independent variable then loss or gain of eyes was not greater than would be expected by chance ($p = 0.116$) on those branches where long first antennae occur. When the character eyes was treated as the independent variable the loss or gain of long antennae was greater than one would expect by chance on those branches where eyes were absent ($p = 0.017$).

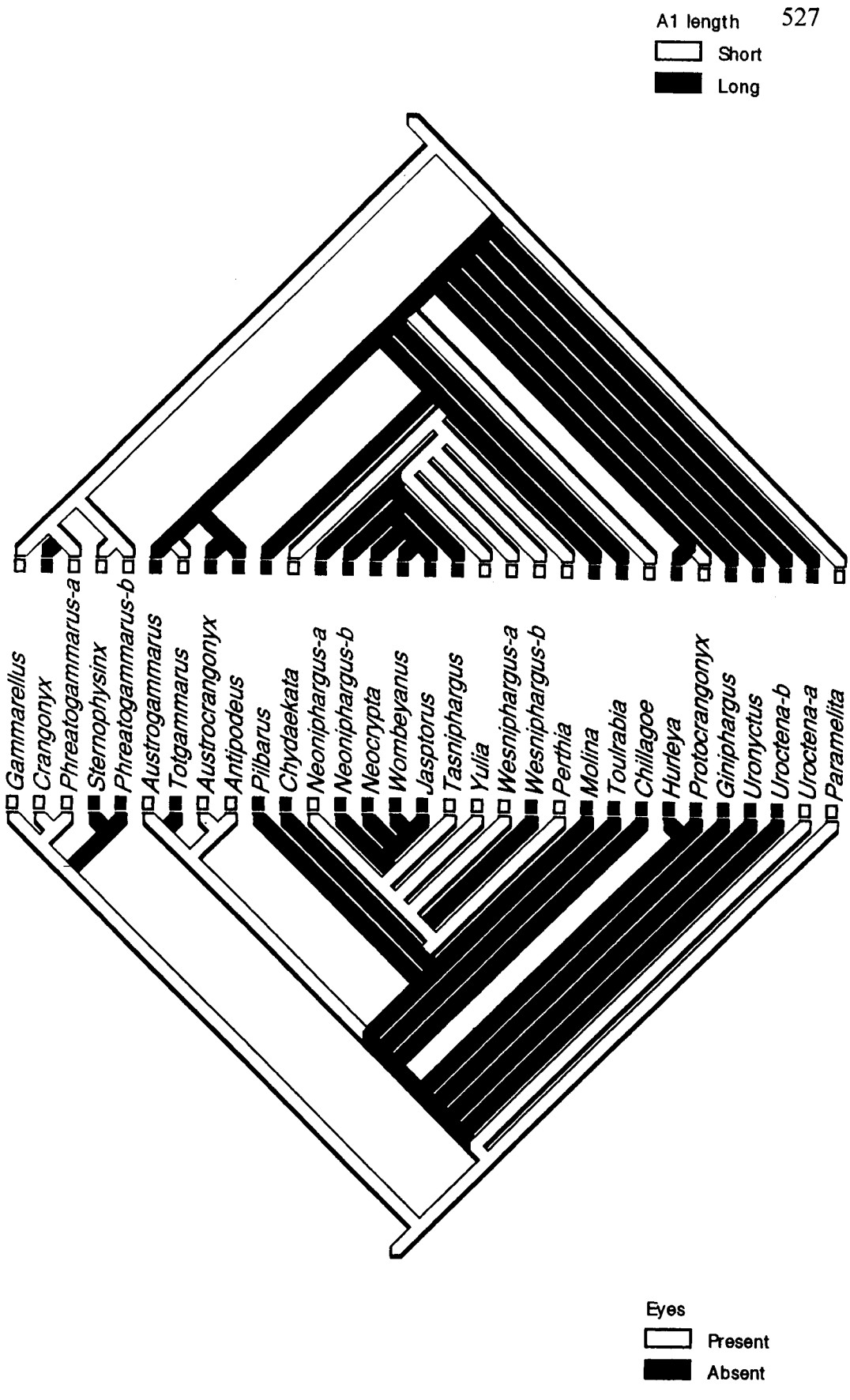

Figure 6.6. Juxtaposed transitions of the characters Presence/Absence of eyes (**7**) and Long/Short first antenna (**9**).

TRANSFORMATIONS	
→No Eyes/A1 long **2** (*Jasptorus - Neoniphargus-b*) (*Uroctena-b - Austrogammarus*)	**→No Eyes/A1 short** **3** (*Sternophysinx - Phreatogammarus-b*) *Wesniphargus-b, Totgammarus**
→Eyes/A1 long **1** (*Antipodeus - Austrogammarus*)	**→Eyes/A1 short** **1** (*Perthia - Neoniphargus-a*)
No Eyes/→A1 long **0**	**No Eyes/→A1 short** **2** (*Perthia - Chydaekata*) *Chillagoe* *Protocrangonyx*
Eyes/→A1 long **3** (*Uroctena-a - Austrogammarus*) (*Tasniphargus - Neoniphargus-a*) *Crangonyx*	**Eyes/→A1 short** **0**

Table 6.3 Transformations involving length of first antenna and gain or loss of eyes. Data derived from the juxtaposed transitions for each character in Figure 6.6. There are a total of 12 transformation events, one of which involved double transformations on the same branch, resulting in a total of 11 events counted here. The Concentrated Changes test in MacClade 4.03 (see text for details) indicated overall no relation between the evolution of eyes and the presence of long first antennae (see text for details).

The clades mentioned above are used to point out the relevant node where the change occurred but note that subsequent changes may have occurred above these nodes. * This clade is scored here to represent a simultaneous transition to short first antenna and loss of eyes. It is assumed here the loss of eyes occurred after shortening of the antenna.

6.4 Discussion

The monophyly of the ingroup was supported since the outgroups *Crangonyx*, *Sternophysinx* and *Phreatogammarus a* and *b* were free to vary, but all were outside the nominated ingroup. In the most recent examination of Australian Crangonyctoidea systematics Williams and Barnard (1988) regarded the Paramelitidae as the most primitive of the three Australian Crangonyctoidea families, displaying plesiomorphic characteristics including the possession of a seventh coxal gill, and simple sternal gills of 'sausage' form, and they regarded *Austrogammarus* as the 'basic (most primitive) genus of Australian Paramelitidae'. Results of this study indicate that Williams and Barnard (1988) were correct in the first instance, and wrong in the second. Their concept of Paramelitidae as primitive was supported, however given that monophyletic groups are accepted here the results of this study indicate Australian crangonyctoids are all of the family Paramelitidae (see section 6.5 Systematics).

Stygobiotic lifestyle is frequently accompanied by anatomical modification (Camachoo *et al* 1992), and among Amphipoda such modifications have also been reported (Fong 1989; Holsinger 1994a, b). The development of stygobiotic characteristics in amphipods was discussed by Culver *et al* (1995) and Fong (1989). Many cave organisms display characteristics such as lack of pigment, absence of eyes, attenuation of antennae and limbs and restricted geographic range. Holsinger (1994b) argued that while rudimentation or loss of eyes is an almost invariable characteristic of stygobiont amphipods, attenuation of body and appendages is variable, and that this was correlated with the physical nature of the particular subterranean habitat. Indeed, the absence of eyes is predominant among the Australian stygobiont amphipods, and there is only one incidence of a probable stygobite bearing eyes, whereas a short first antenna occurred in about 30% of stygobites. However, testing for correlation between presence or absence of eyes and of epigean or stygobiotic habit among the Australian Crangonyctoidea indicated no significant support for the association of these features. More sampling is required before this can be resolved conclusively. Other characteristics of cave dwelling amphipods include the production and brooding of fewer but larger eggs, increased lifespan, and population structures skewed toward older age classes which

contain a low proportion of reproducing females, but with sex ratios strongly favouring females (Holsinger 1994b). Insufficient data are available to allow testing for correlation between these various characters and occupation of a stygobiont habitat among Australian crangonyctoids.

Some seemingly anomalous results can be seen in the transformations. The taxa *Totgammarus*, and *Protocrangonx* although epigean in habitat were without eyes, and *Perthia* although stygobiotic in habit, bore eyes. These differences, however, need to be considered according to the conditions of collection of the taxa and their habits. *Totgammarus eximius* was collected from a roadside pool in south west Western Australia following heavy rains and localised flooding. Attempts to collect the species at the type location have since failed (Bradbury and Williams 1995). Unfortunately it has not been possible to sample underground waters in the vicinity, but it is possible this species was washed from underground by flooding. *Protocrangonyx fontinalis*, another Western Australian species, from the valley of Yule Brook in the Darling Range, was named from a 1923 collection, and no further habitat or collecting information is available, except that the collection site was a stream. However, it is likely, considering the occurrence of *Hurleya kalamunda* at Kalamunda also in the Darling Range, and which is restricted to underground waters, that *Protocrangonyx* is associated with up-welling of underground water, and actually stygobiotic. This dubious occurrence of blind Australian crangonyctoids in surface waters contrasts with the situation in the Palearctic genus *Niphargus*. All species in this taxon are blind, except in a very few species in which only non-ommatidial structures are present, and subterranean, although many species survive in springs, and a few species live in lakes and in the Black and Caspian seas. However, these are possibly emerged stygobiotes, as their main populations may also live in subterranean waters (Barnard and Barnard 1983). *Perthia*, on the other hand was scored stygobiotic. Although it has an epigean taxon, *P. branchialis*, the more common species *P. acutitelson* has well developed eyes and is known to inhabit caves, but whether as a permanent resident, or as itinerant is not known (Chapter 3.2). Certainly, pigmentation of the eyes is reduced or lost under some circumstances, but the eyes themselves are retained (Chapter 3). This taxon was therefore included in the analysis as stygobiotic, but with eyes

present. The presence in underground waters and the reduction of eye pigment may indicate this an example of a recent invasion of stygobiotic habitat.

Among the Australian crangonyctoids, eyes have been lost four times and regained twice. This would seem to contradict Dollo's Law of the irreversibility of evolution. However, Culver *et al* (1995) report eyed *Gammarus minus* living in karst windows (regions of caves where the roof had collapsed allowing ingress of light), to be derived from blind cave populations rather than eyed, epigean populations downstream of the 'windows'. These had re-acquired compound eyes, in apparent violation of Dollo's law. They concluded cave populations of *Gammarus minus* retained genes for eye formation, but that the genes were not expressed in the stygobiotic environment. Marshall *et al* (1994) show a significant probability of re-activation of silenced genes over an evolutionary time scale up to 6 million years. Over longer periods, greater than 10 million years, they found re-activation of unexpressed genes is not possible except where other selective constraints had maintained their function. The age of the Australian stygobiont fauna is not known, although there is consensus the crangonyctoid fauna is considerably older than 6-10 million years, perhaps dating from the break-up of Pangea (Barnard and Barnard 1983; Williams and Barnard 1988; Bousfield 1982b). Taking the estimate of Marshall *et al* (1994) for maximum time for re-activation of suppressed genes, then those genera regaining eyes after a stygobiotic existence would not have remained underground continuously for more than 10 million years.

A stygobiotic habitat was adopted by Australian crangonyctoids three times, and a return to epigean habitat also occurred three times. Whether adaptations to epigean or stygobiotic lifestyle can be successfully carried into the other habitat is unknown. However, several taxa, including *Uroctena-a, Toulrabia, Tasniphargus, Neoniphargus-a, Antipodeus, Austrocrangonyx*, and *Austrogammarus* all bear long first antennae despite occupying an epigean habitat. Furthermore, as discussed above, *Toulrabia* and *Uroctena* are eyeless, although occupying an epigean habitat, and *Perthia* bears eyes despite living as a stygobite. In the case of *Gammarus minus* occupation of epigean habitat from stygobiotic habitat was clearly observed, the recovery of measurable epigean characteristics apparently being a gradual rather

than rapid process as eyes were only partially developed among karst window populations (Culver *et al* 1995).

Among suggested mechanisms underlying adaptations to stygobiotic life are regressive evolution, accumulation of neutral mutations, energy economy (trade-off) and pleiotropy (Culver *et al* 1995). The energy economy effect associates phenomena such as eye size reduction with development of other sensory organs, like elongation of antennae, whereby one sensory mechanism is substituted by another (Fong 1989). Supposedly stygobiont-linked characters involving attenuation of appendages and absence of eyes, have been postulated 'trade-off' events (Culver *et al* 1995; Fong 1989). This was tested here for the Australian crangonyctoids by comparing loss of eye events with the elongation of the first antenna (Fig. 6.6). No significant correlation was found between eye loss and long first antenna. Rather, short first antenna was seen to be correlated with absence of eyes. Thus a 'trade-off' of the sensory organs eyes and antennae has not been shown among the Australian Crangonyctoids. The absence of eyes has nothing to do with the evolution of long antennae, rather there seems an opposite relationship of absence of eyes and short antennae. On the basis of these results the adaptive value of long antennae in a stygobiotic environment must be questioned. Holsinger (1994b) notes loss or rudimentation of eyes and of pigmentation is invariably characteristic of cave dwellers. However, the degree of attenuation in body and limbs is often greater between taxa of different families than between epigean and hypogean species within a single family and thus not characteristically troglobitic. Furthermore, the degree of attenuation of appendages and body is often correlated with habitat structure, and perhaps significantly influenced by it (Holsinger 1994b). Holsinger provides no data whereby the length of antennae might be related to a particular habitat type, and no habitat data are available for the taxa examined in this study.

6.5 Systematics

The phylogenetic concept of Barnard and Barnard (1983) and Williams and Barnard (1988) was based upon the recognition of primitive (including the possession of a

seventh coxal gill, and simple sternal gills of 'sausage' form) as well as derived characters. They recognised apomorphic groups as the basis of families and genera, the residual resulting in paraphyletic groups, their 'primitive' groups. However, contemporary practice is to consider monophylic groups as valid taxa. Cladistics recognises synapomorphies and constructs a phylogeny on those characters. The results of the cladistic analyses shown here do not support the three family composition of Australian Crangonyctoidea of Williams and Barnard (1988). Paramelitidae *sensu* Bousfield is shown here to be paraphyletic because the 'Neoniphargidae' (*Wesniphargus* - *Neoniphargus-a*) and 'Perthiidae' (*Perthia*) form clades within it (Fig. 6.7). The paraphyly of Paramelitidae means that the Neoniphargidae and Perthiidae must be regarded as junior synonyms to make this a monophyletic group. Neonipharginae (*Wesniphargus-b* - *Neoniphargus-a*) and Perthiinae (*Perthia*) are hereby established as new sub-families, meaning that Paramelitinae (*Paramelita*) is also established (ICZN Code 1999; Article 34.1). The clade (*Austrogammarus* - *Antipodeus*) is also established here as the new sub-family Austrogammarinae. This clade is distinguished by characters **18**(1) and **19**(1) the presence of A and B setae on the third article of the mandibular palp, **75**(1) and **77**(0) presence of a coxal gill on pereopods two to seven, and **97**(1) the presence of medial setae on the inner ramus of the third uropod. The redundant name Perthiinae is retained here in anticipation of new taxa within the sub-family, as has been noted in Chapter 3.2 . The clade Neonipharginae is distinct, based on the characters; **3**(3) few setae on the pleon, **19**(1) and **20**(1) presence of B and C setae on the third article of the mandibular palp, **30**(not 1) the inner plate of the first maxilla not triangular, **38**(1) the inner plate of the second maxilla lacking an oblique row of facial setae, **58**(1) presence of rugosities on the carpus of both gnathopods, **59**(1) presence of a lobe-keel on the propodus of both gnathopods **60**(1) presence of rugosities on the propodus of both gnathopods, **61**(1) presence of a non-hyaline expansion of the merus of the first gnathopod, **65**(?), **68**(?), **70**(2,3) moderate to strong posterior expansion of the basis of pereopods five to seven. The remaining paramelitid genera *Chillagoe, Chydaekata, Giniphargus, Hurleya, Molina, Pilbarus, Protocrangonyx, Toulrabia, Uroctena*, and *Uronyctus* are not placed in any sub-family at this time. The new family structure is shown in Table 6.4 in comparison with the old family structure. In Figure 6.7 the consensus tree is shown with both old and new family structures.

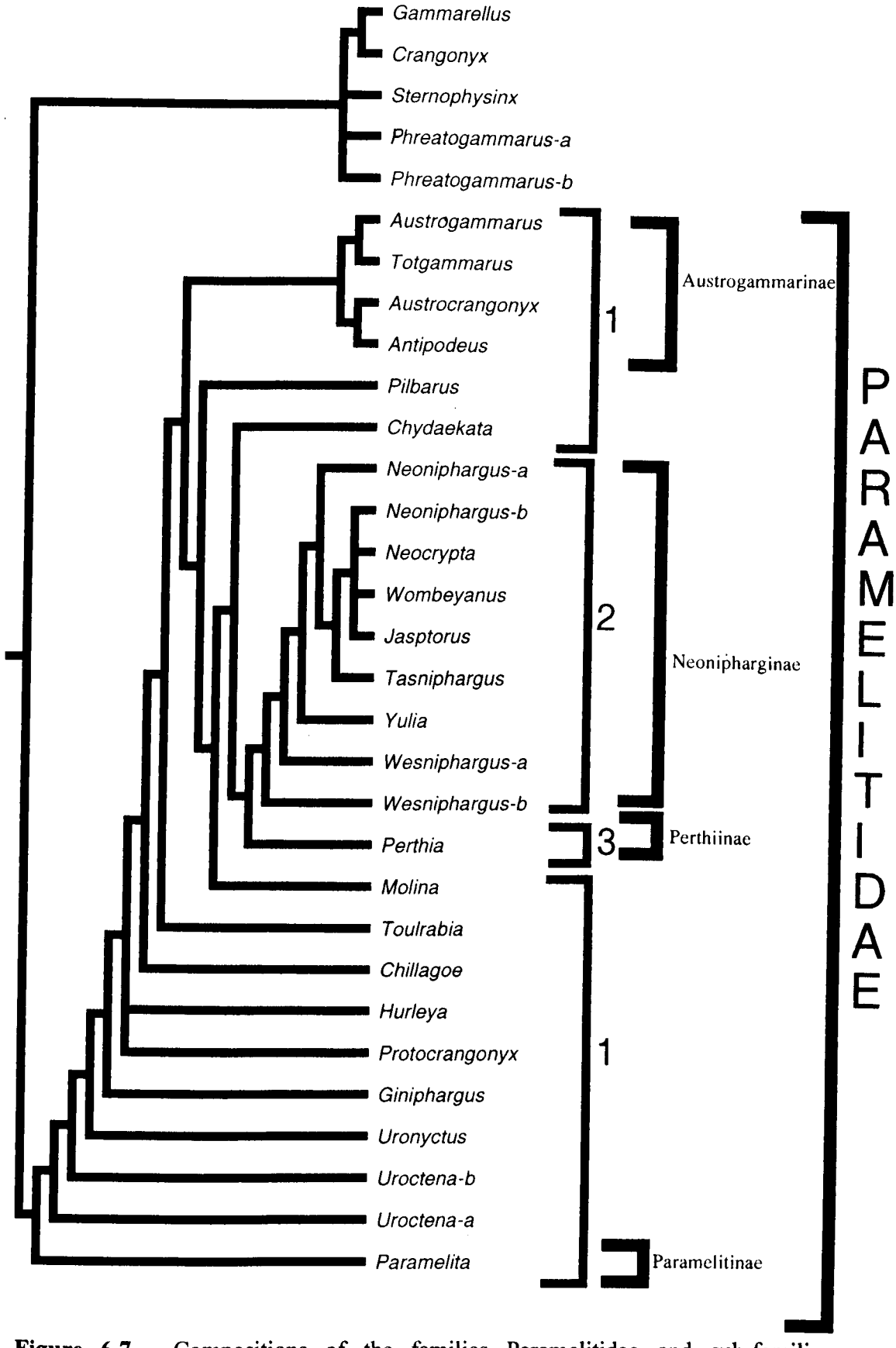

Figure 6.7. Compositions of the families Paramelitidae and sub-families Paramelitinae, Perthiinae, Neonipharginae and Austrogammarinae compared with the three family organisation of Williams and Barnard (1988).
1: Paramelitidae; 2: Neoniphargidae; 3: Perthiidae .

Austrogammarus is shown here to be a derived paramelitid, not a plesiomorphic group as stated by Barnard and Barnard (1983) and Williams and Barnard (1988). *Paramelita*, a southern African genus of more than ten species, is the only representative of the family Paramelitidae outside Australia. However its existence supports the concept of Gondwanan or Pangean links between the two faunas.

Sternophysinx, which Barnard an Barnard (1983) show as apomorphic to *Paramelita* and which Holsinger (1992) ascribed to the new family Sternophysingidae, is shown to be plesiomorphic to the Paramelitidae. Holsinger (1992) pointed to a number of apomorphies within the group, including bladder like sternal gills shared with *Stygobromus* and the Pseudocrangonyctidae. He regarded the Sternophysingidae closer to the Pseudocrangonyctidae than to other groups of crangonyctoids, including Paramelitidae and Neoniphargidae. Morphological similarities of *Sternophysinx* with *Hurleya* and *Protocrangonyx* were possibly convergences related to stygobiont life. This latter point seems to be supported here since *Sternophysinx*, *Hurleya* and *Protocrangonyx* do not group together at all.

Superfamily	Family	Sub-Family	Genus
Crangonyctoidea Bousfield 1977	Paramelitidae Bousfield 1977	Austrogammarinae new sub-fam.	*Austrogammarus* Barnard and Karaman, 1983
			Totgammarus n. gen
			Austrocrangonyx Barnard and Karaman, 1983
			Antipodeus Williams and Barnard, 1988
		Neonipharginae (Bousfield, 1977)	*Neoniphargus* Stebbing, 1899
			Neocrypta n. gen.
			Wombeyanus n. gen
			Jasptorus n. gen
			Tasnipargus Williams and Barnard, 1988
			Yulia Williams and Barnard, 1988
			Wesniphargus Williams and Barnard, 1988
		Perthiinae(Williams and Barnard, 1988)	*Perthia* Williams and Barnard, 1988
		Paramelitinae (Bousfield, 1977)	*Paramelita* Schellenberg, 1926
		Unplaced	*Toulrabia* Barnard and Williams, 1995
			Chillagoe Barnard and Williams, 1995
			Hurleya Straškraba, 1966
			Protocrangonyx Nicholls, 1926
			Giniphargus Karaman and Barnard, 1979
			Uronyctus Stock and Iliffe, 1990
			Uroctena Nicholls, 1926
			Chydaekata n. gen
			Molina n. gen
			Pilbarus n. gen

Table 6.4 New classification for Families and Genera of the Australian Crangonyctoidea including new genera, and *Paramelita* of South Africa.

1 HABITAT: 0. epigean. 1. stygobiont.
2 BODY: 0. normal. 1. slightly attenuated. 2. strongly attenuated.
3. PLEONITE SETATION: 0. smooth. 1. normal. 2. less setous and spinous. 3. few setae.
4. moderately setous.
4. ROSTRUM CONDITION: 0. nil. 1. obsolescen. 2. small.
5. LATERAL CEPHALIC LOBES: 0. weak. 1. moderate. 2. strong
6. ANTENNAL SINUS: 0. absent. 1. weak. 2. moderate. 3. strong.
7. EYES: 0. absent. 1. present.
8. EYES: 0. large, well pigmented, reniform. 1. moderate, round/ovate. 2. v. small. round
9. A1 LENGTH: 0. long - 50% body length or more. 1.30-50%. 2.< 30%.
10. A1 PEDUNCLE LENGTH: 0. 1st longest. 1. 2nd longest. 2. 3rd longest.
11. A1 ACCESSORY FLAGELLUM - NUMBER OF ARTICLES: 0. 2 arts. 1. 3-4 articless.
2. 5-6 articles. 3. 7+ articles.
12. A2 CONDITION: 0. normal. 1. pediform.
13. A2 LENGTH RELATIVE TO A1: 0. A2<<A1. 1. A2 < A1. 2. A2 ~= A1.
14. A2 LENGTH OF FLAGELLUM vs. PEDUNCLE: 0. A2 > peduncle. 1. A2 = peduncle.
2. A2 < peduncle.
15. A2 CALCEOLI: 0. absent. 1. present.
16. MANDIBULAR PALP MEDIAL SETAE OF ARTICLE 2: 0. absent. 1. present.
17. MANDIB PALP ARTICLE 2 BEARING OBLIQUE (RASTELLATE) ROW: 0. absent.
1. present.
18. MANDIBULAR PALP ARTICLE 3 **A** SETAE: 0. absent. 1. present.
19. MANDIBULAR PALP ARTICLE 3 **B** SETAE: 0. absent. 1. present.
20. MANDIBULAR PALP ARTICLE 3 **C** SETAE: 0. absent. 1. present.
21. MANDIBULAR PALP ARTICLE 3 **D** SETAE: 0. absent. 1. present.
22. MANDIBULAR PALP ARTICLE 3 **E** SETAE: 0. absent. 1. present.
23. MANDIBULAR PALP ARTICLE 3 FORM: 0. falcate. 1. linear.
24. MANDIBLES - INTERRAKER PLUMOSE SETAE: 0. absent. 1. present.
25. MANDIBLE - PLUMOSE SETAE ONTO MOLAR BASE: 0. absent. 1. present.
26. MANDIBLE - RAGGED SETAE ONTO MOLAR BASE (some bent): 0. absent. 1. present.
27. LOWER LIP INNER LOBES: 0. absent. 1. present.
28. MAXILLI 1-2 MEDIAL SETAE: 0. absent. 1. present.
29. MAXILLI 1-2 MEDIAL SETAE: 0. few. 1. moderate numbers of setae. 2. many setae.
30. MAXILLA 1: FORM OF INNER PLATE: 0. triangular. 1. ovate. 2. ovato-triangular. 3.
quadrate. 4. sub rectangular. 5. linear. 6. ovato-linear.
31. MAXILLA 1 INNER PLATE MEDIAL SEATE: 0. fully setose. 1. apical 1/2 setose. 2. few
setae. 3. no medial setae.
32. MAXILLA 1 OUTER PLATE SPINE SETAE: 0. 10 or more. 1. 8 or 9. 2. up to 7
33. MAXILLA 1 PALP SYMMETRY: 0. asymmetric. 1. symmetric.
34. MAXILLA 1 INNER PLATE PUBESCENT SETAE: 0. absent. 1. present.
35. MAXILLA 2 INNER PLATE PUBESCENT SETAE: 0. absent. 1. present.
36. MAXILLA 2 INNER PLATE PUBESCENT SETAE: 0. sparse. 1. moderate. 2. dense .
37. MAXILLA 1 INNER PLATE PUBESCENT SETAE: 0. sparse. 1. moderate. 2. dense .
38.MAXILLA 2 INNER PLATE OBLIQUE FACIAL SETAL ROW: 0. absent. 1. present.
39. MAXILLIPEDAL PALP - APEX OF THIRD ARTICLE: 0. not produced. 1. weakly produced.
2. produced.
40. MAXILLIPEDAL PALP ARTS. 2-3 LATERAL SETAE: 0. absent. 1. present.
41. MAXILLIPEDAL PALP ARTS. 2-3 LATERAL SETAE: 0. sparse. 1. moderate. 2. dense.
42. MAXILLIPEDAL PALP ART. 3 BASAL SCYTHE SETA: 0. absent. 1. present.
43. COXAE 1-4 VENTRAL SETAE: 0. absent. 1. present.
44. COXAE 1-4 VENTRAL SETAE: 0. moderate nos. 1. few. 2. many.
45. COXAE 1-4 LENGTH: 0. long-elongate. 1. short. 2. moderate.
46 COXAE 1-3 POSTERIOR ROBUST SETAE: 0. absent. 1. present.

Table 6.5 Character list of amphipod taxa used in the cladistic analysis.
For an explanation of Characters see text (continued next page).

47. COXA 1 VENTRAL SHAPE: 0. not tapering. 1. tapering.
48. COXA 4 EMARGINATION: 0. absent. 1. present.
49. COXA 4 EMARGINATION: 0. weak. 1. moderate. 2. strong.
50. COXA 5 vs COXA 4 LENGTH: 0. C4 much longer. 1. C4 = C5. 2. C4 shorter than C5.
51. GNATHOPOD SIZE - FEMALE: 0. large. 1. medium. 2. small. 3. mixed sizes.
52. GNATHOPOD 1 RELATIVE to G2 SIZE - FEMALE: 0. G1 = G2. 1. G1 <<< G2. 2. G1 < G2. 3. G1 dominant.
53. GNATHOPOD SIZE - MALE: 0. large. 1. medium. 2. small. 3. mixed sizes.
54. GNATHOPOD 1 RELATIVE to G2 SIZE - MALE: 0. G1 = G2. 1. G1 <<< G2. 2. G1 < G2. 3. G1 dominant.
55. GNATHOPOD 1 ARTICLE 4 SCYTHE SETA: 0. absent. 1. present.
56. GNATHOPOD 1 ARTICLE 4 HYALINE LOBE: 0. absent. 1. present.
57. G1-2 CARPUS BEARING LOBE: 0. absent. 1. present.
58. G1-2 CARPUS BEARING RUGOSITIES ON LOBE/KEEL: 0. absent. 1. present.
59. G1-2 PROPODUS BEARING LOBE/KEEL: 0. absent. 1. present.
60. G1-2 PROPODUS BEARING RUGOSITIES ON LOBE/KEEL: 0. absent. 1. present.
61. GNATHOPOD 1 ART 4 POST. EXPANSION - NON HYALINE: 0. absent. 1. present.
62. GNATHOPOD FORM: 0. both ovate. 1. normal. 2. like *Antipodeus*. 3. hammer. 4. cantilevered.
63. GNATHOPOD 1 PALMAR ANGLE: 0. strongly oblique. 1. oblique. 2. slightly oblique. 3. transverse.
64. GNATHOPOD 2 PALMAR ANGLE: 0. strongly oblique. 1. oblique. 2. slightly oblique. 3. transverse.
65. PALMAR CORNER APPEARING RUGOSE: 0. not rugose. 1. rugose. 2. false rugosities.
66. PALMAR SETAE: 0. simple. 1. simple bearing triggers. 2. notched with triggers. 3.bifid.
67. PALMAR SETAE - DENSITY: 0. dense. 1. moderate. 2. sparse.
68. GNATHOPODS 1-2 RECUMBENT INNER TOOTH SPINE ON DACTYLS: 0. absent. 1. present.
69. PEREOPODS 5-7 LENGTH: 0. long. 1. short/ moderate.
70. PEREOPODS 5-7 SECOND ARTICLE EXPANSION: 0. not expanded. 1. slightly expanded. 2. moderately expanded. 3. strongly expanded.
71. PEREOPODS 5-7 SECOND ARTICLE LOBE: 0. absent. 1. small. 2. moderate. 3. large.
72. PEREOPODS 3-7 (OR PART) MULTISPINOUS DACTYLS: 0. not multispinous. 1. multispinous.
73. PEREOPODS 5-7 DACTYLS GENICULATE: 0. not geniculate. 1. geniculate.
74. PEREOPODS 6-7 RELATIVE LENGTHS: 0. P6 < P7. 1. P6 = P7. 2. P6 > P7.
75. COXAL GILL 7: 0. absent. 1. present.
76. COXAL GILL 7: 0 - reduced. 1 - not reduced.
77. COXAL GILLS: 0. present on C2-7. 1. present on C2-6. 2. present on C2-5.
78. STERNAL GILLS: 0. absent. 1. present.
79. STERNAL GILLS: 0. present on 2-7. 1. present on 2-6. 2. present on 3-6. 3. present on 6-7.
80. PLEOPOD PEDUNCLE BASOMEDIAL SETAE: 0. bifid. 1. simple - not bifid.
81. PLEOPOD RETINACULAE: 0. none. 1. 2. 2. 3+.
82. PLEOPOD ACCESSORY RETINACULAE: 0. none. 1. 1. 2. 2. 3. 3+.
83. PLEOPOD RAMI RELATIVE LENGTHS: 0. outer ramus shorter. 1. rami equal. 2. outer longer. 3. inner ramus very reduced.
84. PLEONITES - DORSAL SETAE: 0. absent. 1. present.
85. EPIMERA 1 - POSTERIOR MARGINS: 0. without setae. 1. weakly setulate. 2. setulate.
86. EPIMERA 2 - POSTERIOR MARGIN: 0. without setae. 1. weakly setulate. 2. setulate.
87. EPIMERA 3 - POSTERIOR MARGIN: 0. without setae. 1. weakly setulate. 2. setulate.
88. EPIMERA POST-VENTRAL CORNER: 0. rounded. 1. bearing seta. 2. bearing spine-tooth.
89. FIRST UROPOD PEDUNCLE BEARING BASOFACIAL SETA: 0. absent. 1. present.
90. UROPOD 3 EXTENDING BEYOND U1-2 IN INTACT SPECIMEN: 0. longer than U1-2. 1. shorter than U1-2. 2. equal to U1-2.
91. UROPOD 3 PEDUNCLE LENGTH: 0. short. 1. moderate. 2. long.

Table 6.5 continued.

92. UROPOD 3 OUTER RAMUS FIRST ARTICLE LENGTH: 0. short. 1. moderate. 2. long. 3. very long.
93. UROPOD 3 OUTER RAMUS SECOND ARTICLE: 0. absent. 1. present.
94. UROPOD 3 OUTER RAMUS SECOND ARTICLE: 0. short. 1. tiny. 2. moderately long. 3. extremely long.
95. UROPOD 3 RAMI: 0. inner ramus absent. 1. inner ramus present.
96. UROPOD 3 RAMI RELATIVE LENGTHS OF ARTICLES: 0. magniramous.1. parviramous. 3. variramous.
97. UROPOD 3 OUTER RAMUS MEDIAL SETAE: 0. absent. 1. present.
98. UROPOD 3 PEDUNCLE ROBUST SETAE: 0. apical and medial. 1. all apical.
99. TELSON LENGTH: 0. short. 1. long. 2. moderate.
100. TELSON FORM: 0. broad - broader than long. 1. elongate - longer than broad.
101. TELSON LATERAL SHAPE: 0. lobes laterally tumid. 1 lobes laterally straight.
102. TELSON LATERALLY TUMID: 0 apically rounded. 1. apically truncated. 2. apically notched.
103. TELSON LATERALLY STRAIGHT: 0. apically rounded. 1. apically truncated. 2. apically notched.
104. TELSON CLEFT: 0. not cleft. 1. cleft 80-100%. 2. 5-40%. 3. cleft 40-80%.
105. TELSON DORSAL SETAE: 0. absent. 1. present.
106. TELSON APICAL SETAE: 0. 1-3 setae. 1. 4 or more.
107. TELSON LATERAL PENICILLATE SETAE: 0. absent. 1. M0.4-5. 2. M0.6-7. 3. M0.8-9.
108. TELSON APICAL PENICILLATE SETAE: 0. absent. 1. single. 2. paired
109. OOSTEGITES: 0 - present on Coxae 2-5. 1. other.

Table 6.5 continued.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Gammarellus	0	0	0	2	2	2	1	0	1/2	0	1	0	2	0	1	1	0	1	1	0	1	1
Crangonyx	0	0	0	1	1	0	1	0	0	1	0	0	0	2	1	1	0	1	0	1	1	1
Sternophysinx	1	1	3	1	1	1	0	3	1	0	0	0	0	2	1	1	0	1	1	0	1	1
Phreatogammarus-a	0	1	1	2	1	0	1	0	1	0	3	0	2	1	1	1	1	1	1	1	1	1
Phreatogammarus-b	1	1	1	0	1	0	0	-	1	0	3	0	0	1	?	1	1	1	1	0	1	1
Austrogammarus	0	0	1	1	0	3	1	0	0	0	3	0	0	1	1	1	1	1	1	0	1	1
Austrocrangonyx	0	0	2	1	0	3	1	1	0	0	1	0	0	2	?	1	1	1	1	0	1	1
Antipodeus	0	0	1	1	0	2	1	1	0	0	0	0	0	1	1	1	0	1	1	1	1	1
Hurleya	1	1	3	1	1	1	0	-	0	0	2	0	0	2	?	0	1	0	0	0	1	1
Uroctena-a	0	1	1	1	1	3	1	2	0	0	2	1	0	2	0	0	0	1	1	0	1	1
Uroctena-b	1	1	1	1	1	3	0	-	0	0	2	1	0	2	1	1	0	1	1	1	1	1
Protocrangonyx	0	1	3	1	0	3	0	-	1	0	0	0	1	1	0	1	0	0	0	0	1	1
Giniphargus	1	2	1	1	2	3	0	-	0	0	2	1	0	2	0	1	1	0	1	0	1	1
Toulrabia	0	0	0	1	2	3	0	-	0	0	0	0	0	2	?	1	1	0	0	1	1	1
Chillagoe	1	1	1	1	2	3	0	-	1	0	0	0	0	2	0	1	0	0	0	0	1	1
Totgammarus	0	0	1	1	2	3	0	-	1	0	3	0	0	1	1	1	1	1	1	0	1	1
Pilbarus	0	0	4	1	2	3	0	-	0	0	1	0	0	2	1	0	1	0	0	1	1	1
Chydaekata	1	1	1	1	1	1	0	-	1	0	2	0	0	2	1	0	1	0	0	0	1	1
Molina	1	0	1	1	1	1	0	-	0	0	3	0	0	1	?	0	1	0	0	0	1	1
Paramelita	0	1	1	0	0	3	1	0	1	0	2	1	1	2	0	1	0	1	1	0	1	1
Neoniphargus-a	0	0	3	1	1	1	1	1	0	0	0	0	0	2	1	1	0	0	1	1	1	1
Neoniphargus-b	1	0	3	2	1	1	0	-	0	0	0	0	0	2	1	1	0	0	1	1	1	1
Tasniphargus	0	0	3	2	0	1	1	0	0	1	0	0	0	2	0	1	0	1	0	1	1	1
Wesniphargus-a	0	0	3	1	1	1	1	0	1	0	0	0	0	2	1	1	1	0	1	1	1	1
Wesniphargus-b	1	1	3	1	1	2	0	-	1	0	0	0	0	2	1	1	1	0	1	1	1	1
Yulia	0	0	3	2	0	1	1	0	1	0	0	0	0	2	1	1	0	0	1	0	1	1
Neocrypta	1	1	3	2	1	1	0	-	0	1	0	0	0	2	0	1	0	0	0	1	1	1
Wombeyanus	1	0	3	2	0	1	0	-	0	0	0	0	0	2	1	1	0	0	1	1	1	1
Jasptorus	1	0	3	2	2	2	0	-	0	0	0	0	0	2	1	1	1	0	1	1	1	1
Uronyctus	1	2	1	0	2	2	0	-	0	1	2	0	0	2	0	1	1	1	1	0	1	1
Perthia	1	0	1	1	1	1	1	0	1	0	0	0	2	0	1	1	0	1	0	0	1	1

Table 6.6. Matrix of coding scores used in the cladistic analysis.

	23	24	25	26	27	28	29	30	31	32	33	34	35	35	37	38	39	40	41	42	43	44
Gammarellus	0	-	-	-	0	1	1	0	0	1	1	-	-	-	-	1	-	-	-	0	0	-
Crangonyx	0	0	1	-	1	1	1	4	1	1	1	0	0	-	-	1	0	1	0	0	1	0
Sternophysinx	0	0	0	0	1	0	-	1	3	1	1	1	1	0	0	1	0	1	0	0	1	1
Phreatogammarus-a	1	0	0	0	0	0	-	2	3	1	0	1	1	0	1	1	1	1	0	0	1	0
Phreatogammarus-b	0	0	1	0	0	1	0	2	0	0	0	0	1	0	-	1	0	0	-	0	1	1
Austrogammarus	0	1	1	0	0	1	2	0	0	0	0	1	1	2	2	1	1	1	2	1	1	2
Austrocrangonyx	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1
Antipodeus	0	1	1	0	0	1	2	2	1	0	0	1	1	1	1	0	0	1	1	1	0	-
Hurleya	0	1	1	1	0	1	0	2	2	1	0	1	1	1	0	0	1	1	0	0	1	1
Uroctena-a	0	1	1	1	0	1	0	2	3	0	?	?	?	?	?	?	?	1	0	0	1	0
Uroctena-b	0	1	0	1	0	1	1	0	1	0	0	1	1	0	0	1	1	1	0	0	1	0
Protocrangonyx	1	1	0	1	0	1	2	1	2	1	0	1	1	0	0	0	0	1	0	0	1	1
Giniphargus	0	0	1	1	0	1	2	0	1	0	0	1	1	2	1	1	2	1	0	0	1	1
Toulrabia	0	0	1	1	0	1	2	2	2	1	0	0	1	0	-	0	1	1	1	0	0	-
Chillagoe	0	1	1	1	0	1	2	2	2	1	0	1	1	1	1	0	1	0	-	0	1	1
Totgammarus	0	1	1	1	0	1	2	0	1	0	0	1	1	1	1	0	1	1	0	1	0	-
Pilbarus	0	1	0	0	1	0	-	1	1	0	0	1	1	1	1	0	1	1	0	1	1	2
Chydaekata	1	1	0	1	0	1	0	2	2	0	0	1	1	1	0	0	2	1	0	0	0	-
Molina	1	1	1	1	0	1	0	1	2	0	0	1	1	1	1	0	1	1	0	0	0	-
Paramelita	0	0	-	-	0	1	0	2	2	0	0	1	1	1	1	0	0	1	1	0	0	-
Neoniphargus-a	0	1	0	0	0	0	-	6	3	2	0	1	1	2	1	1	2	1	0	0	1	0
Neoniphargus-b	0	1	1	1	0	0	-	6	3	2	0	1	1	1	2	1	2	1	0	0	1	1
Tasniphargus	0	0	0	1	0	1	0	1	3	2	0	1	1	0	0	1	2	1	0	0	1	1
Wesniphargus-a	0	1	0	1	0	0	0	4	3	2	0	1	1	1	0	1	2	0	-	0	1	1
Wesniphargus-b	0	1	1	0	0	0	-	4	3	2	0	1	1	1	1	1	1	1	0	0	1	1
Yulia	0	1	1	0	0	0	-	2	3	1	0	1	1	0	1	1	2	1	0	0	0	-
Neocrypta	1	1	0	1	0	0	-	5	3	2	0	1	1	0	0	1	2	0	-	0	1	1
Wombeyanus	0	1	0	1	0	0	-	2	3	2	0	1	1	0	0	1	2	1	0	0	1	1
Jasptorus	0	1	1	1	0	1	0	2	3	2	0	1	1	0	0	1	2	1	-	0	1	1
Uronyctus	1	1	1	1	0	1	0	2	0	0	0	1	1	0	1	1	1	1	0	0	1	1
Perthia	0	1	0	0	1	0	-	1	3	2	0	0	0	-	-	0	1	0	-	0	1	1

Table 6.6. (Continued).

	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
Gammarellus	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
Crangonyx	0	0	0	1	0	0	1	3	1	3	0	0	1	0	0	0	0	3	1	0	0	3
Sternophysinx	1	0	0	1	2	0	0	3	0	3	0	0	1	0	0	0	0	0	0	0	0	0
Phreatogammarus-a	2	0	0	1	1	0	3	2	3	2	0	0	0	0	0	0	0	0	1	0	0	0
Phreatogammarus-b	2	0	0	1	0	0	0	2	0	2	0	0	1	0	0	0	1	0	0	0	0	0
Austrogammarus	0	1	0	1	0	0	2	2	2	2	1	0	0	0	0	0	0	1	2	2	0	0
Austrocrangonyx	2	0	0	1	0	0	2	2	2	2	0	1	0	0	0	0	0	1	2	2	0	0
Antipodeus	0	0	1	1	0	0	0	2	0	2	0	0	0	0	0	0	0	2	1	1	0	0
Hurleya	2	0	1	1	2	0	3	1	?	?	0	0	0	0	1	0	1	0	0	0	0	0
Uroctena-a	2	0	0	1	2	0	2	2	3	1	0	0	0	0	1	0	0	2	1	0	0	0
Uroctena-b	2	0	0	1	2	0	2	2	3	1	0	0	0	0	1	0	0	2	1	1	0	0
Protocrangonyx	2	0	1	0	-	2	1	0	1	0	0	0	0	0	1	0	0	2	1	1	2	1
Giniphargus	1	0	1	0	-	1	?	?	2	2	0	0	0	0	1	0	1	3	2	2	0	1
Toulrabia	0	0	1	1	2	0	1	2	?	?	0	0	0	0	0	0	0	2	1	1	0	0
Chillagoe	2	0	1	1	2	0	0	0	?	?	0	0	1	0	0	0	0	2	1	1	0	0
Totgammarus	0	1	1	1	0	0	?	?	3	1	0	0	0	0	0	0	-	1	3	3	0	0
Pilbarus	0	0	1	1	2	0	2	2	2	2	1	0	0	0	0	0	0	1	2	2	0	0
Chydaekata	2	0	1	1	0	0	2	2	2	2	1	0	0	0	0	0	0	1	2	2	0	0
Molina	0	0	1	1	1	0	2	2	2	2	1	0	0	0	0	0	0	1	2	2	0	1
Paramelita	2	0	0	1	2	0	1	2	3	1	0	0	1	0	0	0	1	1	1	1	0	0
Neoniphargus-a	0	0	1	1	0	0	2	2	2	2	0	0	1	1	1	1	1	3	3	3	1	2
Neoniphargus-b	2	0	0	1	0	0	2	2	2	2	0	0	1	1	1	1	1	3	2	2	1	1
Tasniphargus	2	0	1	1	0	0	2	2	2	2	0	0	1	1	1	1	1	3	2	2	1	1
Wesniphargus-a	0	0	1	1	0	0	2	2	2	2	0	0	1	1	1	1	1	3	2	2	1	1
Wesniphargus-b	0	0	1	1	0	0	2	2	2	2	0	0	1	1	1	1	1	3	2	2	1	2
Yulia	0	0	1	1	0	0	1	2	1	2	0	0	1	1	1	1	1	3	2	2	1	1
Neocrypta	2	0	1	1	2	0	2	2	2	2	0	0	1	1	1	1	1	3	2	2	1	0
Wombeyanus	2	0	1	1	0	0	2	0	2	2	0	0	1	1	1	1	1	3	1	1	1	0
Jasptorus	2	0	1	1	2	0	2	2	1	2	0	0	1	1	1	1	1	3	1	1	1	0
Uronyctus	2	0	0	0	-	0	2	1	2	1	1	0	0	1	1	1	1	3	3	3	1	2
Perthia	0	0	0	1	0	0	0	2	0	2	0	0	1	0	0	0	0	4	1	1	0	1

Table 6.6. (Continued).

	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
Gammarellus	2	0	1	2	1	0	0	1	1	1	0	0	-	-	-	-	1	0	0	0	0	0
Crangonyx	0	0	0	3	1	1	0	2	1	1	0	1	1	?	-	-	2	0	1	1	1	2
Sternophysinx	0	0	1	1	0	0/1	0	1	0	-	1	1	0	1	2	?	0	1	?	?	?	1
Phreatogammarus-a	0	0	1	2	1	0	0	2	1	1	0	0	-	-	-	-	?	0	1	1	1	0
Phreatogammarus-b	0	0	0	0	0	1	0	1	1	1	0	1	0	1	2	3	0	1	2	2	2	0
Austrogammarus	1	1	1	2	0	0	0	2	1	1	0	1	0	0	-	-	1	1	1	1	1	2
Austrocrangonyx	2	1	1	2	1	0	0	2	1	0	0	1	0	0	-	-	1	1	0	1	0	2
Antipodeus	2	1	1	2	0	0	0	2	1	1	0	0	-	0	-	-	1	1	1	1	1	2
Hurleya	1	1	0	1	2	1	0	0	0	-	1	1	3	1	-	-	1	0	0	2	2	0
Uroctena-a	1	0	0	2	1	1	0	1	0	-	1	1	0	-	-	-	1	1	0	2	2	0
Uroctena-b	1	0	0	2	2	1	0	1	0	-	1	1	0	1	1	0	1	1	1	1	1	0
Protocrangonyx	1	1	1	1	2	0	0	0	0	-	1	1	2	1	-	-	2	0	1	1	1	0
Giniphargus	2	1	1	1	2	0	1	0	0	-	1	1	3	1	-	-	1	0	0	0	0	0
Toulrabia	1	1	1	2	1	1	0	2	0	-	1	1	3	0	-	-	1/2	0	1	1	1	0
Chillagoe	2	0	1	1	0	0	0	2	0	-	1	1	1	1	-	-	0	1	1	1	1	0
Totgammarus	0	1	1	2	0	1	0	2	1	0	0	1	0	1	-	-	1	1	1	1	1	1
Pilbarus	0	1	1	2	0	0	0	2	0	-	1	0	-	0	-	-	0	1	0	0	0	0
Chydaekata	1	1	0	2	1	0	0	2	0	-	1	1	3	0	-	-	1	1	0	0	0	2
Molina	2	1	1	2	1	1	0	2	1	1	0	1	0	0	-	-	1	1	0	0	0	2
Paramelita	2	0	1	1	1	1	0	2	1	0	0	1	0	?	-	-	1	1	0	0	0	0
Neoniphargus-a	1	0	1	2	2	0	0	2	1	0	0/1	1	1	0	1	0	1	1	1	1	1	2
Neoniphargus-b	1	0	0	2	1	0	0	2	0	-	1	1	1	0	2	1	1	1	1	1	1	2
Tasniphargus	1	0	1	2	2	0	0	1	0	-	1	1	1	0	1	0	1	1	1	1	1	2
Wesniphargus-a	1	0	1	3	2	0	0	2	0	-	1	1	1	0	2	0/1	1	1	1	1	1	2
Wesniphargus-b	1	0	0	3	3	0	0	-	0	-	1	1	1	0	3	1	1	1	0	0	0	2
Yulia	1	0	?	3	2	0	0	2	0	-	1	1	1	0	-	-	1	1	-	-	-	-
Neocrypta	1	0	0	2	1	0	0	1	0	-	1	1	1	1	1	0	3	1	1	1	1	0
Wombeyanus	1	0	0	2	1	0	0	1	0	-	1	1	1	0	1	0	1	1	1	1	1	1
Jasptorus	1	0	0	2	1	0	0	2	0	-	1	1	1	1	2	0	1	1	1	1	1	1
Uronyctus	1	0	0	1	2	1	0	1	1	0	0	1	3	0	1	?	1	1	1	1	1	1
Perthia	0	1	0	2	2	1	0	2	0	-	1	1	1	0	1	2	2	1	1	1	1	1

Table 6.6. (Continued).

	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109
Gammarellus	0	2	0	1	0	-	1	0	1	0	1	1	1	-	0	0	1	1	-	-	-
Crangonyx	0	2	0	0	0	-	1	1	0	0	2	0	1	-	1	2	0	0	1	0	1
Sternophysinx	0	0	0	3	0	-	1	1	1	1	1	0	0	0	-	2	0	1	0	2	?
Phreatogammarus-a	1	0	2	2	0	-	0	-	1	0	0	0	0	0	-	1	1	0	0	2	0
Phreatogammarus-b	1	0	1	2	0	-	1	0	1	0	2	0	0	2	-	1	0	0	?	?	0
Austrogammarus	0	0	1	1	1	1	1	2	1	1	0	0	0	0	-	1	1	0	-	-	0
Austrocrangonyx	0	0	1	1	1	1	1	2	1	1	0	0	0	0	-	3	1	0	-	-	0
Antipodeus	0	0	1	1	1	1	1	1	1	0	0	0	0	2	-	3	0	0	-	-	1
Hurleya	0	1	1	1	1	1	1	1	0	1	0	0	0	0	-	3	0	1	-	-	0
Uroctena-a	0	0	1	1	1	2	1	2	1	1	2	0	1	-	2	3	1	0	-	1	0
Uroctena-b	0	0	1	1	1	2	1	1	0	1	0	0	1	-	2	3	1	0	1	1	0
Protocrangonyx	0	1	1	0	0	-	1	1	1	0	0	0	0	0	-	0	0	1	-	-	0
Giniphargus	0	0	0	2	1	3	0	-	1	1	0	1	0	0	-	3	0	1	-	-	?
Toulrabia	0	0	1	1	0	-	1	2	0	0	0	0	0	0	-	3	1	0	-	-	0
Chillagoe	1	0	1	2	1	1	1	-	0	1	0	1	1	-	2	3	0	1	-	-	1
Totgammarus	0	0	1	1	1	1	1	0	1	1	1	1	1	-	2	1	1	0	-	-	?
Pilbarus	0	0	1	1	1	1	1	2	0	1	0	0	0	0	-	3	1	0	-	-	1
Chydaekata	0	0	1	1	1	1	1	2	0	1	0	1	0	2	-	3	0	1	-	-	0
Molina	0	0	1	1	1	1	1	2	0	1	0	0	0	2	-	3	1	0	-	-	0
Paramelita	0	1	1	1	1	1	1	1	1	1	0	0	0	0	-	1	1	0	-	-	0
Neoniphargus-a	0	0	1	0	1	1	1	1	1	0	1	1	1	-	2	3	1	1	2	0	0
Neoniphargus-b	0	0	1	1	1	1	1	1	0	0	2	1	1	-	3	3	0	1	1	0	1
Tasniphargus	0	0	1	2	1	1	1	1	1	0	2	1	1	-	2	3	0	1	2	1	1
Wesniphargus-a	0	0	1	1	1	1	1	2	1	0	2	1	1	-	2	3	0	1	2	1	0
Wesniphargus-b	0	0	1	1	1	1	1	2	1	1	1	1	0	2	-	3	1	1	2	1	1
Yulia	0	0	1	0	1	1	1	1	1	0	1	1	1	-	2	3	0	1	?	?	0
Neocrypta	0	0	1	2	1	1	1	1	1	1	1	1	0	2	-	2	1	1	2	1	1
Wombeyanus	0	0	1	3	1	1	1	1	1	0	1	1	0	2	-	3	0	1	2	0	1
Jasptorus	0	0	1	3	1	1	1	1	1	0	2	1	0	2	-	3	0	1	2	2	?
Uronyctus	0	0	1	2	1	3	0	-	1	1	2	0	1	-	1	3	0	0	2	0	?
Perthia	0	0	1	1	1	1	1	2	1	0	1	1	1	-	0	3	1	1	2	1	1

Table 6.6. (Continued).

Chapter 7

KEY TO THE FRESHWATER AMPHIPODA OF AUSTRALIA

Introduction

The absence of a comprehensive key to the species of Australian freshwater Amphipoda has diminished their usefulness as sensitive indicators of water quality. In an era of high demand for water for both domestic and industrial purposes, and concern over environmental effects of water extraction, there is a real need for species level information of amphipoda, which are often the major fauna of impacted water bodies. Possibly, the frequently cryptic nature of many amphipod species has contributed to a neglect of amphipod taxonomy (Williams and Barnard 1988). Nevertheless, knowledge of Australian freshwater Amphipoda has grown significantly since Williams (1968) published a key to Australian amphipod families, and Barnard and Barnard (1983), Williams and Barnard (1988) and Barnard and Williams (1995) published keys to known crangonyctoid taxa. Another key, (Horwitz *et al.* 1995), addressed only higher order taxa and is of little use when attempting to distinguish genera and species. The number of described Australian freshwater amphipod taxa has increased to over 100 species, the majority of which are Crangonyctoidea.

This key includes all presently described Australian freshwater Amphipoda as well as reference to some closely associated taxa, including Talitridae, and Bogidiellidae. The key is in two parts: a key to families, and a key to genera and species. A checklist of species is included, as well as illustrations of body parts used in the key (**Figs. 7.1 - 7.5**). [Cladistic analysis (Chapter 6) of the Australian crongonyctids showed Paramelitidae to be paraphyletic, placing the perthiids and neoniphargids into the sub families Perthiinae and Neonipharginae. These changes have not been included in the functional key, but are indicated in the checklist of species].

7.1 Key To Australian Freshwater Amphipod Families

1. Third uropod reduced, ramus, if present, minute; mandibles without palps **2**

   Third uropod prominent and biramous (with few exceptions), mandibles with palps **3**

2. First antenna larger than second .....**Ceinidae**

   First antenna smaller than second .....**Talitridae**

   (Land hoppers. Talitridae sometimes occur as accidentals in streams or littoral regions. Not included in this key)

3. Peduncle of uropod 1 bearing robust basofacial seta; antennae without calceoli; sternal gills absent; .....**Melitidae**

   Peduncle of uropod 1 without robust basofacial seta; antennae with or without calceoli, sternal gills present or absent (but where sternal gills absent, calceoli present) **4**

4. Rami of uropod 3 equal or subequal, undifferentiated (magniramous).....**5**

   Rami of uropod 3 unequal, differentiated (ie. dispariramous), inner ramus modified, reduced,sometimes absent **7**

5. Rami of uropod 3 cylindrical, gnathopod 1 distinctly larger than gnathopod 2 .....**Bogidiellidae**

   Rami of uropod 3 lanceolate, gnathopods subequal **6**

6. Urosomites 2-3 fused; dactylus of pereopod 7 elongate, longer than propodus, setose .....**Paracalliopiidae**

   Urosomites 2-3 separate; dactylus of pereopod 7 neither elongate nor setose .....**Eusiridae**

7. Telson entire; antenna 1 accessory flagellum absent ....**Corophiidae**

   Telson cleft or notched; antenna 1 accessory flagellum present, with 2 or more articles ...**(Crangonyctoidea) 8**

8. Gnathopod carpus cantilevered with propodus, sternal gills dendritic .....**Perthiidae**

Gnathopod carpus/propodus joint ordinary; sternal gills absent, simple, lumped or dendritic **9**

9. Sternal gills simple or absent, gnathopods without posterior distal rugosities .....**Paramelitidae**

Sternal gills simple, dendritic or lumpy, gnathopods with posterior distal rugosities ..... **Neoniphargidae**

7.2 Key To Genera And Species

7.2.1 Family Ceinidae

The widespread genus *Austrochiltonia* is the principal representative of this family. There is some dispute on the familial position of the genus; Barnard and Barnard (1983) placed the genus in the Ceinidae, whereas Zeidler (1991) recommended the family Hyalellidae as more appropriate on the basis of the form of the mandible, third uropod and telson. Two very similar, widespread, species, *A. australis* and *A. subtenuis*, have been recognised (Sayce 1901, 1902; Williams 1962), but some dispute the validity of this distinction, pointing out that they are often sympatric and can interbreed (Smith and Swain 1982). For the sake of completeness, and pending revision, both are included in this key. Another two taxa, *A. dalhousiensis* and *Phreatochiltonia anopthalma*, are described from Dalhousie Springs, South Australia (Zeidler, 1991, 1997).

1. Eyes absent; coxa 4 poorly excavate posteriorly; pereopod 4 distinctly longer than pereopod 5 .....***Phreatochiltonia anopthalma***

Eyes present; coxa 4 moderately to deeply excavate posteriorly; pereopod 4 shorter than pereopod 5 .....**2**

2 Third uropod without rami .....***Austrochiltonia subtenuis***
Third uropod uniramous **3**

3. Carpus of gnathopod 1 shorter than propodus, antennal flagellae of less than 10 articles .....***Austrochiltonia dalhousiensis***
Carpus of gnathopod 1 longer than propodus, antennal flagellae more than 10 articles .....***Austrochiltonia australis***

7.2.2 Melitidae

1. Lower lip bearing distinct inner lobes; **2**
Lower lip inner lobes absent or obsolescent; **11**

2 Third uropod outer ramus second article absent; telson setation strong with robust setae dorsally and apically .....***Nurina poulteri***
Third uropod outer ramus second article large, foliaceous; telson setation weak with few small apical setae and no dorsal setae **3**

3. Mandibular palp of three articles.....***Norcapensis mandibulis***
Mandibular palp reduced to two articles.....**4**

4. Second maxilla with sparse marginal basomedial pubescence on inner plate only, or no pubescence on either plate **5**
Second maxilla with moderate to dense marginal pubescence on both plates **7**

5. Pleonites without dorsal robust setae.....***Nedsia straskraba***
Pleonites with dorsal robust setae.....**6**

6. **E**pimera 1 without disto-lateral robust setae; peduncle of uropod 1 with a lateral row of short facial robust setae besides the basofacial and distal robust setae; palmar corner of gnathopod 1 rounded; outer plate of maxilliped tapering from base to apex and with weak medial cusps .....***Nedsia fragilis***

Epimera 1 with disto-lateral robust setae, peduncle of uropod 1 without facial robust setae besides basofacial and distal robust setae, palmar corner of gnathopod 1 sub-quadrate, outer plate of maxilliped not tapering, but rounded apically and with strong medial cusps.....***Nedsia humphreysi***

7. **P**osterior margins of pleon smooth, epimera without facial robust setae other than ventral sub-marginal robust setae.....**8**

Posterior margins of pleon sculptured into cusps, epimera with facial robust setae as well as ventral sub-marginal robust setae.....**10**

8. **U**rosomite 1 bearing a post-ventral spine at the base of the first uropod, rami of pleopods with more than six articles, maxillipedal palp article 3 without organised comb rows of setae at base of dactyl.....***Nedsia hurlberti***

Urosomite 1 without spine at base of uropod 1, rami of pleopods of less than 6 articles, maxillipedal palp article 3 bearing rows of comb setae basal to dactyl **9**

9. **C**oxa 1 with one or more anterior robust setae, without slender anterior setae; telson without dorsal setae; length of maxillipedal outer plate 2 x width .....***Nedsia urifimbriata***

Coxa 1 without anterior robust seta(s), with slender anterior setae; telson with dorsal setae; length of maxillipedal outer plate not more than 1.6 x width .....***Nedsia douglasi***

10. **P**ostero-lateral margins of pleonite 4 with robust setae, medial margin of outer plate of maxilliped rough, with 5 indentations...***Nedsia macrosculptilis***

Postero-lateral margins of pleonite 4 without robust setae, medial margin of outer plate of maxilliped smooth, with 4 indentations.....***Nedsia sculptilis***

11. Mandibular palp two articulate; propodus of first gnathopod without anterior or medial palmar humps; setae of antennae, pereopods, uropods and telson not plumose .....***Brachina invasa***

Mandibular palp three articulate; propodus of first gnathopod with anterior and medial palmar humps; plumose setae on antennae, pereopods, uropods and telson .....***Melita plumulosa***

7.2.3 Family Bogidiellidae

Hypogean or interstitial. One species is known; ***Bogidomma australis***. It is recorded from Barrow Island, Western Australia.

7.2.4 Family Paracalliopiidae

Represented by a single genus, *Paracalliope*; two inland aquatic species recorded from Tasmania.

1. Mandibular palp third article bearing 0-1 basofacial robust setae; uropod 1 outer ramus with 2 robust setae; epimeron 3 without robust setae .....***Paracalliope larai***

Mandibular palp third article bearing 3 basofacial robust setae; uropod 1 outer ramus with 0-1 robust seta; epimeron 3 with 3 robust setae .....***Paracalliope vicinus***

7.2.5 Family Eusiridae

Represented in Australian inland waters by two genera, *Pseudomoera* and *Paraleptamphopus*. The genus *Paraleptamphopus* is reported from Tasmania (Richardson, 1987), without specific identification; *Pseudomoera* is present as two species, both reasonably widespread in mainland south-eastern Australia.

1. Telson entire .....***Paraleptamphopus***

Telson cleft **2**

2. First maxilla inner plate medial margin oblique, bearing medial setae .....***Pseudomoera fontana***

First maxilla inner plate bearing only terminal setae....***Pseudomoera gabrieli***

7.2.6 Family Corophiidae

This family is represented by one known species, ***Paracorophium brisbanensis*** Chapman, 2002, from the Brisbane River. This species, formerly defined as *P. excavatum* (Thomson, 1884), was reviewed and redescribed by Chapman (2002). Further records of occurrence of this family are reported by Taylor (2002). She recorded specimens of Corophiidae, apparently close to *P. excavatum*, from a number of South Australian sites, including the Bremer River, Reedy Creek, Tod River, Lake Frome outlet drain, George Creek, and Lake Bonney in the south east of the state. Whether this species can be regarded as truly freshwater is debatable. Lake Bonney is of increasingly high salinity (6000-9300µS/cm in 2002), and, like Tod River and Lake Frome outlet, has close connections to the sea. The other sites, whilst now flowing into the artificially fresh Lake Alexandrina, were once connected to the sea via the Murray River mouth.

7.2.7 Superfamily Crangonyctoidea

This superfamily, represented also in the Holarctic, but dominantly Nearctic, is the most widespread and significant of Australian freshwater amphipod groups, and is thought to have dispersed from Pangea via Notogean fresh waters (Barnard and Barnard 1983). Three Australian families are recognised, two endemic to Australia. All are species derived from ancient pre-Gondwanan stock, and are restricted to those areas of the continent not inundated by the sea during the Cretaceous, often where cool waters are found. They are most numerous in Tasmania and the highlands of the south-east and the cool, wet south-west, but do occur as relict species in underground waters in warmer areas. Among the three families, Perthiidae have been described from Western Australia but are recorded from other regions, whereas Neoniphargidae and Paramelitidae occur in Tasmania, Victoria,

New South Wales and Western Australia, with a few specialised members elsewhere.

7.2.7.1 Family Perthiidae

There is only one known genus of the family, *Perthia*, with two species found in south-western Western Australia.

1. Uropod 3 parviramous, inner ramus short; telson without dorsal robust setae; merus and carpus of pereopods 3-7 with long setae.....***Perthia branchialis***
   Uropod 3 variramous, inner ramus long; telson with dorsal robust setae; merus and carpus of pereopods 3-7 without long setae....***Perthia acutitelson***

7.2.7.2 Family Paramelitidae

The family Paramelitidae is represented in Australia by thirteen genera, of which eight are monospecific: *Chillagoe*, from Chillagoe caves, Queensland, *Giniphargus*, from Gippsland, Victoria, *Hurleya*, *Protocrangonyx*, *Totgammarus* and *Toulrabia* from south western Australia, and *Pilbarus* and *Molina* from north western Autralia. Of the other genera, *Austrogammarus* is widespread across south eastern Australia, *Austrocrangonyx* is found around the Barrington Tops in New South Wales, *Antipodeus* is restricted to Tasmania, and *Uroctena* to south western Australia.

1. Sternal gills absent **2**
   Sternal gills present and simple.....**8**

2. Mandibular palp article 1 much longer than wide, article 2 with few setae, article 3 without A setae .....***Pilbarus millsi***
   Mandibular palp article 1 about as long as wide, article 2 moderately setose, article 3 bearing A setae. .....***(Antipodeus)*** **3**

3. Posterior setae on article 2 of pereopods 5-7 long; long setae present on articles 2-6 of pereopods 5-7; coxae 1-3 with long ventral setae .....***Antipodeus niger***

Posterior setae on article 2 of pereopods 5-7 short; long setae absent on articles 2-6 of pereopods 5-7; coxae 1-3 with only short ventral setae.....**4**

4. Ventral setae of antennae 1-2 long and dense; telson very short, apical setae absent **5**

Ventral setae on antennae 1-2 short to long and sparse to numerous (but never long and dense); telson not very short, with apical setae **6**

5. Gnathopods sexually dimorphic - male palm notched; article 6 of pereopods 3-4 with evenly spaced robust sets of setae; rami of uropods 1-2 with long marginal and apical robust setae.....***Antipodeus wellingtoni***

Gnathopods not sexually dimorphic; article 6 of pereopods 3-4 with unevenly spaced robust sets of setae; rami of uropods 1-2 with short marginal and apical robust setae .....***Antipodeus ripensis***

6. Article 2 of mandibular palp only slightly longer than article 3; gnathopods not sexually dimorphic; telson cleft 100 percent.....***Antipodeus mortoni***

Article 2 of mandibular palp distinctly longer than article 3; gnathopods sexually dimorphic; telson cleft about 70 percent **7**

7 Ventral setae on antennae 1-2 short and numerous; calceoli absent on male antenna 2; basodactylar robust setae and setae of pereopods 5-7 short; setae on article 2 of mandibular palp mostly short.....***Antipodeus antipodeus***

Ventral setae on antennae 1-2 long and sparse; calceoli present on male antenna 2; basodactylar robust setae and setae of pereopods 5-7 long; setae on article 2 of mandibular palp mostly long.....***Antipodeus franklini***

8. Telson entire .....***Protocrangonyx fontinalis***

Telson cleft **9**

9. Coxa 1 tapering distally; some dactyls of pereopods 3-7 multispinous .....***Totgammarus eximius***

Coxa 1 not tapering distally; pereopods 3-7 dactyls not multispinous.....**10**

10. Inner ramus of uropod 3 moderately elongate (approximately equal to or greater than 0.5x outer ramus, vari- or magniramous) **11**

Inner ramus of uropod 3 short (generally less than 0.5x outer ramus, parviramous) or absent **22**

11. Sternal gills present on sternites 2-7 .....**12**

Sternal gills present on sternites 6-7 .....(***Chydaekata***) **32**

12. Mandibular palp article three bearing ABDE setae.....(***Austrogammarus***) **13**

Mandibular palp article three bearing DE setae.....***Molina pleobranchos***

13. Uropod 3: extending equally with uropods 1-2 in intact specimen.....**14**

Uropod 3: extending moderately beyond uropods 1-2 in intact specimen...**16**

Uropod 3: much longer than uropods 1-2 in intact specimen .....***Austrogammarus robbins***

14. Head: eyes present.....**15**

Head: eyes absent.....***Austrogammarus telsosetosus***

15. Head: eyes round.....***Austrogammarus australis***

Head: eyes ovate.....***Austrogammarus smithi***

16. Gnathopod 2: propodus subrectangular.....**17**

Gnathopod 2: propodus trapezoidal.....**19**

17. Antenna 1: long(approximately 50% of body length).***Austrogammarus dovel***

Antenna 1: very long(approximately 70% of body length).....**18**

18. Antenna 2: slender, similar to antenna 1.....***Austrogammarus saycei***

Antenna 2: robust, tending pediform.....***Austrogammarus pegarah***

19. Pereopod 3: propodus with no or one robust seta in posterior sets.....**20**
Pereopod 3: propodus with more than one robust seta in posterior sets.....**21**

20. Antenna 1: with few setae.....***Austrogammarus spinatus***
Antenna 1: with moderate numbers of setae.....***Austrogammarus haasei***

21. Gnathopod 1: with no recumbent inner tooth spine
.....***Austrogammarus multispinatus***
Gnathopod 1: with single recumbent inner tooth spine
.....***Austrogammarus badgerhill***

22. Inner ramus of uropod 3 absent or minute, less than 0.1x length of outer ramus **23**
Inner ramus of uropod 3 present, 0.1x or more than length of outer ramus
.....**24**

23. Gnathopods small, gnathopod 2 smaller than gnathopod 1; antenna 2 tending pediform; antenna 1 accessory flagellum 4 articles; body vermiform
.....***Giniphargus pulchellus***
Gnathopods large, subequal; antenna 2 normal; antenna 1 accessory flagellum 2 articles; body not vermiform .....***Chillagoe thea***

24. Article 2 of outer ramus of uropod 3 large; 0.4x or more length of article one
.....***Uroctena*** **25**
Article 2 of outer ramus of uropod 3 absent or short, less than 0.4x length of article one **29**

25. Antennae 1-2 densely setose, setae long and drooping; telson cleft 50%; gnathopods of both sexes bearing long anterior setae on carpus and propodus, article 2 of male gnathopod 2 lacking robust setae .....***Uroctena setosa***

Antennae 1-2 poorly setose, setae short and stiff; telson cleft 75+ percent; gnathopods of both sexes lacking long anterior setae on carpus and propodus, article 2 of male gnathopod 2 with robust setae.....**26**

26. Article 2 of male gnathopod 2 with stout anterior robust setae **27**

Article 2 of male gnathopod 2 with thin anterior robust setae or setae.....**28**

27. Article 2 of male gnathopod 2 with 4 sets (3-4 each) of post lateral robust setae .....***Uroctena affinis***

Article 2 of male gnathopod 2 with 2 sets (2 each) of post lateral robust setae .....***Uroctena whadjukia***

28. Article 2 of male gnathopod 2 with about 10-14 lateral robust setae; eyes absent .....***Uroctena westralis***

(and young of *U. affinis*)

Article 2 of male gnathopod 2 with about 6-8 lateral robust setae; eyes well-developed, but white .....***Uroctena yellandi***

(and young of *U. affinis*)

29. Coxal gill 7 present .....***Austrocrangonyx* 30**

Coxal gill 7 absent **31**

30. Hyaline hump on article 4 of gnathopod 1 obvious; dominant robust seta number in sets of article 6 of pereopods 3-4 = 2 .....***Austrocrangonyx barringtonensis***

Hyaline hump on article 4 of gnathopod 1 weak; dominant robust seta number in sets of article 6 of pereopods 3-4 = 1 .....***Austrocrangonyx hynesi***

31. Third uropod outer ramus with small second article; mandibular palp article three lacking C setae .....***Hurleya kalamundae***

Third uropod outer ramus without second article; mandibular palp article three bearing C setae .....***Toulrabia willsi***

32. Left first maxilla inner plate subtriangular, facially and medially setose (pubescent); first antenna accessory flagellum articles uniform.....**33**

Left first maxilla inner plate ovate, facially, but not medially, setose (pubescent); first antenna accessory flagellum articles variable .....***Chydaekata ovatosetosus***

33. Third epimeron: posterior margin straight **34**

Third epimeron: posterior margin sinuous **37**

Third epimeron: posterior margin convex **39**

Third epimeron: posterior margin concave **40**

34. Second antenna: peduncle length greater than flagellum **35**

Second antenna: peduncle length subequal to flagellum **36**

Second antenna: peduncle length less than flagellum .....***Chydaekata brachybasis***

35. First gnathopod dactyl not reaching to palmar corner; second gnathopod dactyl not reaching to palmar corner .....***Chydaekata breviclavus***

First gnathopod dactyl reaching to palmar corner; second gnathopod dactyl reaching to palmar corner .....***Chydaekata simulatum***

First gnathopod dactyl reaching beyond palmar corner; second gnathopod dactyl reaching beyond palmar corner ....***Chydaekata dolichodactylus***

36. First gnathopod palmar angle weakly oblique; left mandible molar without pappose seta; maxilliped palp third article naked laterally .....***Chydaekata transversi***

First gnathopod palmar angle oblique; left mandible molar bearing pappose seta; maxilliped palp third article sparsely setose laterally .....***Chydaekata diagonalis***

37. Third uropod longer than U1-2 in intact specimen; maxilliped inner plate bearing a row of submarginal pappose setae only, palp third article sparsely setose laterally **38**

Third uropod not extending beyond U1-2 in intact specimen; maxilliped inner plate bearing a row of submarginal to subapical pappose setae, palp third article naked laterally .....***Chydaekata nudulum***

38. Second antenna peduncle length greater than flagellum; second gnathopod large; second epimeron posteroventral corner acuminate .....***Chydaekata acuminatum***

Second antenna peduncle length less than flagellum; second gnathopod moderate size; second epimeron posteroventral corner rounded .....***Chydaekata gyraspis***

Second antenna peduncle length subequal to flagellum; second gnathopod small; second epimeron posteroventral corner subquadrate .....***Chydaekata tetraspis***

39. Maxilliped inner plate with a row of submarginal pappose setae; left mandible molar bearing pappose seta, and bearing penicillate hooked brushy basal setae .....***Chydaekata scopula***

Maxilliped inner plate with a row of submarginal to subapical pappose setae; left mandible molar without pappose seta and without penicillate hooked brushy basal setae .....***Chydaekata anophelma***

40. Left mandible molar bearing pappose seta; second antenna article 4 shorter than article 5; right mandible without penicillate hooked brushy basal setae .....***Chydaekata scuticari***

Left mandible molar without pappose seta; second antenna article 4 subequal with article 5; right mandible bearing penicillate hooked brushy basal setae: .....***Chydaekata carscuticum***

7.2.7.3 Family Neoniphargidae

This family consists of eight genera: *Neoniphargus*, the largest, with ten species from New South Wales, Victoria and Tasmania; *Wesniphargus* with two species from Western Australia; *Neocrypta* with six species from caves in New South Wales, and five monospecific genera: *Jasptorus solepti* and *Wombeyanus botellus* from caves in New South Wales, *Tasniphargus tyleri* and *Yulia yuli* from Tasmania, and *Uronyctus longicaudus* from South Australia.

1. Sternal gills simple (sausage shaped) **2**
Sternal gills dendritic or bearing lumps **9**

2. Gnathopods 1-2, ischium, merus and propodus, but not carpus, bearing rugose posterior keels .....***Uronyctus longicaudatus***
Gnathopods 1-2 carpus and propodus bearing rugose posterior keels.....**3**

3. Telson cleft 50% .....***Wombeyanus botulosus***
Telson cleft less than 25% .....(***Neocrypta***) **4**

4. Flagellum of second antenna of 4 articles **5**
Flagellum of second antenna of 5-8 articles **7**

5. Length of first antenna 0.4x body length .....***Neocrypta robinae***
Length of first antenna 0.5 or more x body length **6**

6. Outer rami of pleopods of 2 or 3 articles .....***Neocrypta simoni***
Outer rami of pleopods of 6 articles .....***Neocrypta annae***

7. Gnathopod 2 bearing facial rugosities ...***Neocrypta georginae***
Gnathopod 2 without facial rugosities **8**

8. Pereopods 5-7 article two moderately expanded posteriorly, ovate, margins convex .....***Neocrypta primaris***

Pereopods 5-7 article two slightly expanded posteriorly, sub rectangular, margins almost straight to concave .....***Neocrypta moniae***

9. Sternal gills bearing lumps **10**

Sternal gills dendritic **12**

10. Propodi of gnathopods expanded apically at palmar corner; third uropod outer ramus first article cylindrical, elongate, length 4x peduncle; plumose setae absent from both rami .....***Jasptorus solepti***

Propodi of gnathopods not apically expanded at palmar corner; third uropod outer ramus first article foliaceous, length 2x peduncle, medial plumose setae present on both rami .....(***Wesniphargus***) **11**

11. Propodi of gnathopods bearing posterior rugosities; pereopod 5 moderately setate with few robust setae; carpus and propodus of pereopod 6 strongly setose; coxa four apically ovate; inner ramus of third uropod extending to M0.7 of article 1 of outer ramus

.....***Wesniphargus yanchepensis***

Propodi of gnathopods without posterior rugosities; pereopod 5 bearing few setae and numerous robust setae; carpus and propodus of pereopod 6 without setae; coxa four apically sub-quadrate; inner ramus of third uropod extending to less than M0.4 of article 1 of outer ramus

.....***Wesniphargus nichollsi***

12. Antennae 1-2 with long dense setae, basal articles of primary flagella on antennae 1-2 elongate (conjoint) .....***Tasniphargus tyleri***

Antennae 1-2 with short sparse setae, basal articles of primary flagella on antenna 1-2 short **13**

13. Pleopod peduncles strongly setose, outer ramus of uropod 1 with long apical spur in male .....***Yulia yuli***

Pleopod peduncles not strongly setose, outer ramus of uropod 1 without long apical spur in male .....(***Neoniphargus***) **14**

14. Dactyls of pereopods 3-7 multispinose on inner margin; uropod 3 inner ramus wit h 2-3 apical robust setae; posterior lobes of coxae 5-7 with strong setae **15**

Dactyls of pereopods 3-7 not multispinose on inner margin; uropod 3 inner ramus with 0-1 apical robust seta; posterior lobes of coxae 5-7 with weak setae **16**

15. Third uropod inner ramus with a single, naked apical seta; epimera without post-ventral teeth; telson longer than broad, cleft 77%; outer plate of first maxilla bearing 9 denticulate robust setae; antenna 1 accessory flagellum extending beyond first article of primary flagellum .....***Neoniphargus coolemanensis***

Third uropod inner ramus with 2-3 apical setae, one of which is sparsely plumose; epimera with small post-ventral teeth; telson no longer than broad, cleft 56%; outer plate of first maxilla bearing seven denticulate robust setae; antenna 1 accessory flagellum not extending beyond first article of primary flagellum .....***Neoniphargus spenceri***

16. Gnathopods sexually dimorphic (male palms notched); coxa 4 not deeply emarginate in males; robust setae on outer ramus of proximal article uropod 3 arranged singly .....***Neoniphargus tasmanicus***

Gnathopods not sexually dimorphic (male palms not notched); coxa 4 deeply emarginate in males; robust setae on outer ramus of proximal article uropod 3 arranged in multiples **17**

17. Uropod 3 not extending beyond uropods 1-2; robust setae on uropods 1-2 long .....***Neoniphargus thomsoni***

Uropod 3 extending beyond uropods 1-2; robust setae on uropods 1-2 short or medium sized **18**

18. Calceoli present on both antennae 1-2 in males; medial margin of outer ramus of proximal article of uropod 3 with several plumose setae in male .....***Neoniphargus fultoni***

Calceoli not present on antenna 1 (sometimes in antenna 2) in males; medial margin of outer ramus proximal article of uropod 3 without several plumose setae in male **19**

19. Antenna 2 without calceoli in males; long setae present on posterior margins of propodi of pereopods 5-7 .....***Neoniphargus alpinus***

Antenna 2 with calceoli in males; long setae lacking on posterior margins or propodi of pereopods 5-7 .....**20**

20. Uropod 3 peduncle with very long apicomedial robust seta (spur) in male, outer ramus of third uropod less than 2x peduncle; telson cleft 70%; eyes large .....***Neoniphargus exiguus***

Uropod 3 peduncle with only short apicomedial robust seta in male, outer ramus of third uropod 2-3x peduncle; telson cleft less than 70%; eyes vestigial or absent **21**

21. Eyes vestigial; outer plate of maxilla 1 bearing 7 denticulate robust setae; posterior lobes of coxae 5-7 without robust setae; outer ramus of third uropod 2x length of peduncle; telson cleft 60%, each lobe bearing 2 lateral robust setae .....***Neoniphargus obrieni***

Eyes absent; outer plate maxilla 1 bearing 5 or 9 denticulate robust setae; posterior lobes of coxae 5-7 with 1-2 robust setae; outer ramus of third uropod 3x length of peduncle; telson cleft 50% or less, lobes without lateral setation **22**

22. **O**uter plate of maxilla 1 bearing 9 denticulate robust setae; peduncle of uropod 1 bearing medial robust setae; telson as long as third urosomite, cleft 40%, with 3 apical robust setae on each lobe ....***Neoniphargus secus***

Outer plate of maxilla 1 bearing 5 denticulate robust setae; peduncles of uropod 1 without medial robust setae; telson shorter than third urosomite, cleft 50%, with 1 apical robust seta on each lobe.....***Neoniphargus richardi***

7.3 Checklist of Australian Freshwater Amphipoda

Corophiidae

Paracorophium brisbanensis Chapman 2002 - Brisbane R. Qld.

Ceinidae

Austrochiltonia australis (Sayce 1901) - widespread

Austrochiltonia subtenuis (Sayce 1902) - widespread

Austrochiltonia dalhousiensis Zeidler 1997 - Dalhousie Springs, S.A.

Phreatochiltonia anopthalma Zeidler 1991 - Dalhousie Springs, S.A.

Eusiridae

Paraleptamphopus sp. (Stebbing, 1899) - Tas.

Pseudomoera fontana (Sayce, 1902) - Woods Point, Vic.

Pseudomoera gabrieli (Sayce, 1901) - Dandenong Rng. and Gippsland, Vic.

Paracalliopiidae

Paracalliope larai Knott 1975 - Tas.

Paracalliope vicinus, Barnard and Drummond, 1992 - Tas. King Is., S. Vic.

Melitidae

Nedsia douglasi Barnard and Williams 1995 - N. West Cape, W.A.

Nedsia straskraba Bradbury and Williams 1996 - Barrow Is. W.A.

Nedsia fragilis Bradbury and Williams 1996 - Barrow Is. W.A.

Nedsia humphreysi Bradbury and Williams 1996 - Barrow Is. W.A.

Nedsia hurlberti Bradbury and Williams 1996 - Barrow Is. W.A.

Nedsia urifimbriata Bradbury and Williams 1996 - Barrow Is. W.A.

Nedsia macrosculptilis Bradbury and Williams 1996 - Barrow Is. W.A.

Nedsia sculptilis Bradbury and Williams 1996 - Barrow Is. W.A.

Norcapensis mandibulis Bradbury and Williams 1997 - N. West Cape, W.A.

Brachina invasa Barnard and Williams 1995 - Flinders Rng., S.A.

Melita plumulosa Zeidler 1988 - coastal N.S.W.

Nurina poulteri Bradbury and Eberhard 2000 - Roe Plain, Nullarbor Plain, W.A.

Bogidiellidae

Bogidomma australis Bradbury and Williams 1996 - Barrow Is. W.A.

Crangonyctoidea

Paramelitidae

(Austrogammarinae)

Austrogammarus australis (Sayce, 1901) - Dandenong Rng., Vic.

Austrogammarus smithi Williams and Barnard 1988 - Magnet Ck. Tas.

Austrogammarus haasei (Sayce, 1901) - Dandenong Rng. Vic.

Austrogammarus saycei Williams and Barnard 1988 - Dandenong Rng., Vic.

Austrogammarus spinatus Williams and Barnard 1988 - Dandenong Rng, Vic.

Austrogammarus multispinatus Williams and Barnard 1988 - Dandenong Rng. Vic.

Austrogammarus telsosetosus Barnard and Williams 1995 - L. Bonney, S.A.

Austrogammarus badgerhill n.sp.Flinders Island, Bass Strait, Tasmania

Austrogammarus pegarah n. sp. King Island, Bass Strait, Tasmania

Austrogammarus robbins n. sp. King Island, Bass Strait, Tasmania

Austrogammarus dovel near Dove Lake, Tasmania

Austrocrangonyx barringtonensis (Chilton, 1916) - Barrington Top, N.S.W.

Austrocrangonyx hynesi Williams and Barnard 1988 - Barrington Top,N.S.W

Antipodeus antipodeus (G.W.Smith, 1909) - Mole Ck.,Tas.

Antipodeus wellingtoni (G.W.Smith, 1909) - Mt. Wellington, Tas.

Antipodeus niger (G.W.Smith, 1909 - Hartz Mts. Tas.

Antipodeus ripensis (G.W.Smith, 1909) - Great Lake, Tas.

Antipodeus mortoni (Thomson, 1893) - Huon R. Valley, Tas.

Antipodeus franklini Williams and Barnard 1988 - Huon R. Valley, Tas.

Totgammarus eximius Bradbury and Williams 1995 - South West, W.A.

(Unplaced)

Hurleya kalamundae Straskraba, 1966 - Kalamunda, W.A.

Uroctena affinis Nicholls, 1926c - nr. Perth, W.A.

Uroctena westralis (Chilton, 1925) - nr. Perth, W.A.

Uroctena setosa Nicholls, 1926c - Katanning and nr. Perth, W.A.

Uroctena yellandi Nicholls, 1926d - south of Armadale, nr. Perth, W.A.

Uroctena whadjukia Barnard and Williams 1995 - Wungong System, W.A.

Giniphargus pulchellus (Sayce, 1899) - Thorpdale, Gippsland, Vic.

Protocrangonyx fontinalis Nicholls, 1926a - Darling Rng. W.A.

Toulrabia willsi Barnard and Williams 1995 - Stirling Rng. W.A.

Chillagoe thea Barnard and Williams 1995 - Chillagoe Caves, Qld.

Pilbarus millsi Bradbury and Williams, 1997b - Millstream, Pilbara, W.A.

Chydaekata acuminatum Bradbury 2000 - Pilbara, W.A.

Chydaekata nudulum Bradbury 2000 - Pilbara, W.A.

Chydaekata dolichodactylus Bradbury 2000 - Pilbara, W.A.

Chydaekata breviclavus Bradbury 2000 - Pilbara, W.A.

Chydaekata transversi Bradbury 2000 - Pilbara, W.A.

Chydaekata diagonalis Bradbury 2000 - Pilbara, W.A.

Chydaekata carscuticum Bradbury 2000 - Pilbara, W.A.

Chydaekata gyraspis Bradbury 2000 - Pilbara, W.A.

Chydaekata simulatum Bradbury 2000 - Pilbara, W.A.

Chydaekata tetraspis Bradbury 2000 - Pilbara, W.A.

Chydaekata ovatosetosus Bradbury 2000 - Pilbara, W.A.

Chydaekata anophelma Bradbury 2000 - Pilbara, W.A.

Chydaekata scopula Bradbury 2000 - Pilbara, W.A.

Chydaekata scuticari Bradbury 2000 - Pilbara, W.A.

Chydaekata brachybasis Bradbury 2000 - Pilbara, W.A.

Molina pleobranchon Bradbury 2000 - Pilbara, W.A.

Neonipharginae

Tasniphargus tyleri Williams and Barnard 1988 - Great Lake, Tas.

Neoniphargus thomsoni Stebbing, 1899 - Mt. Wellington, Tas.

Neoniphargus spenceri (Sayce, 1901) - Plenty Range. Vic.

Neoniphargus fultoni Sayce, 1902 - Warburton, Vic.

Neoniphargus obrieni Nicholls, 1926b - Mt. Buffalo, Vic.

Neoniphargus alpinus G.W.Smith, 1909 - Mt. Read, Tas.

Neoniphargus exiguus G.W.Smith, 1909 - nr. Kingston, Tas.

Neoniphargus tasmanicus G.W.Smith, 1909 - Great Lake, Tas.

Neoniphargus coolemanensis Bradbury and Williams, 1997b - Murray Cv. N.S.W.

Neoniphargus secus Bradbury and Williams, 1997b - Gurungah Cv. N.S.W.

Neoniphargus richardi Bradbury and Williams, 1997b - River Cv. N.S.W.

Wesniphargus nichollsi (Straskraba, 1964) - Cannington, W.A.

Wesniphargus yanchepensis Bradbury and Williams, 1997b - Yanchep Cv. W.A.

Neocrypta primaris Bradbury and Williams, 1997b - Limekiln Cv. N.S.W.

Neocrypta robinae Bradbury and Williams, 1997b - Diprotodon Cv. N.S.W.

Neocrypta moniae Bradbury and Williams, 1997b - Bowan Park Cv N.S.W.

Neocrypta georginae Bradbury and Williams, 1997b - AppleTreeCv.N.S.W.

Neocrypta annae Bradbury and Williams, 1997b - Bowan Park Cv. N.S.W.

Neocrypta simoni Bradbury and Williams, 1997b - Paradox Cv. N.S.W.

Wombeyanus botulosus Bradbury and Williams, 1997b - Bullio Cv. N.S.W.

Jasptorus solepti Bradbury and Williams, 1997b - Wee Jasper Cv. N.S.W.

Uronyctus longicaudus Stock & Iliffe, 1990 - Mt. Gambier area, S.A.

Yulia yuli (G.W.Smith, 1909) - Yules Lake, Tas.

Perthiinae

Perthia branchialis (Nicholls, 1924) - South West W.A.

Perthia acutitelson Straškraba, 1964 - South West W.A.

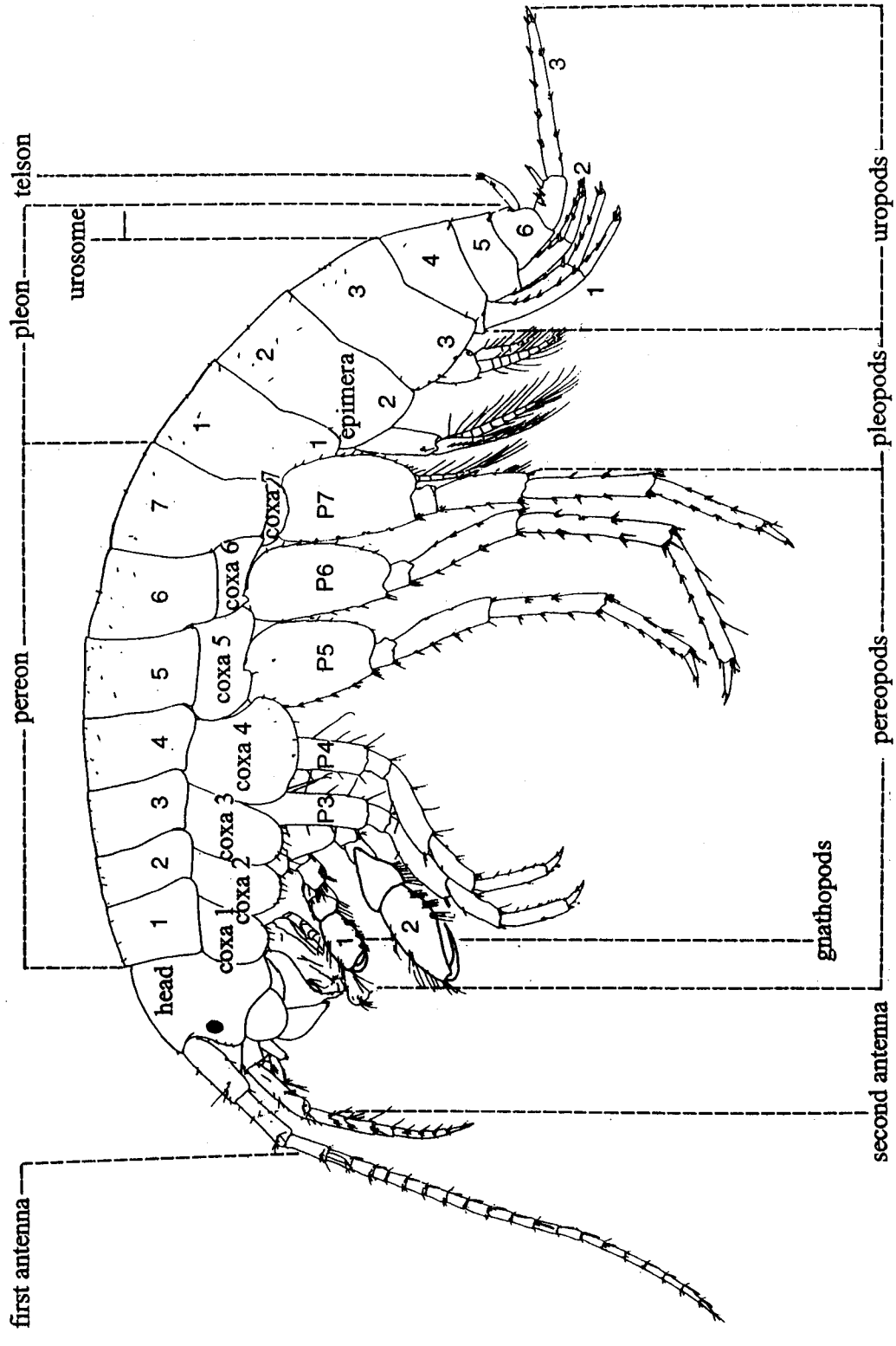

Fig. 7.1. Generalised amphipod showing principal body-parts.

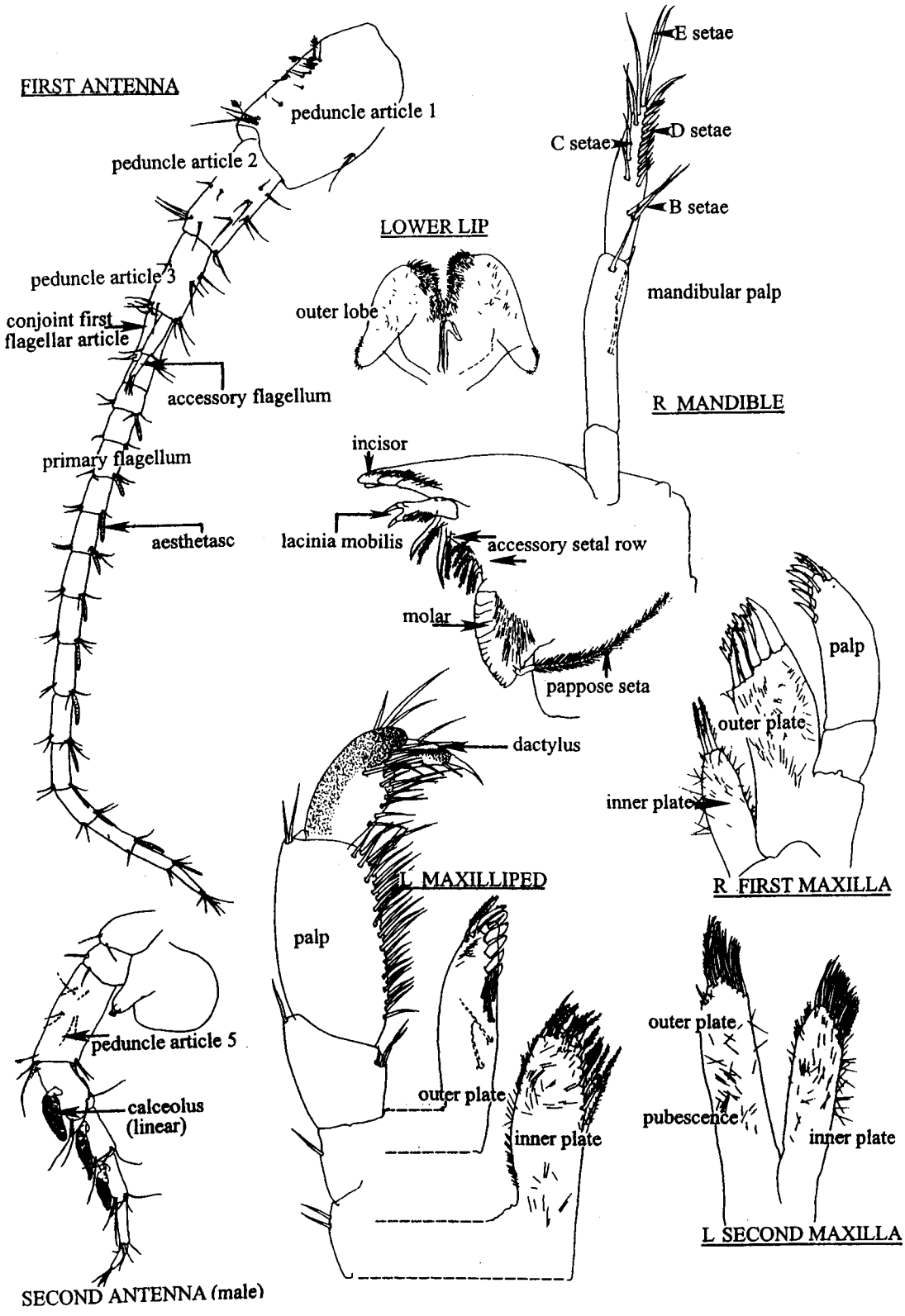

Fig. 7.2. Parts of the head: antennae; lower lip (labium), mandible, first and second maxilla and maxilliped.

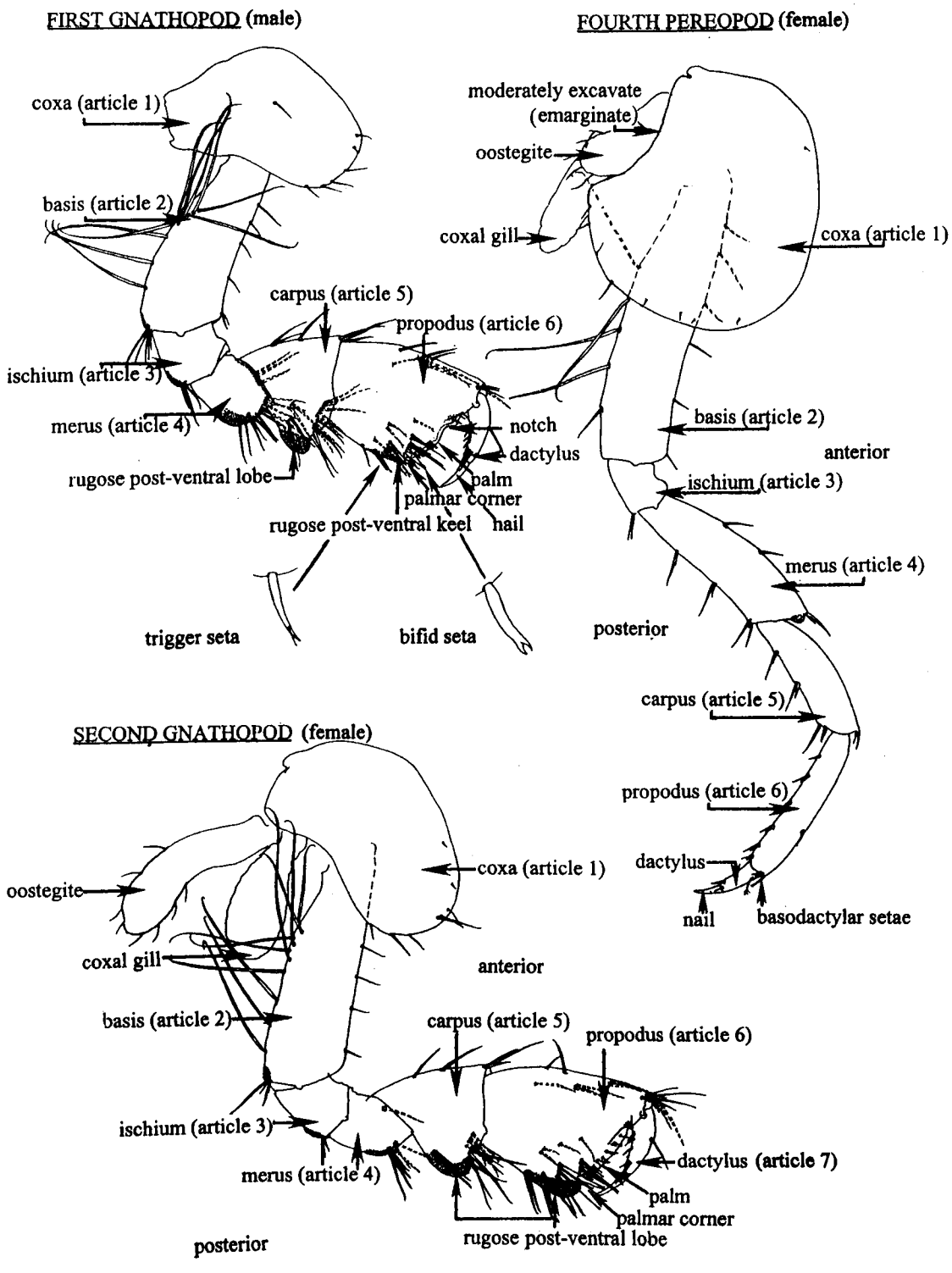

Fig. 7.3. Pereopods: first and second gnathopod, fourth pereopod.

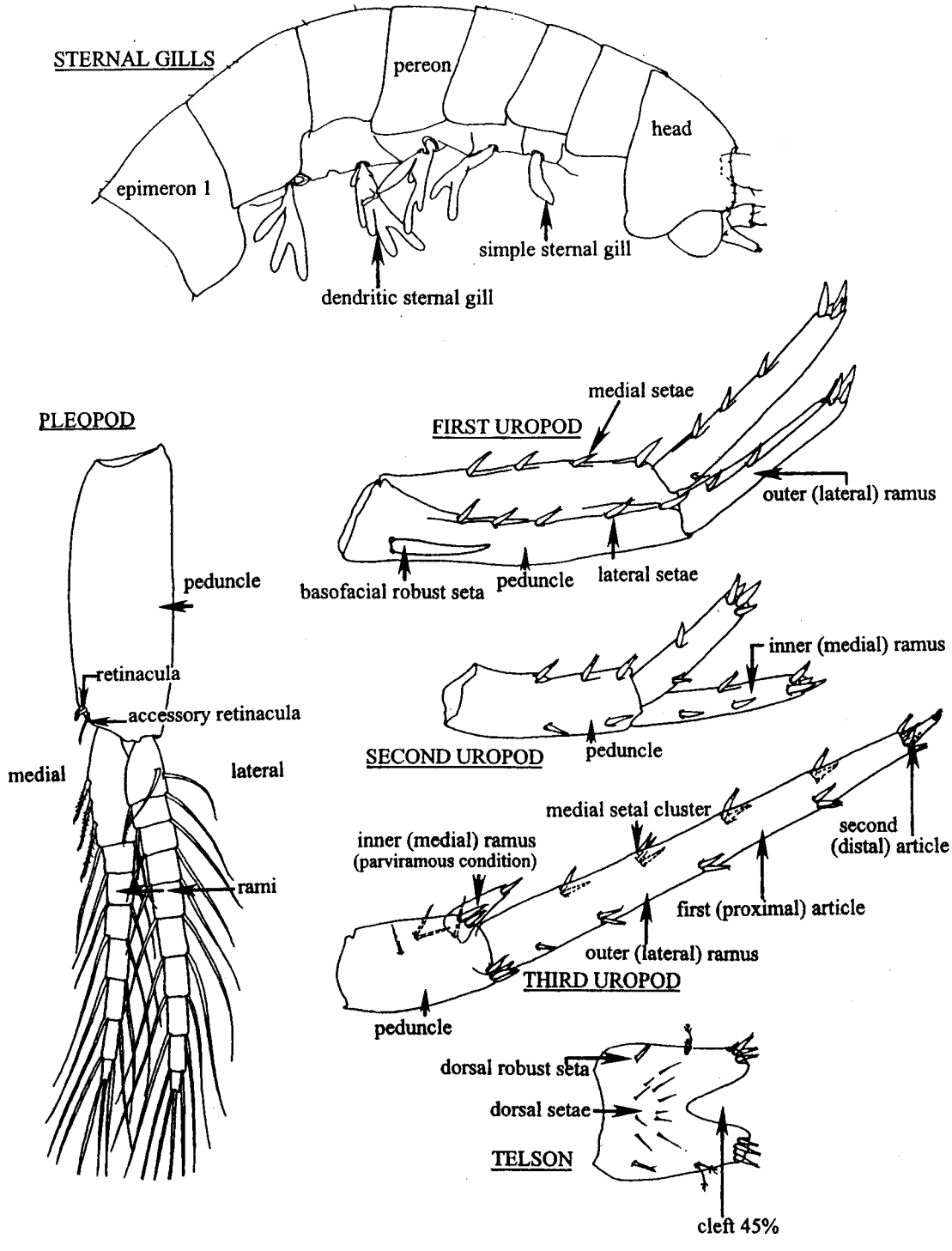

Fig. 7.4. Sternal gills; pleopod; first, second and third uropods; telson.

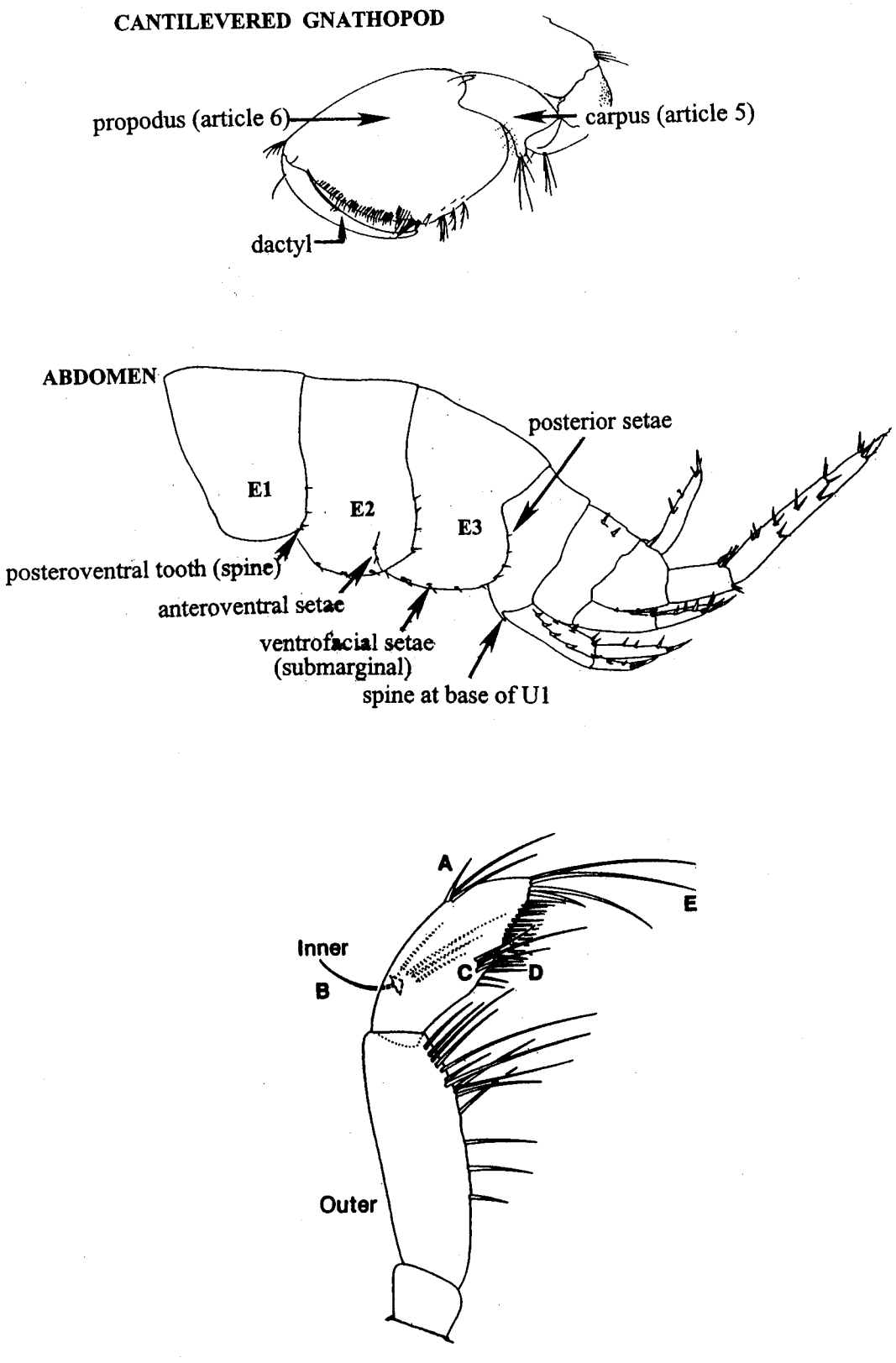

Fig. 7.5. Cantilevered first or second gnathopod, abdomen indicating epimera, stylised mandibular palp indicating setal nomenclature.

Chapter 8

Conclusion

The number of freshwater Australian Amphipoda is demonstrably much greater than recorded, and new taxa described here nearly equal the previously known number of species of this fauna. The majority of new species are crangonyctoids, reinforcing the pattern already recognised by Williams and Barnard (1988) that these strictly freshwater animals of ancient lineage are the principal Amphipoda of Australian fresh waters. They are found only in fresh waters of regions free of marine inundation since before the Late Cretaceous. Distribution of species is not, however, altogether as predicted by Barnard and Barnard (1983), Williams and Barnard (1988) and Barnard and Williams (1995). While epigean species are tied to cool southern climes and alpine regions, the majority of new species, which are stygobionts, are tropical or subtropical, inhabiting regions previously regarded as largely devoid of Amphipoda. These stygobiont species rely upon the permanence, and perhaps also thermal stability, of underground waters in an otherwise hostile environment, only rarely occurring as epigeans where upwelling forces them to the surface.

The other main group of freshwater Amphipoda is the Melitidae. All are stygobionts, some tropical, and these are relatively recent inhabitants of fresh waters, having been stranded in, or invaded regions of marine inundation of the Late Cretaceous.

Interestingly, the restricted occurrences and separations of the two major elements of the Australian amphipod freshwater fauna reflect the global pattern of distribution of these two principal amphipod groups (Holsinger 1986a, b, 1993, 1994a; Notenboom 1986).

The stygobiont amphipod fauna of Australia is seen to be extensive, contrary to predictions (Williams 1986), largely tropical, and is perhaps as diverse as in any comparable region (Humphreys 1993 a, b, c). However, stygobiont species, whilst

the only representatives of freshwater Amphipoda in tropical Australia, are not a feature only of tropical regions. Underground waters of temperate regions, too, are occupied by Amphipoda such as *Hurleya*, *Perthia* and *Nurina* in Western Australia, *Neoniphargus*, *Neocrypta* and *Jasptorus* in New South Wales, *Uronyctus* in South Australia, and *Antipodeus* and *Neoniphargus* in Tasmania.

The family structure of the Australian Crangonyctoidea (plus *Paramelita* of South Africa) has been revised. Cladistic analysis indicated the Paramelitidae (to be) paraphyletic. The Neoniphargidae and Perthiidae form clades within the Paramelitidae, and are thus lowered in rank to sub-family status. The sub-families Paramelitinae, Neonipharginae and Perthiinae are created. The monogeneric Perthiinae is maintained as new taxa are known, although not described.

The Key to species and checklist of species is particularly intended to assist identification of Amphipoda collected in the course of environmental studies. Increasingly, utilisation of ground water by mining and agriculture has led to environmental compliance requirements of species maintenance and water quality.

The extent of freshwater Australian Amphipoda remaining undescribed is significant. Williams and Barnard (1988) considered the Neonipharginae the dominant taxon, yet their studies did not include new material of that group, although some new neoniphargid taxa have been described here. Collections which include the Tasmania endemic *Antipodeus*, which has been shown highly specious, and Neonipharginae, which occupies high alpine habitat, remain largely undescribed. In New South Wales and Victoria also Neonipharginae are frequent inhabitants of alpine regions, and many are yet to be analysed, as well as new species of *Austrocrangonyx* from New South Wales. Collections of stygobiont Amphipoda are proceeding in the Pilbara of Western Australia in conjunction with mining environmental surveys, and these are revealing many new species both of the Paramelitinae and Melitidae. Similarly, surveys in the Yilgarn craton region of central Western Australia have collected new Crangonyctoidea and Ceinidae, as well as Bogidiellidae. Recent surveys in the Flinders Ranges of South Australia have collected new Melitidae as well as Ceinidae. Finally, new Perthiinae are known from South Australia as well as from New South Wales and Victoria; animals which have yet to be described.

BIBLIOGRAPHY

Avise, J. C. (1994). Molecular markers, Natural History and Evolution. Chapman and Hall, New York.

Ayala, F. J. (1982). Population and Evolutionary Genetics: a Primer. The Benjamin Cummings Publishing Company, Inc.: Menlo Park, California.

Barnard, J. L. (1969). The families and genera of marine gammaridean Amphipoda. *United States National Museum Bulletin* **271**: 1-535.

Barnard, J. L (1972a). Gammaridean Amphipoda of Australia, Part 1. *Smithsonian Contributions to Zoology* Number **103**. Smithsonian Institution Press, Washington. pp. 333.

Barnard, J. L. (1972b). The marine fauna of New Zealand: algae living littoral Gammaridea (Crustacea, Amphipoda). *New Zealand Oceanographic Institute Memoirs* **62**: 7-216.

Barnard, J.L. (1980). Australia as a major evolutionary centre for Amphipoda. Int. Conf. on Crustacea, May 19-21, 1980, Sydney.

Barnard, J. L. and Barnard, C. M. (1983). Freshwater amphipoda of the world. I. Evolutionary patterns. II. Handbook and bibliography. *Hayfield Associates,* M t.Vernon, Virginia. pp. 1-830.

Barnard, J. L. and M. M. Drummond (1992). *Paracalliope*, a genus of Australian shorelines (Crustacea: Amphipoda: Paracalliopiidae). *Memoirs of the Museum of Victoria* **53**(1): 1-29.

Barnard J. L. and G. S. Karaman (1982). Classificatory revisions in gammaridean amphipoda (Crustacea), part 2. *Proceedings of the Biological Society of Washington* **95**: 167-187.

Barnard, J. L. and G. S. Karaman (1983). Australia as a major evolutionary centre for Amphipoda (Crustacea). *Memoirs of the Australian Museum* **18**: 45-61.

Barnard, J. L. and G. S. Karaman (1991). The families and genera of marine Gammaridean Amphipoda. Part 1. *Records of the Australian Museum Supplement* **13**:1-866.

Barnard, J. L. and W. D. Williams (1995). The Taxonomy of Amphipoda (Crustacea) from Australian fresh waters, Part 2. *Records of the Australian Museum* **47**(2): 161-201.

Barr, T. C., and Holsinger, J. R. (1985). Speciation in cave faunas. *Annual Review of Ecology and Systematics* **16**: 313-337.

Baverstock, P. R. , C. H. S. Watts, M. Adams and M. Gelder (1980). Chromosomal and Electrophoretic studies of Australian *Melomys* (Rodentia: Muridae). *Australian Journal of Zoology* **28**: 553-574.

Baverstock, P. R. , C. H. S. Watts and S. R. Cole (1977). Electrophoretic comparisons between allopatric populations of five Australian Pseudomyine Rodents (Muridae). *Australian Journal of Biological Science* **30**: 471-485.

Belles, X. (1992). From dragons to allozymes: a brief account on the history of biospeleology. **In**: A. I. Camacho (Ed.). The natural history of biospeleology. Monografias, Museo Nacional de Ciencias Naturalles, Madrid.

Blockwell, S. J., S. J. Maund and D. Pascoe (1999). Effects of the organochlorine insecticide lindane (gamma -C6H6Cl6) on the population responses of the freshwater amphipod *Hyalella azteca*. *Environmental Toxicology and Chemistry*. **18**: 1264-1269.

Bousfield, E. L. (1973). Shallow water gammaridean amphipoda of New England. Cornell University Press, Ithaca, New York. Pp. 1-312.

Bousfield, E.L. (1977). A new look at the systematics of gammaroidean amphipoda of the world. *Crustaceana, Supplement* **4**:282-316.

Bousfield, E. L. (1978). A revised classification and phylogeny of amphipod crustaceans. *Transactions of the Royal Society of Canada* **4**:343-390.

Bousfield, E. L. (1982a). Amphipoda. Gammaridea. **In** S. P. Parker (Ed.) Synopsis and classification of living organisms: 254-285. (McGraw-Hill, New York).

Bousfield, E. L. (1982b). Amphipoda (Palaeohistory). **In** McGraw-Hill yearbook of science and technology for 1982-1983. Pp. 96-100. McGraw-Hill Book Co. New York.

Bousfield, E. L. (1983). An updated phylogenetic classification and palaeohistory of the Amphipoda. **In** F. R. Schramm (Ed.) Crustacean phylogeny: 257-278. (Balkema, Rotterdam).

Bradbury, J. H. (1999). The systematics and distribution of Australian freshwater amphipods: a review. **In** Schram, Frederick R. and J. Carel von Vaupel Kline, (Eds.). *Crustaceans and the Biodiversity Crisis. Proceedings of the Fourth International Crustacean Congress, Amsterdam, The Netherlands, July 20-24, 1998.* Brill, Leiden.

Bradbury, J. H. (2000). Western Australian Stygobiont Amphipods (Crustacea: Paramelitidae) from the Mt. Newman and Millstream Regions. *Records of the Western Australian Museum,* Supplement No. **60**: 1-101.

Bradbury, J. H. (2002). Melitid amphipods of Barrow Island, Western Australia Part II - recent discoveries. *Records of the Western Australian Museum* **21**: 83-103.

Bradbury, J. H. and S. M. Eberhard (2000). A new stygobiont melitid amphipod from the Nullarbor Plain. *Records of the Western Australian Museum* **20**: 39-50.

Bradbury, J. H., and W. D. Williams (1995). A new genus and species of crangonyctoid amphipod (Crustacea) from Western Australian fresh waters. *Transactions of the Royal Society of South Australia* **119**(2): 67-74.

Bradbury, J. H., and W. D. Williams (1996 a). Freshwater amphipods from Barrow Island, Western Australia. *Records of the Australian Museum*, **48**: 33-74.

Bradbury, J. H., and W. D. Williams (1996 b). Two new species of anchialine amphipods (Crustacea, Hadziidae, *Liagoceradocus*) from Barrow Island, Western Australia. *Records of the Western Australian Museum* **17**: 395-409.

Bradbury, J. H. and W. D. Williams (1997a). Amphipod (Crustacea) diversity in underground waters of Australia: an Aladdin's Cave. *Memoirs of the Museum of Victoria* **56**(2): 513-519.

Bradbury, J. H. and W. D. Williams (1997b). The amphipod (Crustacea) stygofauna of Australia: description of new taxa (Melitidae, Neoniphargidae. Paramelitidae), and a synopsis of known species. *Records of the Australian Museum* **49**: 249-341.

Bradbury, J. H. and W. D. Williams (1999). Key to and checklist of the freshwater amphipods of Australia. *Australian Museum, Technical Reports No.* 14.

Bradbury, M. R., J. H. Bradbury and W. D. Williams (1998). Scanning electron microscope studies of rugosities, cuticular microstructures of taxonomic significance of the Australian amphipod family Neoniphargidae (Amphipoda). *Crustaceana* **71**(6): 603-614.

Camacho, A. I., E. Bello, J. M. Becerra and I. Vaticon (1992). A natural history of the subterranean environment and its associated fauna. Chapter 6, pp 171-197, **In**: A. I. Camacho (Ed.). The natural history of biospeleology. Monografias, Museo Nacional de Ciencias Naturalles, Madrid.

Chapman, M. A. (2002). Australasian species of *Paracorophium* (Crustacea: Amphipoda): the separate identities of *P. excavatum* (Thomson 1884) and *P.brisbanensis* sp. nov. *Journal of the Royal Society of New Zealand* **32** (2): 203-228.

Chilton, C. (1916). Some Amphipoda and Isopoda from Barrington Tops (4600 ft. alt.). *Journal and Proceedings of the Royal Society of New South Wales* **50**: 82-98.

Chilton, C. (1925). A new blind freshwater amphipod (genus Neoniphargus) from Western Australia. *Journal of the Royal Society of Western Australia* **11**(9): 81-85.

Clarke, A. (1997). Management prescriptions for Tasmania's cave fauna. Report to the Tasmanian Regional Forest Agreement Environment and Heritage Technical Committee.

Crane, M., C. Attwood, D. Sheahan and S. Morris (1999). Toxicity and bioavailability of the organophosphorus insecticide pirimiphos methyl to the freshwater amphipod Gammarus pulex L. in laboratory and mesocosm systems. *Environmental Toxicology and Chemistry* **18**: 1456-1461.

Culver, D. C. (1982). Cave Life. Evolution and Ecology. Harvard University Press, Cambridge, Mass.

Culver, D.C., T.C. Kane and D.W. Fong (1995). Adaptation and Natural Selection in Caves. The Evolution of *Gammarus minus*. Harvard University Press, Cambridge, Massachusetts.

Dallwitz, M. J. (1980). A general system for coding taxonomic descriptions. *Taxon* **29**: 41-6.

Dallwitz, M. J., T. A. Paine and E. J. Zurcher (1993). Delta user's guide. Fourth Edn. *CSIRO* East Melbourne.

Dana, J. D. (1849). Synopsis of the genera of Gammaracea. *American Journal of Sciences and Arts*, Series 2, **8**: 135-140.

Danielopol, D. (1980). An essay to assess the age of the freshwater interstitial ostracods of Europe. *Bijdr. Dierk.* **50**(2): 243-291.

Davies, J. L. (1974). Geomorphology and Quaternary Environments pp17-27 **In**: W. D. Williams (Ed.) Biogeography and Ecology in Tasmania. Junk, The Hague.

Eberhard, S. M. (2001). Cave fauna monitoring and management at Ida Bay, Tasmania. **In** Humphreys, W. F. and Harvey, M. S. (Eds.) Subterranean Biology in Australia 2000. *Records of the Western Australian Museum.* Supplement No. **64**.

Eberhard, S. M., A.M. M. Richardson and R. Swain (1991). The invertebrate cave fauna of Tasmania: 174 (Department of Zoology, University of Tasmania, Hobart).

Eberhard, S. M. and A. Spate (1995). Cave invertebrate survey: toward an atlas of New South Wales cave fauna: 1-112. (Department of Urban Affairs and Planning and the Australian Heritage Commission).

Felgenhauer, B.E. (1987). Techniques for preparing crustaceans for scanning electron microscopy. *Journal of Crustacean Biology* 7(1): 71-76.

Fish, S. (1972). The setae of *Eurydice pulchra* (Crustacea, Isopoda). *Journal of Zoology*, London, **166**: 163-167

Fong, D. W. (1989). Morphological evolution of the amphipod *Gammarus minus* in caves: Quantitative genetic analysis. *American Midland Naturalist* **121**: 361-378.

France, S. C. (1994). Genetic population structure and gene flow among deep sea amphipods, *Abyssorchomene* spp., from six California Continental Borderland basins. *Marine Biology* **118**: 67-77.

Halcrow, K. and E. L. Bousfield (1987). Scanning electron microscopy of surface microstructures of some gammaridan amphipod crustaceans. *Journal of Crustacean Biology* 7(2): 274-287

Hamilton-Smith, E. (2001). Maintenance of karst biodiversity, with an emphasis upon Australian populations. **In** Humphreys, W. F. and Harvey, M. S. (Eds.) Subterranean Biology in Australia 2000. *Records of the Western Australian Museum*. Supplement No. 64.

Hansen, B., M. Adams, T. Krasnicki and A. M. M. Richardson (2001). Substantial allozyme diversity in the freshwater crayfish *Parastacoides tasmanicus* supports extensive cryptic speciation. *Invertebrate Taxonomy* **15**: 667-679.

Hebert, P. D. N. and M. J. Beaton (1993). Methodologies for allozyme analysis using cellulose acetate electrophoresis. Helena Laboratories, Beaumont, Texas.

Hebert, P. D. N. and C. C. Wilson (2000). Diversity of the genus *Daphniopsis* in the saline waters of Australia. *Canadian Journal of Zoology* **78**: 794-808.

Hillis, D. M. , B. K. Mable and C. Moritz (1996). Applications of molecular systematics. **In** 'Molecular systematics'. (Eds. D. M. Hillis, C. Moritz and B. K. Mable.) Sinauer Associates, Sunderland.

Holsinger, J. R. (1977). A review of the systematics of the Holarctic amphipod family Crangonyctidae. *Crustaceana* **4**: 244-281.

Holsinger, J.R. (1982). Amphipoda, **In** Aquatic biota of Mexico, Central America and the West Indies, S.H.Hurlbert and A. Villaboos-Figuera, eds. pp.209-214. San Diego State University, San Diego, California.

Holsinger, J. R. (1983). Biodiversity of subterranean amphipod crustaceans: global patterns and zoogeographic implications. *Journal of Natural History* **27**: 821-835.

Holsinger, J. R. (1986a). Holarctic crangonyctid amphipods, p. 535-549. **In**: L. Botosaneanu (Ed.). Stygofauna Mundi. E. J. Brill, Leiden.

Holsinger, J. R. (1986b). Zoogeographic patterns of North American subterranean amphipod crustaceans. **In**: R. H. Gore and K. L. Heck (Eds.). Crustacean biogeography. Crustacean Issues **4**: 85-106. Balkema, Rotterdam.

Holsinger, J. R. (1988). Troglobites: the evolution of cave dwelling organisms. *American Scientist* **76**: 146-153.

Holsinger, J. R. (1991). What can vicariance biogeographic models tell us about the distributional history of subterranean amphipods? *Hydrobiologia* **223**: 43-45.

Holsinger, J. R. (1992). Sternophysingidae, a new family of subterranean amphipods (Gammaridea: Crnagonyctoidea) from South Africa, with description of *Sternophysinx calceola*, new species, and comments on phylogenetic and biogeographic relationships. *Texas Memoirs of the Museum of Speleology Monograph* **3**: 1-22.

Holsinger, J. R. (1993). Biodiversity of subterranean amphipod crustaceans: global patterns and zoogeographic implications. *Journal of Natural History* **27**: 821-835.

Holsinger, J. R. (1994a). Pattern and process in the biogeography of subterranean amphipods. *Hydrobiologia* **287**: 131-145.

Holsinger, J. R. (1994b). Amphipoda. **In** C. Juberthie and V. Decou (eds). Encyclopaedia Biospeologica **1**: 147-163. Societé Biospéologie.

Horwitz, P. (1988). The faunal assemblage (or pholeteros) of some freshwater crayfish burrows in Southwest Tasmania. *Bulletin of the Australian Society of Limnol*ogy **12**: 29-36.

Horwitz, P., M. Adams and P. Baverstock (1990). Electrophoretic contributions to the systematics of the freshwater crayfish genus *Engaeus* Ericson (Decapoda, Parasticidae). *Invertebrate Taxonomy* **4**: 615-641.

Horwitz, P., B. Knott and W. D. Williams (1995). A preliminary key to the malacostracan families (Crustacea) found in Australian inland waters. Co-operative Research Centre for Freshwater Ecology Identification Guide No. 4. Murray Darling Freshwater Research Centre, Albury. 31pp.

Humphreys, W. F. (1991). The cave fauna of Cape Range: specific analyses. *Unpublished report to the Australian Heritage Commission and the Western Australian Heritage Committee.* 178pp.

Humphreys, W. F. (1993a). Cave fauna in semi-arid tropical Western Australia: a diverse relict wet-forest litter fauna. *Mémoires de Biospéologie* **20**: 105-110.

Humphreys, W. F. (1993b). Stygofauna in semi-arid tropical Western Australia: a Tethyan connection? *Mémoires de Biospéologie* **20**: 111-116.

Humphreys, W. F. (Ed.) (1993c). The biogeography of Cape Range, Western Australia. *Records of the Western Australian Museum Supplement* **45**: 1-248.

Humphreys, W. F. (1995). Limestone of the east Kimberly, Western Australia karst and cave fauna. Report to the Australian Heritage Commission and to the Western Australian Heritage Committee. 190 pp. Unpublished.

Humphreys, W. F. (1999). Relict stygofauna living in sea salt, karst and calcrete habitats in arid north western Australia contain many ancient lineages. **In** 'The other 99%. The Conservation and Biodiversity of Invertebrates' 219-27. Eds. Winston Ponder and Daniel Lunney, 1999. *Transactions of the Linnean Society of New South Wales*, Mossman.

Humphreys, W. F. (2000). The hypogean fauna of the Cape range peninsula and Barrow Island, north-west Australia. **In** Wilkens, H., Culver, D. C. , and Humphreys, W. F. (Eds.). Ecosystems of the world, Vol. 30. Subterranean Ecosystems: 581-601. Elsevier, Amsterdam.

Humphreys, W. F. and M. Adams (1991). The subterranean fauna of the North West Cape peninsula, Western Australia. *Records of the Western Australian Museum Supplement* **15**: 383-411.

Ingersoll, C. G. Ivey, C. D. Brunson, E. L. Hardesty, D. K. Kemble, N. E. (2000). Evaluation of toxicity: whole-sediment versus overlying-water exposures with amphipod *Hyalella azteca*. *Environmental Toxicology and Chemistry* **19**: 2906-2910.

Jacques, F., (1989). The setal system of crustaceans: Types of setae, groupings, and functional morphology. **In** B. E. Felgenhauer, L. Watling and A. B. Thistle (Eds.), Functional morphology of feeding and grooming in Crustacea - Crustacean Issues **6**: 1-13.

James, J.M., G. Pilkington, P. Rogers and A. Spate (1991). The Nullarbor carbonate aquifer, Australia: the impact of man and suggestions for future management. *Proceedings of the International Conference on Envrionmental Changes in Karst Areas. I.G.U. - I.G.S., Italy, 15-27 September, 1991: Quaderni del Dipartimento di Geografia n. 13, 1991 - University di Padova*: 205-214.

Jasinska, E.J., B. Knott and A. J. McComb (1996). Root mats in ground water: a fauna-rich habitat. *Journal of the North American Benthological Society* **15** (4): 508-519.

Jennings, J. N. (1985). Karst Geomorphology. Blackwell, Oxford.

Kane, T., and D.C. Culver (1992). Biological process in space and time: Analysis of adaptation. **In** A.I.Comacho (Ed.) The Natural History of Biospeleology, 377-399. Monografia del Museo Nacional de Ciencias Naturales, Madrid.

Karaman, G. S. (1969). XXII Beitrag zur Kenntnis der Amphipoden. Über einige Formen des Genus *Sarathrogammarus* (Gammaridae) aus Afghanistan. *Acta Musei Macedonici scientiarum Naturalium* Skopje **11** (11): 195-208.

Kaufmann, R.S., (1994). Structure and function of chemoreceptors in scavenging lysianassoid amphipods. *Journal of Crustacean Biology* **14**(1): 54-71

Knott, B. (1975). A new species of freshwater amphipod *Paracalliope larai*, (Family Eusiridae) from Tasmania. *Papers and Proceedings, Royal Society Tasmania* **109**: 39-52.

Knott, B. (1983). Amphipods from Nurina Cave - Nullabor Plain. Australian Speleological Federation Newsletter **101**: 3-4.

Knott, B. (1985). Australian aquatic cavernicolous amphipods. Paper presented to the 15th biennial conference Australian Speleological Federation, Hobart. pp. 1-11.

Knott, B. (1993). Stygofauna of Cape Range Peninsula, Western Australia: Tethyan relicts. *Records of the Western Australian Museum*, Supplement No. **45**: 109-127.

Koenemann, S. and J. R. Holsinger (1999). Phylogenetic analysis of the amphipod family Bogidiellidae S. Lat., and revision of taxa above the species level. *Crustaceana* **72**(8): 781-816.

Lake, P. S. (1977). Pholeteros - the faunal assemblage found in crayfish burrows. *Australian Society of Limnology Newsletter* **15**: 57-60.

Leight, A. K. and R. F. van. Dolah (1999). Acute toxicity of the insecticides endosulfan, chlorpyrifos, and malathion to the epibenthic estuarine amphipod Gammarus palustris (Bousfield). *Environmental Toxicology and Chemistry*.. **18**(5): 958-964.

Lincoln, R.J. (1985). Morphology of a calceolus, an antennal receptor of gammaridean Amphipoda (Crustacea). *Journal of Natural History*, London **19**: 921-927.

Lincoln, R.J. and D.E. Hurley (1981). The calceolus, a sensory structure of gammaridean amphipods (Amphipoda: Gammaridea). *Bulletin of the British Museum of Natural History (Zool.)* **40**(4):103-116.

Maddison, W. (1990). A method for testing the correlated evolution of two binary characters: are gains or losses concentrated on certain branches of a phylogenetic tree? *Evolution* **44**: 539-557.

Maddison, W. P. and D. R. Maddison (2001). MacClade Version 4.03. Sinauer Associates, Sunderland.

Marshall, C. R., E. C. Raff and R. A. Raff, (1994). Dollo's law and the death and resurrection of genes. *Proceedings of the National Academy of Science, U.S.A.* **91**:12283-12287.

Marzio, W. D., M. E. di. Saenz J. L. Alberdi and M. C. Tortorelli (1999). Assessment of the toxicity of stabilized sludges using Hyalella curvispina. *Bulletin of Environmental Contamination and Toxicology* **63**, 654-659.

Mathews, P. G. (Ed.) (1985). Australian Karst Index. Australian Speleological Federation Inc., Melbourne.

Mayr, E. (1969). Principles of systematic zoology. McGraw-Hill, New York.

Nebeker, A. V. and G. S. Schuytema (1998). Chronic effects of the herbicide diuron on freshwater cladocerans, amphipods, midges, minnows, worms, and snails. *Archives of Environmental Contamination and Toxicology* **35**: 3, 441-446.

Nei, M. (1978). Estimation of average heterozygosity and genetic distance from a small number of individuals. *Genetics* **89**: 583-590.

Nicholls, G. E. (1924). *Neoniphargus branchialis*, a new freshwater amphipod from south-western Australia. *Journal of the Royal Society of Western Australia* **10**: 105-111.

Nicholls, G. E. (1926a). *Protocrangonyx fontinalis*, a new blind freshwater amphipod from Western Australia. *Journal of the Royal Society of Western Australia* **12**: 71-78.

Nicholls, G. E. (1926b). *Neoniphargus obrieni*, a new species of blind amphipod from Victoria. *Journal of the Royal Society of Western Australia* **12:** 79-86

Nicholls, G. E. (1926c). Description of a new genus and two new species of blind freshwater amphipods from Western Australia. *Journal of the Royal Society of Western Australia* **12**: 105-111.

Nicholls, G. E. (1926d). Description of a new species of *Uroctena* from south-western Australia. *Journal of the Royal Society of Western Australia* **12**: 113-116.

Notenboom, J. (1986). Marine regressions and the evolution of groundwater dwelling amphipods (Crustacea). *Bijdragen tot de Dierkunde* **56**(1): 1-25.

Oshel, P. E. and D. H. Steele (1988). Comparative morphology of amphipod setae, and a proposed classification of setal types. *Crustaceana, (Suppl.)* **13**: 90-99.

Oshel, P. E., V. J. Steele, and D. H. Steele (1988). Comparative SEM morphology of amphipod microtrich sensilla. *Crustaceana, (Suppl.)* **13**: 100-106.

Paine, A. G. L. (Ed.) (1990). Australia. Evolution of a Continent. Australian Government Publishing Service, Canberra.

Platvoet, D. (1985). Side-line organ in gammarids (Crustacea, Amphipoda). *Beaufortia*, **35**(7): 129-133.

Pleijel, F. (1995). On character coding for phylogenetic reconstruction. *Cladistics* **11**: 309-315.

Plenet, S. (1999). Metal accumulation by an epigean and a hypogean freshwater amphipod: considerations for water quality assessment. *Water Environment Research*, **71**: 1298-1309.

Ponder, W. F., G. A. Clarke, A. C. Miller and A. Toluzzi (1993). On a major radiation of freshwater snails in Tasmania and Eastern Victoria: a preliminary overview of the *Beddomeia* group (Mollusca, Gastropoda, Hydrobeiidae). *Invertebrate Taxonomy*, **7**(3):501-750.

Read, A. T. and D. D. Williams (1991). The distribution, external morphology, and presumptive function of the surface microstructures of *Gammarus pseudolimnaeus* (Crustacea: Amphipoda), with emphasis on the calceolus. *Canadian Journal of Zoology* **69**: 853-865.

Richards, A. M. (1971). An ecological study of the cavernicolous fauna of the Nullarbor Plain Southern Australia. *Journal of Zoology, London* **164**: 1-60.

Richardson, B. J., P. R. Baverstock and M. Adams (1986). Allozyme electrophoresis: A handbook for animal systematics and population studies. Academic Press, Sydney.

* Addendum - see page 592.

Ride, W. D. L., C. W. Sabrowski, G. Bernardi and R. V. Melville (1985). International Code of Zoological Nomenclature Edn. 3. University of California Press, Berkeley.

Rouse, G. W. and K. Fauchald (1997). Cladistics and polychaetes. *Zoologica Scripta* **26**: 139-204.

Sayce, O.A. (1899). Art. XVII.- *Niphargus pulchellus*, a new Victorian blind amphipod. *Proceedings of the Royal Society of Victoria* (n.s.) **12:** 152-159.

Sayce, O.A. (1901). Art. XVII - Description of some new Victorian freshwater Amphipoda. *Proceedings of the Royal Society of Victoria* (n.s.) **13**: 225-242.

Sayce, O.A. (1902). Art. VI - Description of some new Victorian freshwater Amphipoda, No. 2. *Proceedings of the Royal Society of Victoria* (n.s.) **15**: 47-58.

Schellenberg, A. (1937a). Die amphipodengattengun um *Crangonyx*, ihre Verbreitung und ihre Arten. *Mitteilungen aus dem Zoologischen Museum in Berlin.* **22**: 31-44.

Schellenberg, A. (1937b). Kritische Bemerkungen zur Systematik der Susswassergammariden. *Zoologische Jarbucher, Abteilung für Systematik* **69**: 469-516.

Smith, A. G. and J. C. Briden (1976). Mesozoic and Cenozoic paleocontinental maps. Cambridge earth sciences series. Cambridge University Press, Cambridge.

Smith, G. W. (1909a). The freshwater Crustacea of Tasmania, with remarks on their geographical distribution. *Transactions of the Linnean Society of London* (2, Zoology) **11**: 61-92.

Smith, G. W. (1909b). A naturalist in Tasmania. Clarendon Press, Oxford, London.

Smith, S. J. and R. Swain (1982). Observations on the taxonomy of *Austrochiltonia* (Hurley) (Amphipoda: Ceinidae). *Bulletin of the Australian Society of Limnology* **8**: 39-43.

Sneath, P. H. A. and R. R. Sokal (1973). *Numerical taxonomy.* London: Freeman.

Stapleton, J. L. and W. D. Williams (1988). The morphology of the calceolus of an Australian crangonyctoid freshwater amphipod. *Crustaceana*, **52**(2): 157-162.

Stebbing, T. R. R. (1888). Report on the amphipoda collected by H.M.S. Challenger during the years 1873-76. Report on the Scientific Results of the Voyage of H.M.S. Challenger During the Years 1873-76, *Zoology* **29**: xxiv. London: Eyre and Spotisswoodie.

Stebbing, T. R. R. (1899). Amphipoda from the Copenhagen Museum and other sources. *Transactions of the Linnean Society of London*, (2, Zoology) **8**: 395-432.

Stebbing, T. R. R. (1906). Amphipoda I. *Das Tierreich* **21**: 1-806.

Stewart, B. A. (1992a). The effect of invertebrates on leaf decomposition rates in two small woodland streams. *Archiv fur Hydrobiologie* **124** (1): 19-33.

Stewart, B. A. (1992b). Morphological and genetic differentiation between allopatric populations of a freshwater amphipod. *Journal of Zoology, London* **228**: 287-305.

Stewart, B. A. and C. L. Griffiths (1992a). Four new species of *Paramelita* (Ampipoda: Crangonyctoidea) from South Africa. *Annals of the South African* Museum **101**: 139-158.

Stewart, B. A. and C. L. Griffiths (1992b). Further new species within the freshwater amphipod genus *Paramelita* (Crangonyctoidea: Paramelitidae) from South Africa. *Journal of Natural History* **26**: 489-506.

Stewart, B. A., C. D. Snaddon and C. L. Griffiths (1994). Differentiation between populations of the freshwater amphipod *Paramelita spinicornis* (Crustacea: Amphipoda: Crangonyctoidea), with description of a new species. *Zoological Journal of the Linnean Society* **111**: 179-195.

Stock, J. H. (1980). Regression model evolution as exemplified by the genus *Pseudoniphargus* (Amphipoda). *Bijdragen tot de Dierkunde.* **50**(1): 105-144.

Stock, J. H. (1986). Order Amphipoda: an introduction, pp. 494-496. **In**: L. Botosaneanu (Ed.) Stygofauna Mundi. E. J. Brill, Leiden.

Stock, J. H. and T. M. Iliffe, (1990). A new Australian crangonyctid amphipod with a habit convergent to the Old World genus *Niphargus*. *Stygologia* **5**(3): 137-142.

Straškraba, M. (1964). *Perthia* N.G. (Amphipoda, Gammaridae) from fresh waters of Western Australia, with remarks on the genera *Neoniphargus* and *Uroctena*. *Crustaceana* **7**(2): 125-139.

Straškraba, M. (1966). *Hurleya kalamundae* n.g.n.sp. (Amphipoda, Gammaridae) from subterranean waters of Western Australia. *International Journal of Speleology* **2**: 291-295.

Sutcliffe, D. W. and T. R. Carrick (1981). Number of flagellar segments and moulting in the amphipod *Gammarus pulex*. *Freshwater Biology* **11**: 497-509.

Swofford, D. L. (2000). PAUP*. Phylogenetic Analysis Using Parsimony (*and Other Methods). Version 4. Sinauer Associates, Sunderland, Massachusetts.

Swofford, D. L. and R. B. Selander (1981). BIOSYS-1: a FORTRAN programme for the comprehensive analysis of electrophoretic data in population genetics and systematics. *Journal of Heredity* **72**: 281-283.

Taylor, D. J. (2002). First records of two families of freshwater amphipoda (Corophiidae, Perthiidae) from South Australia. *Transactions of the Royal Society of South Australia*, **126** (2): 125-126.

Thomas, J. D. (1993). Biological monitoring and tropical biodiversity in marine environments: a critique with recommendations, and comments on the use of amphipods as bioindicators. *Journal of Natural History* **27**: 795-800.

Thomson, G. M. (1893). Notes on Tasmanian Crustacea, with descriptions of new species. *Papers and Proceedings of the Royal Society of Tasmania, for 1892*: 45-76.

Thorpe, J. P. (1982). The molecular clock hypothesis: biochemical evolution, genetic differentiation and systematics. *Annual Review of Ecological Systematics* **13**: 139-168

Vainio, J. K., K. Jazdzewski and R. Vainola, (1995). Biochemical systematic relationships among the freshwater amphipods *Gammarus varsoviensis*, *G. lacustris* and *G. pulex*. *Crustaceana* **68**: 687-694.

Wagner, H.P. (1994). A monographic review of the Thermosbaenacea (Crustacea: Peracarida). A study on their morphology, taxonomy, phylogeny and biogeography. *Zoologische Verhandelingen*, **291**: 1-338.

Wang, D. and J. R. Holsinger (2001). Systematics of the subterranean amphipod genus *Stygobromus* (Crangonyctidae) in western North America, with emphasis on the *hubbsi* group. *Amphipacifica* **3** (2): 39-147.

Watling, L. (1989). A classification system for crustacean setae based on the homology concept. **In** B.E. Falgenhauer, L. Watling and A.B.Thistle (Eds.), Functional morphology of feeding and grooming in Crustacea. *Crustacean Issues*, **6**:15-26.

Watts, C. H. S. and Humphreys, W. F. (1999). Three new genera and five species of Dytiscidae (Coleoptera) from underground waters in Australia. *Records of the South Australian Museum* **32** (2): 121-142.

Watts, C.H.S. and Humphreys, W.F. (2000). Six new species of *Nirridessus* and *Tjirtudessus* (Dytiscidae; Coleoptera) from underground waters in Australia. *Records of the South Australian Museum* **33**: 127-144.

Williams, W. D. (1962). The Australian freshwater amphipods. I. The genus *Austrochiltonia* (Crustacea: Amphipoda: Hyalellidae). *Australian Journal of Marine and Freshwater Research* **13**(2): 198-216.

Williams, W.D. (1974). Freshwater crustacea. pp. 63-112. **In** W.D.Williams (ed.). Biogeography and Ecology in Tasmania. Junk, The Hague.

Williams, W. D. (1986). Amphipoda on land masses derived from Gondwana. **In** L. Botosaneanu (ed.) *Stygofauna Mundi*. pp. 551-559. Brill and Backhuys, Leiden.

Williams, W. D., and J. L Barnard (1988). The taxonomy of crangonyctoid Amphipoda (Crustacea) from Australian fresh waters: foundation studies. *Records of the Australian Museum* **10** (Supplement): 1-180.

Zeidler, W. (1991). A new genus and species of phreatic amphipod (Crustacea; Amphipoda) belonging to the "*chiltonia*" generic group, from Dalhousie Springs, South Australia. *Transactions of the Royal Society of South Australia* **115**: 177-187.

Zeidler, W. (1997). A new species of freshwater amphipod *Austrochiltonia dalhousiensis* sp.nov., (Crustacea: Amphipoda: Hyallelidae) from Dalhousie Springs, South Australia. *Transactions of the Royal Society of South Australia* **121**:29-42.

* Addendum
Richardson, A.M.M., 1987. Freshwater Amphipoda. Pp. 23-27. **In** W.W. Fulton and A.M.M. Richardson (eds.), The freshwater fauna of the World Heritage Area, Tasmania. Inland Fisheries Commission, Tasmania.

27.8.03

The Taxonomy of

Australian Freshwater Amphipoda

(Crustacea : Malacostraca)

by

John Hugh Bradbury, B.Sc. (Monash), M.Sc. (Adelaide)

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BRADBURY, J. H. (2000). Western Australian stygobiont amphipods (Crustacea: Paramelitidae) from the Mt Newman and Millstream regions. *Records of the Western Australian Museum*. Supplement **60**: 1-102.

BRADBURY, J. H. (2002). Melitid amphipods of Barrow Island, Western Australia. Part II - Recent Discoveries. *Records of the Western Australian Museum* **21**: 83-103.

BRADBURY, J.H. and S. EBERHARD, 2000. A new stygobiont amphipod from the Nullarbor Plain. *Records of the Western Australian Museum* **20**: 55-66.

BRADBURY, J. H. and W. D. WILLIAMS, 1995. A new genus and species of Crangonyctoid amphipod (Crustacea) from Western Australian fresh waters. *Transactions of the Royal Society of South Australia* **119**(2): 67-74.

BRADBURY, J. H. and W. D. WILLIAMS, 1996. Freshwater amphipods from Barrow Island, Western Australia. *Records of the Australian Museum* **48**(1): 33-74.

BRADBURY, J. H. and W. D. WILLIAMS, 1996. Two new species of anchialine amphipod (Crustacea: Hadziidae: *Liagoceradocus*) from Western Australia.
Records of the Western Australian Museum **17**: 395-409.

BRADBURY, J. H. and W. D. WILLIAMS, 1997. Amphipod (Crustacea) diversity in underground waters in Australia: an Aladdin's Cave.
Memoirs of the Museum of Victoria **56**(2): 513-519.

BRADBURY, J.H. and W. D. WILLIAMS, 1997. The amphipod (Crustacea) stygofauna of Australia: description of new taxa (Melitidae, Neoniphargidae, Paramelitidae), and a synopsis of known species.
Records of the Australian Museum **49**(3): 249-341.

BRADBURY, J. H. and W. D. WILLIAMS, 1999. Key to and checklist of the inland aquatic amphipods of Australia.
Technical Reports of the Australian Museum. Number **14**: 21pp.

BRADBURY, M. R., J. H. BRADBURY, and W. D. WILLIAMS, (1998). Scanning electron microscope studies of rugosities, cuticular microstructures of taxonomic significance of the Australian amphipod family Neoniphargidae (Amphipoda).
Crustaceana **71** (6): 603-614.

Bradbury, J.H. (1999) The systematics and distribution of Australian freshwater amphipods: a review.
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Records of the Western Australian Museum, supplement 60, pp. 1-102.

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This publication is included on pages 608-714 in the print copy of the thesis held in the University of Adelaide Library.

Bradbury, J.H. (2002) Melitid amphipods of Barrow Island, Western Australia Part II - Recent Discoveries.
Records of the Western Australian Museum, 21, pp. 83-103

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This publication is included on pages 715-736 in the print copy of the thesis held in the University of Adelaide Library.

Bradbury, J.H. & Eberhard, S. (2000) A new stygobiont amphipod from the Nullarbor Plain.
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A NEW GENUS AND SPECIES OF CRANGONYCTOID AMPHIPOD (CRUSTACEA) FROM WESTERN AUSTRALIAN FRESH WATERS

by J. H. BRADBURY* & W. D. WILLIAMS*

Summary

BRADBURY, J. H & WILLIAMS, W. D. (1995) A new genus of crangonyctoid amphipod (Crustacea) from Western Australian fresh waters. *Trans. R. Soc. S. Aust.* **119**(2), 67-74, 31 May, 1995.

A new genus of crangonyctoid amphiphod (Crustacea) from Western Australian fresh waters, *Totgammarus*, with a single species, *T. eximius*, is described. The species was collected from roadside pools in the south-west of Western Australia.

KEY WORDS: Amphipoda, *Totgammarus*, Western Australia, crangonyctoid, Paramelitidae.

Introduction

All known crangonyctoid species of Australian fresh waters to 1987 were comprehensively reviewed by Williams & Barnard (1988). In their review, known species were re-examined and redescribed, and some new species were described. They dealt with a total of 12 genera and 33 species. They considered the number of genera probably represented about half the number expected to occur in Australia and noted that the number of species within genera was probably small. Further work (Barnard & Williams, in press) supports this view; they described two new genera, each monotypic, as well as a further new species of both *Austrogammarus* and *Uroctena*. This second review by Barnard & Williams (in press) described, *inter alia*, most material available to them from Western Australia. They did not describe, however, a taxon from that State represented by only a single specimen, pending the collection of further material. Unfortunately, all attempts to obtain more specimens have proven unsuccessful; exhaustive examination of all the known collections from the area have yielded no further specimens and nor did collections made in 1994 on our behalf by A. J. Boulton.

Since the single available specimen represents in our view a new genus, and to facilitate further studies of freshwater amphipods in Western Australia in particular and Australia in general, we now consider it appropriate to describe this single specimen.

Methods of dissection, description and notation follow those of Williams & Barnard (1988). To expedite the use of figures in the present publication, the abbreviations are as follows; "Antennal sinus" refers only to the cephalic sinus receiving antenna 2. A - antenna; Abd - abdomen; acc - accessory; art -article; C - coxa; cox - coxal; d - dorsal; dact - dactylus; e - eye; E - epimeron; flag - flagellum; g - gill; G - gnathopod; Hd - head; i - inner; l - left; lac - lacinia mobilis; lat - lateral; LL - lower lip; MD - mandible; med - medial; mol - molar; MP -maxilliped; MX - maxilla; o - outer; O - oostegite; p -palp; P - pereopod; PC - prebuccal complex; pl - plate; post - posterior; Pp - pleopod; r - right; ret -retinaculum; st - sternal; T - telson; U - uropod; UL -upper lip; v - ventral; 1,2,3...7 - first, second, third...seventh.

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Genus *Totgammarus* gen. nov.

Etymology

Named for the combination of features of several genera.

Type species: *Totgammarus eximius*

Diagnosis

Pleon with sparse dorsal setation, rostrum weak. Lateral cephalic lobes strongly projecting, antennal sinus moderate, eye not discernible in preserved specimen. Flagellum of first antenna lacking major armaments, moderately long, about 0.5x body length, twice A2. Ratio of peduncular articles 2:2:1. Flagellum of second antenna and peduncle of sub-equal length, calceoli of type 9 present (Lincoln & Hurley 1981).

Ratio of mandibular palp articles about 2:9:6, article 2 moderately setose, article 3 falcate, setae = ABDE (Barnard & Barnard 1983). Labium lacking inner lobes. Maxillae 1 - 2 medially setose, inner plate wholly or marginally pubescent. Maxilla 1 outer plate ovate, medially and laterally setose, palps asymmetric; left with thin apical spines, right with thick apical spines. Maxilla 2 inner plate with row of apico-medial weakly sub-marginal setal spines, medial margin heavily setose. Maxillipedal palp articles 2 - 3 with few lateral setae, article 3 with fine facial pubescence dorsally and a ventro-facial row of moderately long, curved setae.

Coxae 1 - 3 with a row of posterior spines, coxae 1 - 4 moderately elongate, coxa 1 tapering below, coxa 4 deeply emarginate post-dorsally, coxae 5 - 6 shorter than 4, coxa 7 shorter than 5 - 6. Gnathopods unequal, gnathopod 1 0.5x gnathopod 2. Carpus of gnathopod 1 long, of gnathopod 2 short. Scythe spine absent from article 4 of both gnathopods, each with a weak lobe, Propodus of both gnathopods rectangular, palms weakly to moderately convex, palmer corners prominent, turned out. First gnathopod lacking strong spines at palmar corner, second with 6 strong spines. Spines along palms of both gnathopods short, simple, without triggers, numerous.

Pereopods 3 - 4 with posterior spine sets on article 6 evenly spaced, P5 - 7 moderately elongate, article 2 broadly expanded, lobate. Dactyls with 1 - 3 spinules.

Coxae 2 - 7 with sac-like gills. Thoracic segments 2 - 7 with lateral sternal gills.

Basomedial setae on inner rami of pleopods 1 - 3 plumose, peduncles each with paired retinacula and paired (first and second pleopod) or single (third pleopod) plumose accessory retinacula.

Pleonites with few dorsal setae and/or spines. Epimera with few ventral spines, posterior margins weakly setulate. Rami of uropods 1 - 2 extending sub-equally, each with 2 rows of spines. Facial armaments of uropod 1 weak, largely absent on uropod 2 which bears a strong, elongate apico-medial spine. Uropod 3 extended, magniramous, peduncle short, outer ramus 2 articulate, article 2 short.

Telson longer than broad, 100% cleft, not laterally tumid, apically and disto-laterally weakly setose, bearing a single sub-apical spine on either lobe.

Additional description

Flagellum of A1 - 2 lacking major armaments. Apical margin of labrum extended. Accessory blades (rakers) on mandibles with inter-raker plumose setae interspersed among rakers and additional short plumose setae lying between rakers and molar. Molar triturative, with plumose apical seta. Mandibular palp article 3 shorter than 2, palp article 2 lacking baso-anterior setae with few median and apico-anterior setae. Both plates of second maxillae with rows of long distal setae. Maxillipedal palp moderately long. Article 3 weakly produced and finely pubescent at the apex which bears long terminal setae; baso-medially bearing a single sub-marginal seta; medially with a row of scythe setae extending to the base of the dactyl; setae of the ventral face constituting a comb row, as well as a single long mid-facial seta and a row of short setae basal to the comb row; the mid-distal dorsal face bearing fine pubescence.

Dactyl of first gnathopod not reaching palmar corner, bearing a small, bent, inner tooth-spine. Dactyl of second gnathopod reaching to end of palm, bearing 2 small inner spines. Pereopod 7 shorter than 6. Article 2 of pereopods 5 - 7 equally setose posteriorly.

Sternal processes: fleshy sausage-shaped gills on thoracic segments 2 - 7, attached to mid-lateral margins of segments.

Postero-ventral apex of epimera 1 - 3 blunt, as in *Austrogammarus*. Pleopods similar, except for numbers of retinaculae, rami approximately equal. Outer ramus of uropods 1 - 2 slightly shorter than inner ramus. Apicolateral corner of peduncle of uropod 1 with 2 spines, rami of both first and second uropods with 5 apical spines. The third uropod extending beyond the first and second in the entire animal, peduncular spines apical and sub-apical, some medial setae of each ramus plumose. Ventrodistal spine on urosomite 1 at base of uropod 1 short, as in *Austrogammarus*.

Relationship

This genus displays the characteristics of crangonyctoid amphipods in possessing (1) sternal gills (2) an accessory flagellum of the first antenna with two or more articles (3) calceoli of type 9 or linear (4) uropod 1 lacking a basofacial spine on the peduncle (5) a lower lip without inner lobes (6) a first gnathopod that is not melitoid or mittenform in shape (7) a first gnathopod that does not dominate the second, and (8) a mandibular palp of typical form (Williams & Barnard 1988).

The new genus fits the essential criteria of the family Paramelitidae in possessing sausage-like sternal gills, dorsal setae on the telson, and linear or type 9 calceoli. It differs from the Neoniphargidae in the absence of rugosities on the third article of the maxillipedal palp and gnathopods, the form of the gnathopods (not small and mittenform), the form of the carpi (not short and lobate), and non-dendritic or lump bearing sternal gills. It differs from the Perthiidae in that the first antenna is significantly longer than the second, the mandibular molar is normally developed and triturative, the outer plate of the maxilliped is not very small, the gnathopods are not large, nor are the carpi short and deeply lobate, the carpi and propodi are not eusirid, and the sternal gills are not dendritic.

Totgammarus bears features in common with other paramelitid genera, such as blindness, which occurs in several, and in possession of an elongate spine on the second male uropod (as in some *Uroctena* spp.). The combination of characteristics however, is unique. The genus varies from *Austrogammarus*, the most primitive Australian paramelitid genus, in several ways. In *Totgammarus*, dorsal setation of the pleonites is weak, the lateral cephalic lobes project strongly, the antennal sinus is moderate, eyes are absent, and the

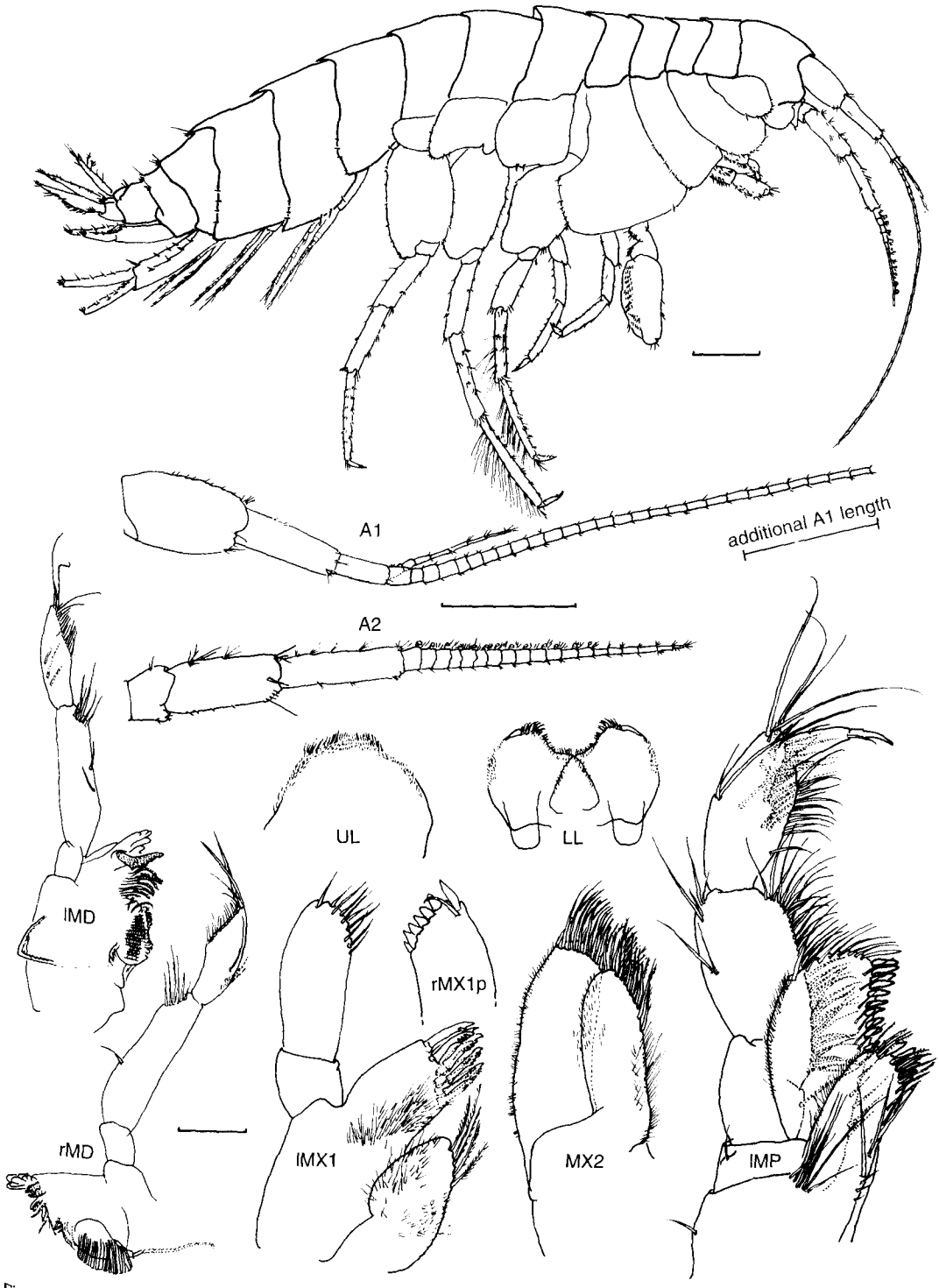

Fig. 1. *Totgammarus eximius*, sp. nov. holotype, male 10.6 mm. Whole animal, antennae and mouthparts. Scale bars: adult and antennae = 1 mm, mouthparts = 200 μm.

second article of the mandibular palp is relatively long with few apico-anterior and no baso-anterior setae. Additionally, there is an extension of the apical margin of the labrum, 5 rather than 3 apical spines occur on the inner plate of the maxilliped, coxae 1 - 4 are moderately long rather than elongate, the apex of coxa 1 tapers, pereopods 5 - 7 are more even in length, and a scythe spine is not present on article four of the gnathopods although a small lobe is present. The dactyls of legs 3 - 7 are multi-spinose. The peduncles of the pleopods are moderately setose, the apico-lateral and apico-medial spines of peduncles of the first uropod differ, as do the relative lengths of the uropod rami which also bear baso-facial armaments. The third uropod is magniramous.

Totgammarus eximius sp. nov.
FIGS 1 - 3.

Etymology
From *eximius*, meaning exceptional or alone.

Type locality
Temporary roadside water in sands along the Scott River Road, south-western Western Australia.

Diagnosis
With the characteristics of the genus (only male known).

Material Examined Holotype
Western Australian Museum WAM14-95, male 10.6 mm in type series.
No other specimens available.

Description of holotype (male)
Body (Fig.1). pleonites 3 - 6 with sparse transverse dorsal setation and dorso-lateral spines on 5 - 6.

First antenna (Fig. 1): primary flagellum sparsely setose, flagellum of 35 articles, 1.8 x peduncle. No calceoli. Accessory flagellum 7 - 8 articulate, reaching to article 8 of the primary flagellum. Second antenna (Fig. 1): length 0.25 x body length, peduncular articles 4 - 5 subequal, flagellum of 19 articles, setae sparse. Calceoli on articles 1 - 13. Labrum (Fig. 1): broadly rounded with apex slightly extended, laterally and apically pilose. Labium (Fig. 1): medially and laterally pilose with 10 curved apico-medial spines on either lobe.

Left mandible (Fig. 1): palp article 3 setation 1A -2B - 15D - 4E, article 2 with 2 medial setae and oblique row of 6 apico-medial setae. Incisor 6-toothed, lacinia mobilis 4-toothed, 9 setose accessory blades, 3 short plumose setae and 1 short blunt spine toward base of molar. Anterior of molar densely pilose. Molar with short plumose seta. Right mandible (Fig. 1): incisor 4-toothed, lacinia mobilis bifid with 4 denticulate teeth on one side and 9 cuspate teeth and a blunt terminal tooth on the other, accessory blades of 3 toothed spines and 4 setose inter-rakers, 3 short plumose setae and 1 narrow blunt spine toward the base of the molar. Molar with 1 setose median, short, blunt spine, and long plumose seta.

Left first maxilla (Fig. 1): palp article 2 with 10 thin apical spines, otherwise naked. Outer plate medially setose, 10 denticulate terminal spines. Inner plate ovate, laterally and medially with sparse straw-like pubescence, 5 apico-medial plumose setae. Right first maxilla (Fig. 1): palp article 2 with 6 thick apical spines, 1 disto-lateral moderately long spine and 1 lateral sub-apical curved spine. Outer plate with 10 denticulate terminal spines and 1 antero-medial plumose seta, median area with long pubescence. Inner plate as for left side.

Second maxillae (Fig. 1): symmetrical, outer plate laterally setose, sub-terminal row of 10 curved spines, terminal row of many curved setae. Inner plate laterally setose, sub- marginally pubescent; medial margin with fine setae proximally, row of setal spines distally.

Maxilliped (Fig. 1): palp article 3 with 9 medial scythe setae, 16 antero-facial comb row setae extending from M0.4 to the sub-apex, 4 long terminal setae, 2 mid lateral setae and 1 median seta. Dactyl bearing 1 distal and 1 medial accessory spines and, dorsally, 4 short post-facial setae basal to the comb row; outer plate laterally setose, apically bearing sub- terminal row of 8 strong curved spines, a disto-medial sub-facial row of 10 tooth spines and 13 setae, setae distally sub-facial to the teeth, proximally facial. Inner plate terminating in 5 strong tooth spines and 8 plumose setae; medially 6 long setal spines, the distal 4 plumose; basal to the inner plate a transverse row of 8 medium to long naked setae.

First gnathopod (Fig. 2): coxa tapered, 3 posterior spines, weakly setose marginally; carpus moderately long, sub-equal to propodus, not lobed; propodus rectangular, palmar corner prominent, extended posteriorly, palm acute, convex, dactyl reaching corner of palm, bearing small bent inner tooth, 5 plumose and 1 naked spines at palmar corner; numerous short spines along palm.

Second gnathopod (Fig. 2): larger than the first (Left 2x, Right 1.7x); coxa with row of 4 or 5 posterior spines, few small distal setae; carpus short, about 0.5x propodus; propodus rectangular, longer than wide, palmar corner with 2 strong, naked spines and 4 plumose spines, corner prominent and slightly extended posteriorly; dactyl not reaching corner, but reaching to the second naked spine, bearing 2 inner teeth at approximately M0.5; palm slightly convex with numerous short spines.

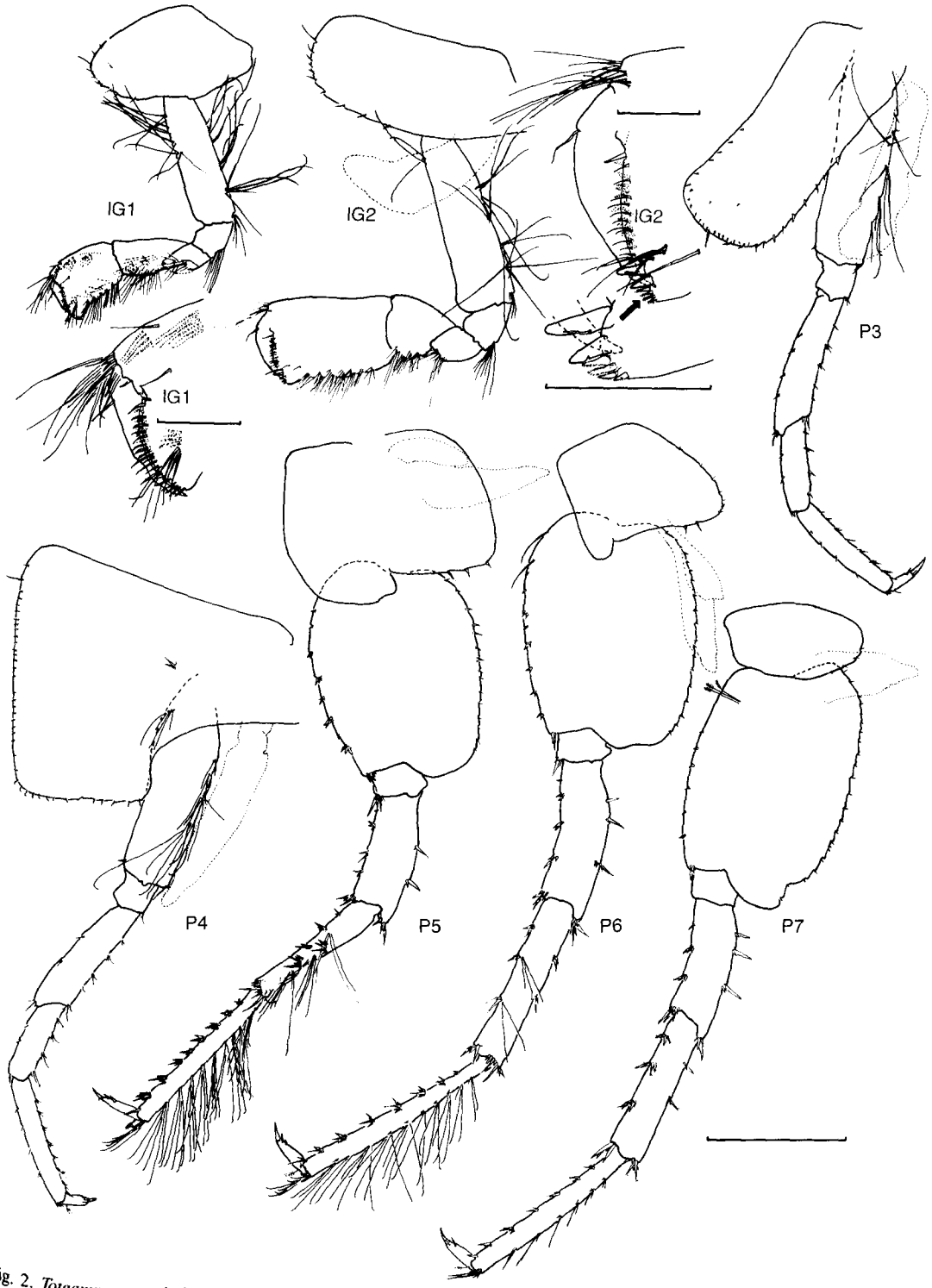

Fig. 2. *Totgammarus eximius*, sp. nov. holotype, male 10.6 mm. Gnathopods and pereopods. Scale bars: gnathopods and pereopods = 1 mm, dactylar enlargements = 200 μm.

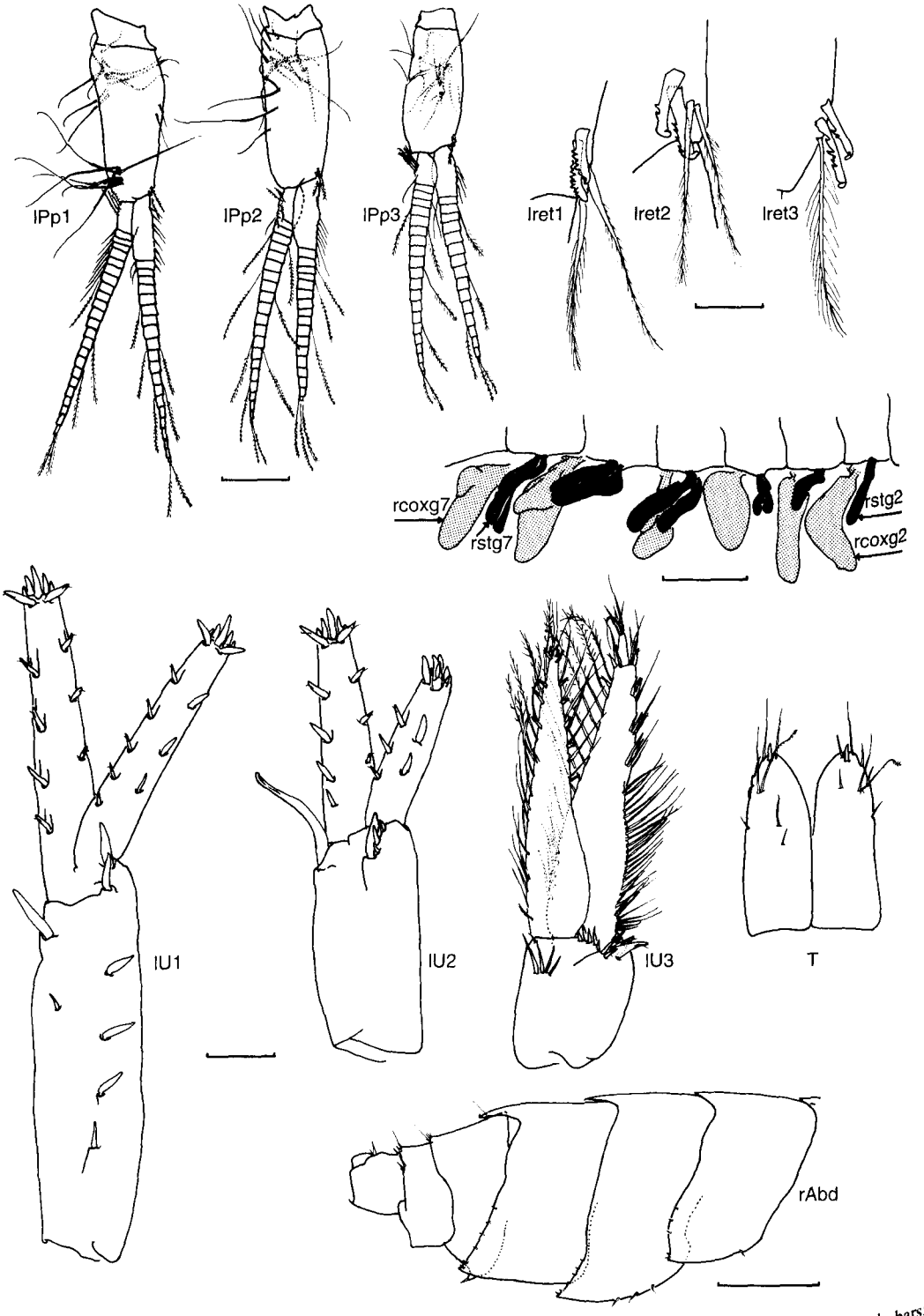

Fig. 3. *Totgammarus eximius*, sp. nov. holotype, male 10.6 mm. Pleopods, uropods, telson, gills and abdomen. Scale bars: abdomen and gills = 1 mm, pleopods, uropods and telson = 200 μm, retinaculae = 50 μm.

Pereopods (Fig. 2): coxa 3 with 9 posterior spines, coxa 4 deeply emarginate, small setae and spines below, no posterior spines. Coxa 5 bearing 3 posterior ventral spines, coxa 6 with 3 posterior ventral spines and 4 small posterior setules. Coxa 7 with 4 posterior spines Pereopods 3 - 4 length 1.2 x G2, subequal, article 2 of both bearing long posterior setae. Article 5 of P3 apico-posterior spine formula (proximal to distal); 1 - 2 - 2 - 2, article 6; 1 - 3 - 3 - 3 - 2 - 2 - 2, article 5 of P4; 2 - 3 - 3 - 4, article 6; 3 - 3 - 3 - 3 - 3 -3 -3. Pereopods 5 - 7 of approximately equal length. Pereopod 5 articles 5 - 6 bearing long apico- posterior setae, apico-anterior spine formulae 2 - 3 - 2 and 3 - 4 - 4 - 4 - 3 - 3 - 4 - 4. Pereopod 6 article 5 bearing few long setae, article 6 many apico-posterior setae, spine formulae 4 - 3 - 4 - 0 and 2 - 4 - 4 -5 - 0 - -3 respectively. Pereopod 7 apico-anterior spine formulae: article 5: 4 - 6 - 6 and article 6: 3 - 3 - 4 - 4 - 4 - 3.

Gills (Fig.3): coxall gill 5 slightly reduced, gills 5 -7 bi-lobed. Sternal gills 2-7 lateral.

Epimera (Fig. 3): with few ventro-facial spines, posterior margins with few small setules. Epimeron 1 slightly rounded posteriorly with single antero-ventral spine. Epimeron 2 with 3 small mid-ventral setae only. Epimeron 3 naked ventrally.

Pleon (Fig. 3): pleonites 3 - 6 with dorsal spines and/or setae. Pleonite 5 with 5 spines in transverse groups of 2 and 3. Urosomite 6 with 1 dorsal spine on either side.

Pleopods: pleopods 1 and 2 bearing paired, hooked retinaculae and paired accessory retinaculae, pleopod 3 lacking second accessory retinacula. Uropods (Fig. 3): first uropod; peduncle length 1.2 x rami, outer margin with 1 apico-facial spine, 2 medial spines, and strong row of 5 dorsal spines, without setae. Rami sub-equal, terminating in a cluster of 5 spines. Second uropod: peduncle length equal to rami, lacking spine rows, but with a cluster of 1 large and 4 short apico-facial spines. Inner medial angle with elongate spine 0.5 x length of peduncle, terminally spoon shaped. Inner ramus 1.3 x length of outer, lacking setae. Both rami terminating in a cluster of 5 spines. Third uropod: peduncle length 0.35 x length of outer ramus, about the same length as urosomite 3, bearing median transverse row of 5 spines, distal transverse row of 7 spines at the base of the outer ramus and a group of 4 apico-lateral spines. Outer ramus proximal article strongly setose baso-laterally with 4 disto-lateral clusters of spines and setae, paired medial and single lateral trigger spines apically, medially a single sub-apical trigger spine and evenly spaced plumose setae. Small distal article, 0.13 x proximal, terminating in 3 short and 2 long setae. Inner ramus of a single article, equal to the length of the proximal article of the outer ramus, marginally setose, the medial setae plumose, 6 lateral and 5 medial trigger spines distally, 2 terminal spines and 4 setae.

Telson (Fig. 3): 1.25 x urosomite 3, cleft 100%. Disto-lateral margins and apex with sparse dorsal setation, paired penicillate setules sub-marginal at M.80. Single sub-apical spine on either lobe.

Distribution

Western Australia (south west), Scott River Road, sands in a roadside ditch coll. K. Davies, B. Knott, 03 Oct. 1981.

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References

BARNARD, J. L. & BARNARD, C. M. (1983) "Freshwater amphipoda of the world. I. Evolutionary patterns. II. Handbook and bibliography" (Hayfield Associates, Mt. Vernon, Virginia).

——— & WILLIAMS, W. D. (in press) The taxonomy of Freshwater Amphipoda (Crustacea) from Australian Fresh Waters: Part 2. *Rec. Aust. Mus. suppl.*

LINCOLN, R. J. & HURLEY, D. E. (1981) The calceolus, a sensory structure of gammaridean amphipods (Amphipoda: Gammaridea). *Bull. Brit. Mus. Nat. Hist. (Zool.)* **40**, 103-116.

WILLIAMS, W. D. & BARNARD, J. L. (1988) The taxonomy of crangonyctoid Amphipoda (Crustacea) from Australian Fresh Waters: foundation studies. *Rec. Aust. Mus. suppl.* **10**, 1-180.

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Freshwater Amphipods from Barrow Island, Western Australia

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ABSTRACT. Amphipods collected from bore-holes and caves on Barrow Island, Western Australia are reported. Seven new species of the family Melitidae, genus *Nedsia* Barnard & Williams, 1995, and one of the family Bogidiellidae, genus *Bogidomma* n.gen., are described. A key to the species of *Nedsia* is provided.

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Unlike many other areas of the world, gammarid amphipods have not often been reported as components of Australian subterranean freshwater faunas (Williams, 1986; Holsinger, 1994). Recent reports from Western Australia (Humphreys & Adams, 1991; Knott, 1993; Barnard & Williams, 1995), Tasmania (Horwitz, 1988; Eberhard *et al.*, 1991), New South Wales (Eberhard, pers. comm.), and Queensland (Barnard & Williams, 1995) indicate that there is, in fact, a significant and diverse amphipod component among aquatic stygofauna over a wide area of the continent. Moreover, this diversity appears to extend over the coastally located underground waters (e.g., anchialine caves; Bradbury & Williams, 1996). This communication reports a further eight new species of amphipod taken from underground waters of Barrow Island, Western Australia.

Barnard & Williams (1995) describe a mono-specific melitid amphipod genus *Nedsia* from underground waters of North West Cape, Western Australia. Extensive collections on Barrow Island (geologically, an isolated section of the Cape Range and located some 55 km off the coast of Western Australia at 20°46'S 115°24'E), reveal eight species within underground water systems there. Several are unique, some damaged, but nevertheless described here. Conditions of collection prevailing on Barrow Island preclude re-examination of some sampling sites as many are temporary boreholes, or the fauna has been destroyed as part of the programme of electrolytic protection undertaken in oil drilling procedures. Seven new hadziid species and one new species of bogidiellid are described. Bogidiellids have not previously been recorded from Western Australia, the only other Australian record being from Heron Island, Queensland (Stock, 1984).

Methods of Dissection and Description

Methods of dissection and description closely follow those of Williams & Barnard (1988) and Barnard & Williams (1995) except in the use of upper case letters to indicate right or left.

The notation **M**, with an appended number, indicates the position of an object as a fraction of the distance

from the base to the apex of an appendage; **S**, large spine; **s**, small spine.

A key to the abbreviations used in the figures is as follows: **A**, antenna; **Abd**, abdomen; **acc**, accessory; **C**, coxa; **d**, dorsal; **dact**, dactylus; **E** [in figures only], epimeron (cf. E in text, for large seta); **fl**, flake; **flag**, flagellum; **g**, gill; **G**, gnathopod; **Hd**, head; **i**, inner; **juv**, juvenile; **L**, left; **lac**, lacinia mobilis mobilis; **LL**, lower lip; **MD**, mandible; **med**, medial; **mol**, molar; **MP**, maxilliped; **MX**, maxilla; **o**, outer; **O**, oostegite; **opp**, opposite; **p**, palp; **P**, pereopod; **PC**, prebuccal complex; **pl**, plate; **Pp**, pleopod; **R**, right; **sp**, spine; **sq**, square view; **sr**, setae removed (sometimes marked by sockets); **st**, sternal gill; **T**, telson; **U**, uropod; **UL**, upper lip; **UR**, urosome; **1, 2, 3.. 7**, first, second, third... seventh article, segment, somite or epimeron (as appropriate).

Setae of the mandibular palp are described using the method of Karaman (1969) and Barnard & Barnard (1983). Lowry & Stoddart (1993) proposed a modification of that scheme which removes many of the discrepancies found in the original. However, as description of the few setae present on the mandibular palp of these taxa does not impinge upon the areas of confusion within the original scheme, nor contradict the new, we have been able to employ conventional terminology.

Family Melitidae

Barnard & Williams (1995) assigned *Nedsia* to the family Melitidae, within the hadzioid superfamily. The hadziid/melitid group is complex and not clearly defined. Holsinger (1994) groups Melitidae within the Hadziidae, pointing to "considerable taxonomic instability within this group, much of which has apparently resulted from rampant parallelism and excessive homoplasy." We do not wish to add to the confusion over affinities within this group, so accept Barnard & Williams (1995) placement for the present.

The genus displays similarities to eriopisids (Karaman, 1984), particularly in the presence of an elongate second article of the outer ramus of the third uropod, which is uncommon, but does occur elsewhere, for example, in *Pseudoniphargus adriaticus* Karaman, 1955 and *Niphargus longicaudatus* Costa, 1851. Unlike *Eriopisa* or *Psammogammarus*, however, the anterior coxae of *Nedsia* are not significantly reduced, nor is the female second gnathopod hadziid, or the first gnathopod ceradocid as in *Psammogammarus*. Moreover, the mandibular palp is reduced to two articles, although the terminal article is linear as in eriopisids, rather than falcate with distinct D- and E-setae as in *Hadzia*.

Nedsia Barnard & Williams, 1995

Nedsia Barnard & Williams, 1995: 197.

Type species. *Nedsia douglasi* Barnard & Williams, 1995, by original designation.

Introduction. This genus was erected by Barnard & Williams (1995) for a single species collected from North West Cape in Western Australia; only females were represented in the collection. We now redefine the genus, include description of a male specimen of *N. douglasi* and describe seven further *Nedsia* species from Barrow Island, Western Australia.

Modification of the original diagnosis is intended to accommodate: additional dorsal spination of the pleonites, variation in the ratio of lengths of articles of the peduncle of the first antenna and length of the second antenna, variation in the medial setation of the maxillae, asymmetry of the palps of the first maxilla, greater relative length of some coxae with more posterior spines, provision for some variation of length of the inner ramus of the third uropod and division of the telson. Additional diagnostic features include allowance for a symmetrical non-excavate upper lip, presence of three, rather than two, blunt naked spines on the inner plate of the maxilliped, and lack of a contiguous naked tooth spine on the maxillipedal outer plate. Reference to exclusively blunt submarginal setae is deleted, as are variation of the apex of the maxillipedal palp, additional numbers of peduncular setae of the pleopods, equal pleopodal rami, and reduction of the spination of the rami of the first and second uropods.

The species described in this report are congeneric with the hitherto mono-typic genus *Nedsia*. Examination of these new *Nedsia* species led to a review of generic characteristics and a redefinition of the genus. All the Barrow Island species of *Nedsia* display apically dentate palmar spines on the first gnathopod and several also bear posterior hadziid setae on the second gnathopod. Whilst the descriptions (Barnard & Williams, 1995) of *Nedsia* and *N. douglasi* do not make reference to bifid palmar spines, examination of others of the species from North West Cape indicates their presence in all cases. Included in the redefinition is information on sexual differences, since the original description was based only on females; male material is now available.

Diagnosis. *Pleonites* with few dorsal spines. *Head*: rostrum weak; lateral cephalic lobes moderately to strongly projecting, very broad; no antennal sinus present; eyes absent. *First antenna*: elongate, longer than antenna-2; ratio of peduncular articles from 3:2:1 to 2.7:2.6:1; accessory flagellum 2-articulate. *Second antenna*: short to very short; flagellum much shorter than peduncle; calceoli absent. *Mandible*: palp reduced, 2-articulate; ratio of mandibular palp articles variable, article-1 not setose, terminal article linear or tapered, subtruncate; setae few or nil C- or D-setae, 2 or 3 E-setae. *Lower lip*: with inner lobes. *Maxillae*: moderately to well setose medially; inner plate of maxilla 1 ovate with variable number of medial setae, outer plate with denticulate spines, palps symmetric or nearly so, with thin apical spines; inner plate of maxilla 2 with row of medial setae extending onto face apically, other medial setae few or absent. *Coxae*: 1–7 mostly short, broader than long, with few or no posterior spines; coxa

1 not expanded below; coxa 4 not excavate posteriorly; coxa 5 as long as 4. *Gnathopods* 1–2 diverse: first gnathopod small, feeble; carpus longer than propodus, not lobate; merus lacking hyaline lobe; palm transverse, spines simple, some bearing trigger hairs and thus asymmetrically bifid, some apically dentate; spines at corner of palm—lateral 2–4 long, medial 2–5 short; setae along palm moderate to sparse and simple; second gnathopod weakly enlarged; carpus short and lobate; propodus of medium enlargement and ovate; palm oblique, irregularly spinose and sparsely setose, defining corner with 1–3 spines. *Pereopods* 5–7 moderately elongate: pereopod 7 longer than pereopods 5–6; article-2 moderately expanded, ovato-rectangular, posteroventrally extended but not lobate; dactyls of pereopods 3–7 lacking accessory spinules. *Coxae*: 2–6 each with flask-shaped gill; coxal gill 6 not reduced; coxae 2–5 each with a thin, poorly setose oostegite. *Thoracic segments*: lacking sternal gills. *Uropod* 3: strongly extended, parviramous; peduncle short; outer ramus 2-articulate, huge; inner ramus scale like, reaching to M0.15–0.25 on article-1 of outer ramus. *Telson*: longer than broad; cleft 90–100%; lobes weakly convex laterally, with subapical setation; setal spines, where present, lateral; single lateral penicillate setules at M0.6 to M0.7 on each side.

Additional description. *Upper lip*: symmetrical or asymmetrical; sometimes weakly excavate below. *Mandibles*: accessory blades (rakers) very few (3–4) on right side, with or without interraker plumose setae between each main raker; both mandibles with few or no additional serrations beyond rakers. *Maxillae*: both plates of second maxilla with apical setae of medium length; inner plates of maxillae 1–2 and medial and lateral margins of maxilla 2 poorly covered with pubescence. *Maxilliped*: inner plate very long with distal row of several plumose setae and 3 blunt naked spines, and short medial row of plumose setae; outer plate large, with few distal plumose setae, continuous with a blunt naked tooth spine in some; medial margin carved into sinuosities, spineless; submarginal face with pairs of setae; palp articles 2–3 weakly setose laterally, article-2 moderately setose medially, article-3 with setae or comb rows of setae near the base of the dactyl, apex weakly or not produced, dactyl unguiform, with short to moderate length nail. *Gnathopods*: dactyls lacking inner tooth spine, lacking nail; *first gnathopod* without rastellate seta of article-4. *Pereopods*: 3–4 of proportions similar to pereopods 5–7; posterior spine sets on article-6 of pereopods 3–4 unevenly spaced. *Pleopods*: similar; peduncles with 1–3 setae each; rami extending subequally to equally, basomedial setae of inner rami of some bifid; retinaculae 2 or 3, no more than one accessory retinaculum present. *Epimera*: posteroventral tooth of epimera 1–3 usually absent; posterior margins smooth, and/or sinuous and sparsely setulose; some bearing facial spines near ventral margin. *Uropods*: apicolateral corner of peduncles on uropods 1–2 with 1 and 2 spines (thus with no more than 1 ventrally displaced spine on uropod 2); dorsal margins with or without spines; medial margin of uropod 1 with 1 or 2 apical spines; rami of uropod 1 extending subequally; outer ramus of uropod 2 shortened; uropod 1 with basofacial spine; most rami of uropods 1–2 with two spine rows, albeit reduced; medial setae of outer ramus of uropod 3 sparse, usually with subdistal peduncular setae or spines. *Urosome*: ventrodistal spine on urosomite 1 at base of uropod 1 absent.

Composition. *Nedsia* now contains eight species. All the species recorded here are thought to be marine invaders or "strandings".

Key to Species of *Nedsia*

1. Second maxilla with sparse marginal basomedial pubescence on inner plate (e.g., Fig. 3) or no pubescence on either plate 2

—— Second maxilla with moderate to dense marginal pubescence both plates (e.g., Fig. 6) 4

2. Pleonites without dorsal spines ..... *N. straskraba*

—— Pleonites with dorsal spines 3

3. Epimeron 1 without distolateral spines, peduncle of uropod 1 with a lateral row of short facial spines besides the basofacial and distal spines, the palmar corner of gnathopod 1 rounded, the outer plate of the maxilliped tapering apically and with weak medial cusps ..... *N. fragilis*

—— Epimeron 1 with distolateral spines, peduncle of uropod 1 without facial spines besides basofacial and distal spines, palmar corner of gnathopod 1 subquadrate, outer plate of maxilliped not tapering, but rounded apically and with strong medial cusps ..... *N. humphreysi*

4. Posterior margins of pleon sculpted, epimera with facial spines as well as ventral submarginal spines (e.g., Fig. 18) 7

—— Posterior margins of pleon smooth, epimera without facial spines other than ventral submarginal spines (e.g., Fig. 8) 5

5. Epimera 2–3 with few ventral submarginal spines, urosomite 1 with a spine-like extension at the base of the first uropod, rami of pleopods with more than six articles, maxillipedal palp article-3 without organised comb rows of setae at base of dactyl ..... *N. hurlberti*

—— Not as above 6

6. Coxa 1 with one or more anterior spines, without anterior setae, telson without dorsal setae, length of the maxillipedal outer plate 2 × width ..... *N. urifimbriata*

—— Coxa 1 without anterior spine(s), with anterior setae, telson with dorsal setae, length of the maxillipedal outer plate not more than 1.6 × width ..... *N. douglasi*

7. Posterolateral margins of pleonite 4 with spines, medial margin of outer plate of maxilliped rugose, with 5 indentations ..... *N. macrosculptilis*

—— Posterolateral margins of pleonite 4 without spines, medial margin of outer plate of maxilliped not rugose, with 4 indentations ..... *N. sculptilis*

Nedsia douglasi Barnard & Williams, 1995

Nedsia douglasi Barnard & Williams, 1995: 198–201.

Diagnosis. *Body*: only pleonite 6 with 2 dorsal spines. Lateral cephalic lobes strongly projecting. *Antennae*: ratio of length of peduncular articles of first antenna = 45:35:8. *Upper lip*: asymmetrical; weakly excavate below. Mandibles: accessory blades (rakers) very few (3–4), no additional serrations beyond rakers; mandibular palp 2-articulate, ratio of articles 5:8, article-2 linear, subtruncate, 2 or 3 E-setae. *Maxillae*: inner plates of maxillae 1–2 poorly covered in pubescence; well setose medially; inner plate of maxilla 1 with 6 medial setae, palps symmetric; inner plate of maxilla 2 with no setae other than medial row extending onto face apically. *Maxilliped*: naked tooth spine of outer plate blunt, palp articles 2–3 weakly setose laterally, setae of article-3 organised into comb rows near base of dactyl; nail of dactyl short. *Coxae*: 1–7 short; coxae 1–4 lacking posterior spines. *Gnathopods* 1–2 diverse in female (male unknown): palmar spines of *first gnathopod* asymmetrically bifid, spines at corner of palm = lateral 3 long, medial 4 short; setae along palm sparse and simple; defining corner of *second gnathopod* with 1 spine. *Gills*: coxae 2–4 each with flask shaped gill. *Oostegites*: present on coxae 2–5. *Pleopods*: peduncles with 1 seta each; retinaculae = 2, accessory retinaculae = 1. *Epimera*: posteroventral tooth of epimera 1–3 absent. *Uropods*: apicolateral corner of peduncles on uropods 1–2 with 1 and 2 spines (thus with 0–1 ventrally displaced spines), dorsal margins spinose, medial margin of uropod 1 with 2 apical spines, all rami of uropods 1–2 with 2 spine rows, albeit weakly furnished; inner ramus of uropod 3 reaching to M0.16 on article-1 of outer ramus. *Telson*: cleft 100%; setal spines, where present, lateral; single lateral penicillate setules at M0.6 on either side.

Description. As recorded for the holotype (Barnard & Williams, 1995).

A single male specimen was collected from a related site on North West Cape. This specimen, male "c", bears many similarities to the female holotype and is believed to represent the same species. Variations from the holotype are set out within the description below.

Material examined. Male "c", 5 mm: Cape Range, Western Australia. North West Cape region, subterranean fresh waters of the coastal plain. Western Australian Museum sample BES186. Not from type locality.

Description of male "c" (Figs 1, 2). *Body* 5 mm. *First antenna*: ratio of peduncular articles 50:48:18

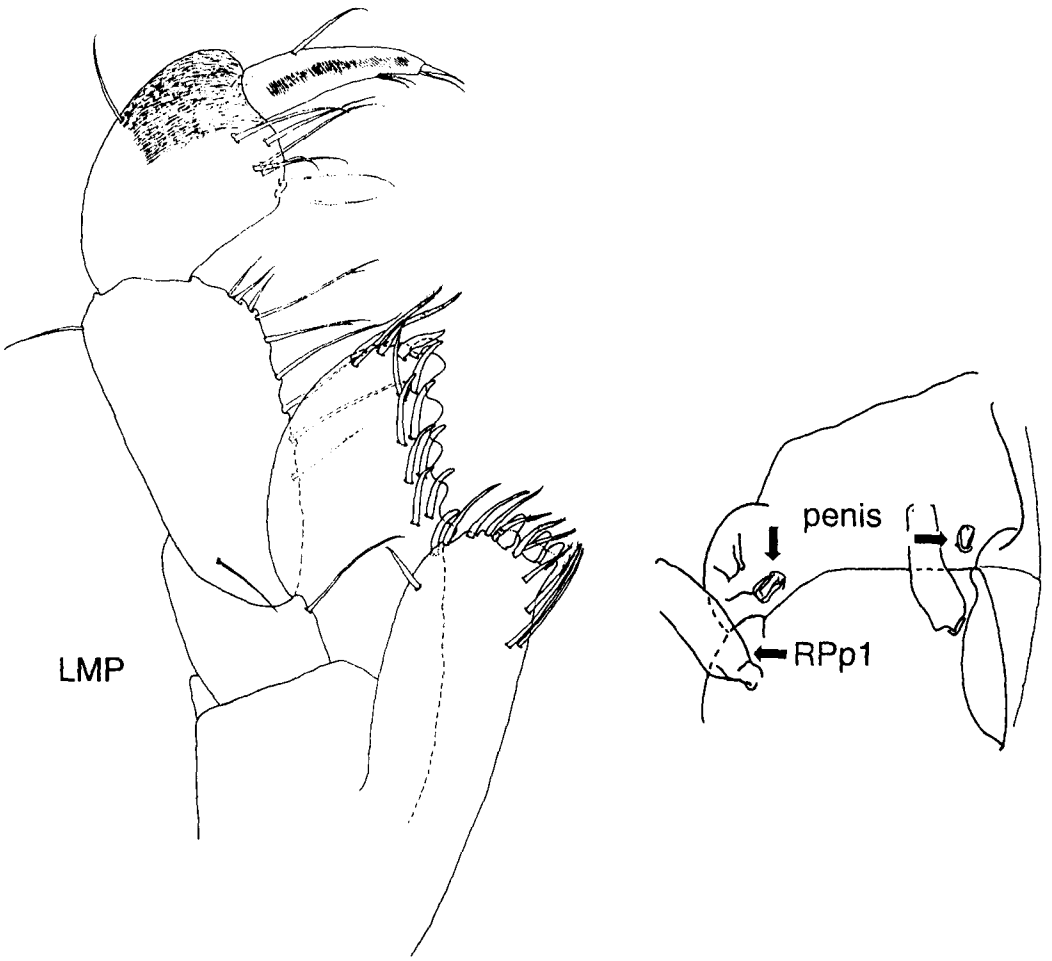

Fig. 1. *Nedsia douglasi* male "c" 5 mm. Maxilliped and penis.

(converts to 45:43:16 compared with female type = 45:35:8). *Upper lip*: apex rounded, not excavate, connection symmetrical. *Left mandible*: palp article-1 shorter than 2; article-2 with 2 apical setae; incisor 5 teeth; lacinia mobilis with 4 or 5 teeth; 5 setose accessory blades. *Right mandible*: incisor with 5 teeth; lacinia mobilis bifid; 4 moderately setose accessory blades. *Maxilliped* (Fig. 1): 3 blunt naked tooth spines on the inner plate. *Gnathopods* (Fig. 2): palm of gnathopod 1 more setose than female type, of gnathopod 2 similar. *Pereopods* (Fig. 2): similar to female type. *Uropods*: lengths relative to uropod 1 = 1:0.6:1.6 (vs. 1:0.5:1.33 in the female type): uropod 1 peduncle 1.14× outer ramus (vs 1.3×); inner ramus 1.14× outer; apices of both rami bearing 4 spines (vs 4–6); uropod 2 rami with marginal spines 1–1 and 1–2 (vs 1–1 and 1–3). *Telson*: fewer dorsal setae than the female type. *Penis*: small penial processes borne on either side of the posterior ventral surface of the seventh thoracic segment (Fig. 1).

Distribution. Coastal plain, North West Cape, Western Australia, Western Australian Museum sample BES186.

***Nedsia straskraba* n.sp.**

Figs 3–5

Etymology. Named for Milan Straskraba, noted limnologist and early contributor to our knowledge of the taxonomy of Australian freshwater amphipods.

Type locality. Barrow Island, Western Australia, Western Australian Museum sample BES531.

Material examined. HOLOTYPE (Western Australian Museum WAM 1-96) male "a", 3 mm; male "b", 2.5 mm (collected at same site, at different date. Western Australian Museum sample BES539).

Diagnosis. *Pleonite* 6 without dorsal spines. *First antenna*: ratio of peduncular articles about 3:2:1. *Second antenna*: very short. *Upper lip*: margin not excavate; apically rounded and pilose. *Mandibles*: mandibular palp 2-articulate, article-2 cone like, setae 2E or 2D2E; interraker plumose setae absent; no additional serrations

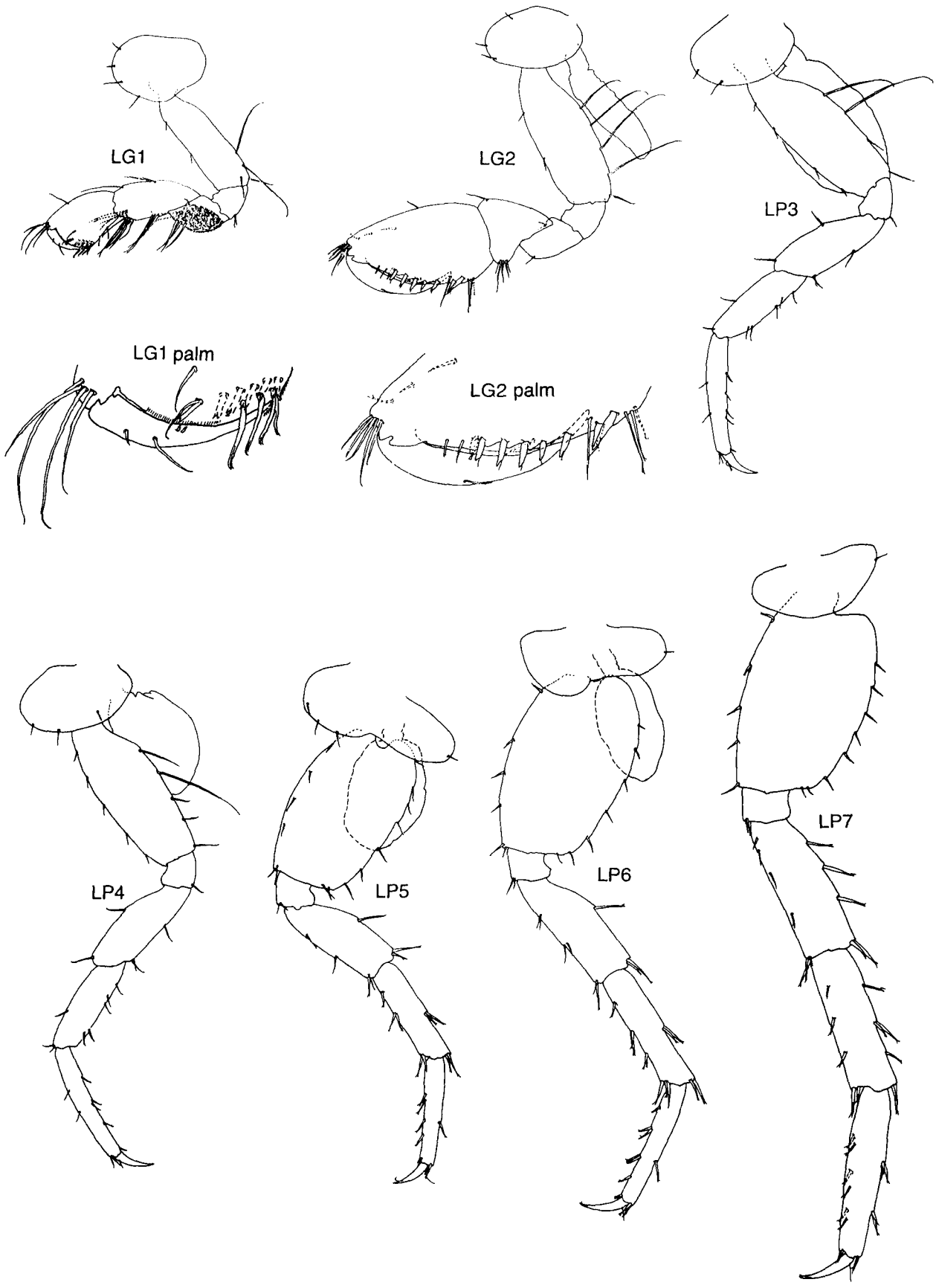

Fig. 2. *Nedsia douglasi* male "c" 5 mm. Legs.

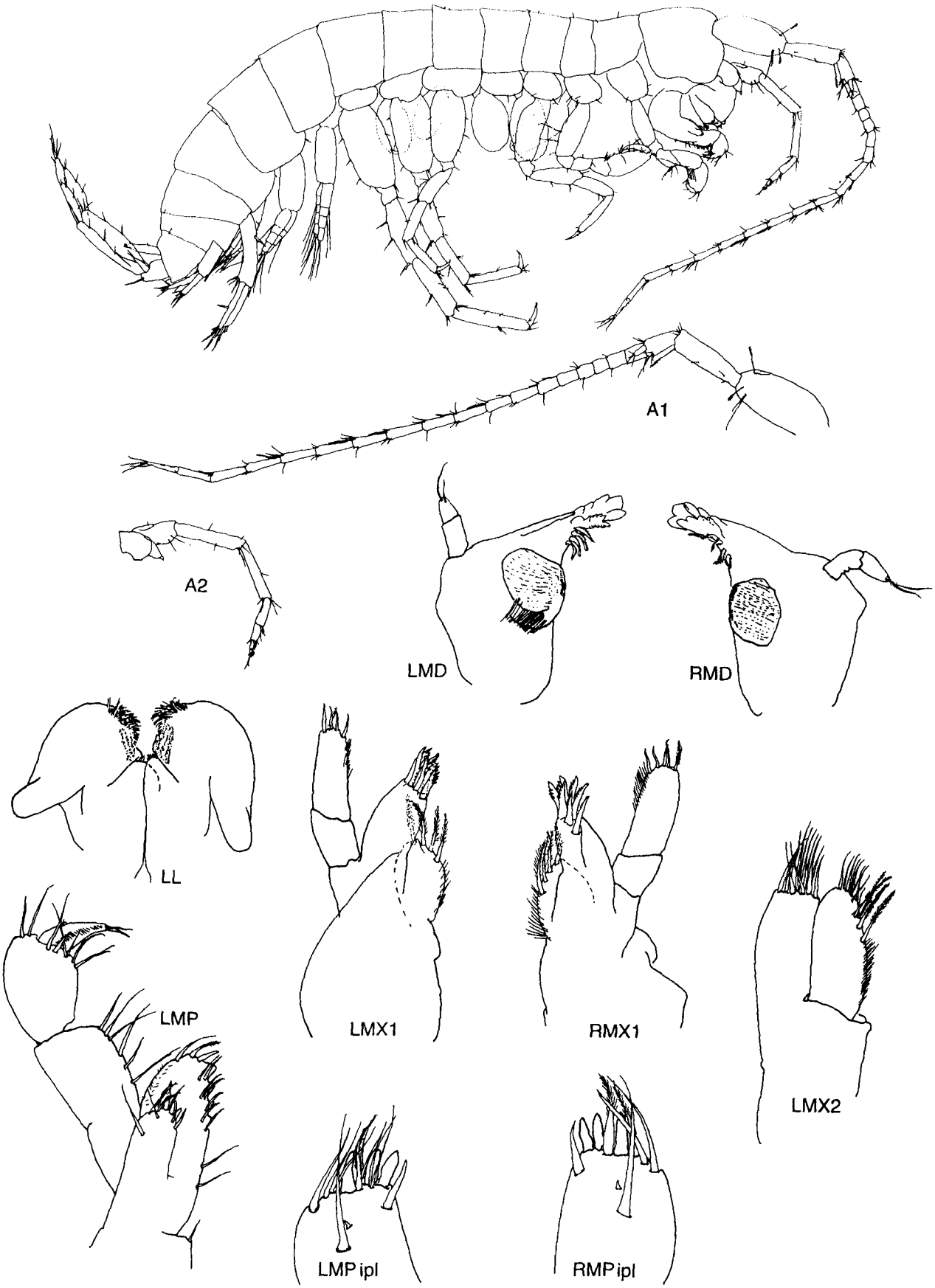

Fig. 3. *Nedsia straskraba* holotype male "a" 2.7 mm. Body, antennae, mouthparts.

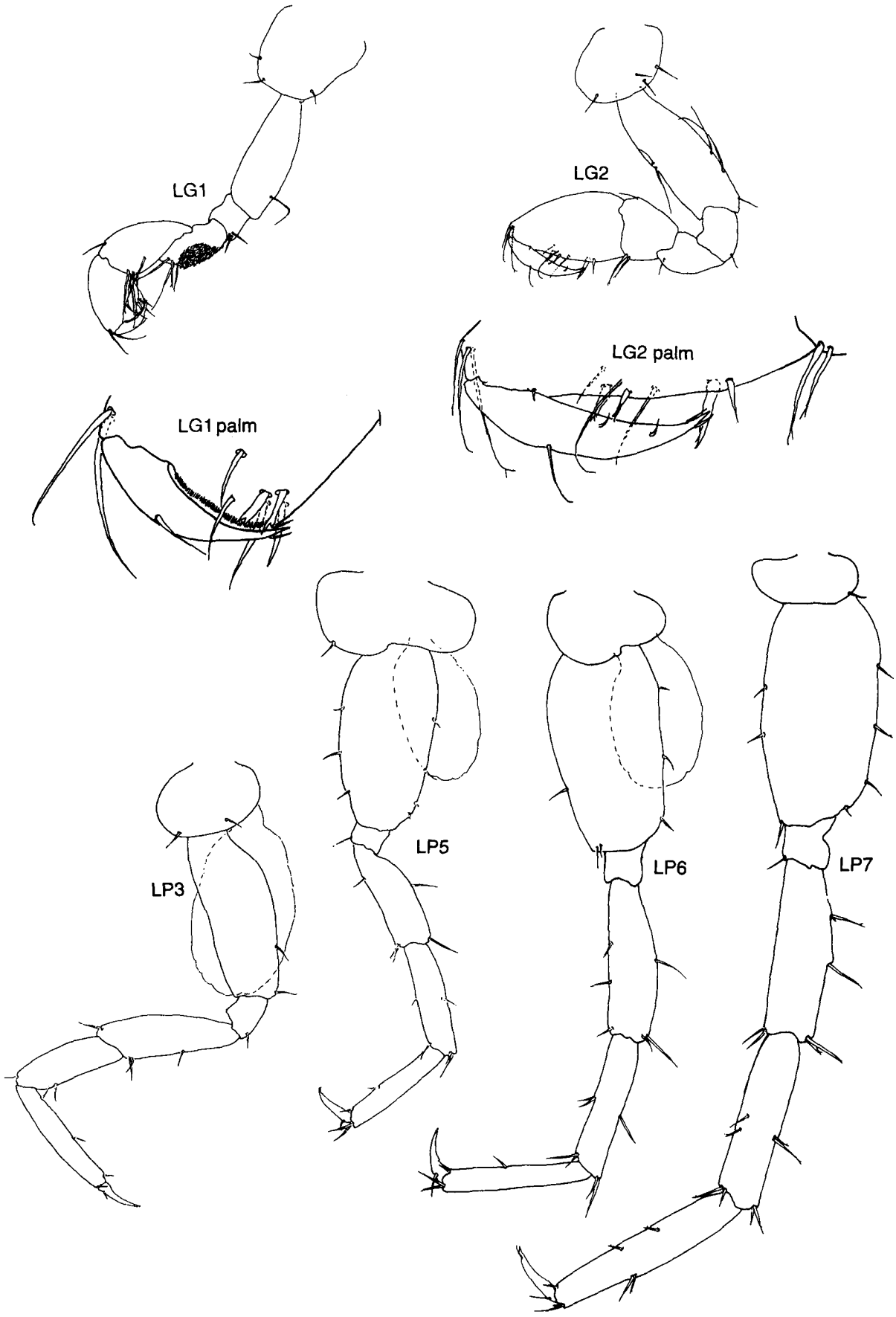

Fig. 4. *Nedsia straskraba* holotype male "a" 2.7 mm. Legs.

beyond rakers. *Maxillae*: moderately setose medially: *first maxilla* inner plate with 4 mediodistal setae; palps almost symmetric. *Maxilliped*: inner plate moderately long, no additional setae (plumose or naked) medially; outer plate with a blunt, naked tooth spine medially, the second pair of submarginal facial setae reduced to a single seta; palp article-3 lacking comb rows of setae near the base of the dactyl, facial comb row of setae from dactylar base to nail, nail of moderate length with similar length distal spine. *Coxae*: coxa 1 not expanded below; coxae 1–2 longer than broad with 1–3 posterior spines respectively; coxae 3–4 lacking posterior spines. *First gnathopod*: palmar spines evenly bifid; spines at corner of palm = lateral 2 long, medial 2 stout and bifid; setae along palm sparse; cutting edge of palm with many fine serrations. *Second gnathopod*: carpus only slightly lobate; defining corner of palm with 2 spines. *Pereopods*: posterior spine sets of article-6 of pereopods 3–4 reduced to 2 spines on pereopod 3. *Gills*: coxal gills 5–6 slightly reduced. *Pleopods*: peduncles with 0 or 1 seta each; rami extending subequally; basomedial seta on inner rami not bifid; retinaculae 2 on each pleopod, accessory retinaculae 1,0,1. *Uropods*: apicolateral corner of peduncles of uropods 1–2 each with 1 spine; dorsal margins of uropod 2 naked; spine rows of rami of uropods 1–2 reduced to 1 (uropod 1) and 2 (uropod 2) medial spines. *Telson*: cleft 100%.

Description of holotype (male "a"). *Body* (Fig. 3) 2.7 mm. *Urosome*: poorly armed dorsally. *Head*: rostrum obsolescent; eyes absent. *First antenna* (Fig. 3): length 0.9× body, 3.2× antenna-2; flagellum longer than peduncle (470:188); peduncular article-3 shortest, article-1 longest, ratio of lengths = 88:68:32; setae sparse; aesthetascs present on articles 8, 9, 11, 12, 14; calceoli absent; flagellum of 18 articles; accessory flagellum 2-articulate, reaching M0.7 of article-1 of primary flagellum, article-2 tiny; articles of primary flagellum not uniform, sparsely setulate. *Second antenna* (Fig. 3): length 0.28× body (206:745); peduncle much longer than flagellum, articles 4–5 equally long, 3–5 with weak ventral setation, article-3 with 1 dorsomedial spine; flagellum 4-articulate, no calceoli. *Upper lip*: margin not excavate. *Mandibles* (Fig. 3): left mandibular palp 2-articulate, articles unequal in length (17:10), article-2 with 2 long apical setae (2E) and 2 short setae (2D); incisor 5 toothed; lacinia mobilis with 4 denticles; 5 setose accessory blades; molar without distal plumose seta (probably lost by damage to specimen), triturative; no other pubescence; right mandibular incisor 4 toothed; lacinia mobilis bifid, broad, finely denticulate; accessory blades of 5 plumose spines; palp 2-articulate, length ratio of articles 17:10. *First maxilla* (Fig. 3): palp article-2 with 5 thin apical spines, all naked on R, one plumose on left side; outer plate of left with 7 denticulate spines, of right with 6; inner plate bearing 4 terminal plumose setae medially, medial margin pubescent. *Second maxilla* (Fig. 3): outer plate devoid of pubescence; inner plate pubescent on basomedial margin. *Maxilliped* (Fig. 3): nail of palp short (11:32 of dactyl), article-3 with few thin setae at inner edge, none proximal; inner plate with single ventrofacial spine and short spur at M0.5 and 0.6, and a single submarginal medial naked spine at M0.8. *First gnathopod* (Fig. 4): coxal plate with several short setae apically and one posteroventrally; article-4 slightly bulbous posteriorly, carpus not lobate; propodus trapezoidal, expanding slightly apically, longer than wide, the posterior edge naked, corner of palm rounded, 2 long, naked lateral spines, 2 stout bifid spines medially, palm slightly convex, dactyl reaching beyond the palm. *Second gnathopod* (Fig. 4): palm with 2 medial and 2 lateral spines, all but the corner spines being bifid, and 2 long and 1 medium setae; spines at palmar corner = 1 medial and 1 lateral (naked); coxal plate similar to first with 1 anterior and 3 posterior setae. *Pereopods* (Fig. 4): coxa 3 with setae similar to coxa 1, arranged 1 anterior, 1 posterior; coxa 4 similar, both setae anterior; pereopods 3–(4) longer than gnathopod 2; pereopods 3–5 approximately equal, articles 4,5 sparsely setose posteriorly, the posterior margin of article-6 (pereopod 3 only) with armament formula = ---1--1, thus with only one locking spine; pereopods 5–7 similar but consecutively elongate, with 1,2,1 locking spines; pereopod 7 anterior spines of articles 5 and 6 displaced inward by keel-like expansion of the segment; coxae 5–7 bearing 0,0,1 setae on posterior lobes, article-2 weakly expanded progressively from pereopods 5–7, not lobate, but extended posteriorly and bearing few setae on pereopod5, becoming increasingly robust in pereopods 6 and 7; dactyls of pereopods 3–7 simple, naked except for an anterior basal penicillate setule, with the addition of an outer terminal setule on pereopod 7. *Gills*: coxae 2–6 with flask shaped gills, gill of coxa 3 largest, of coxae 5–6 slightly reduced. *Pleopods* (Fig. 5): retinaculae 2 per pleopod, one accessory each; peduncles 1 and 3 with an apicolateral seta, 2 without; rami extending subequally, the inner with 5:5:5 articles, the outer with 6:6:5; no bifid setae on basal articles. *Epimera* (Fig. 5): epimera posteroventrally quadrate; posterior margins scarcely convex on 1–2, concave on epimeron 3, all smooth, with few or no setae; epimera 2–3 with 2 and 1 weak ventral spines, lacking lateral oblique ridge. *Pleon* (Fig. 5): pleonites 1–4 with dorsolateral posterior setae; pleonite 6 with 1 dorsolateral and 1 distoventral spinule. *Uropods* (Fig. 5): uropod lengths relative to uropod 1 are uropod 2 = 0.6×, uropod 3 = 1.5×; uropod 1 peduncle length 1.3× inner ramus, the outer margin bearing a single apicodistal spine and reduced row of 2 mid-dorsal spines, the medial apex bearing 2 spines; rami of subequal length (inner : outer = 62:54), both naked except for a single mid-dorsal spine on the inner ramus; both rami with 5 terminal spines; uropod 2 peduncle length 0.9× inner ramus, bearing a single apicolateral spine only; inner ramus length 1.4× outer, the medial margin bearing 2 spines only, 5 terminal spines; outer ramus shorter, devoid of any but 5 terminal spines; uropod 3 strongly extended beyond uropods 1–2 in entire animal; peduncle length 0.14× outer ramus, shorter than urosomite 3 (25:50), bearing single mid-dorsal and laterodistal marginal setae, 1 subapical lateral seta, and 1 small mid-medial submarginal, facial seta; outer ramus proximal article

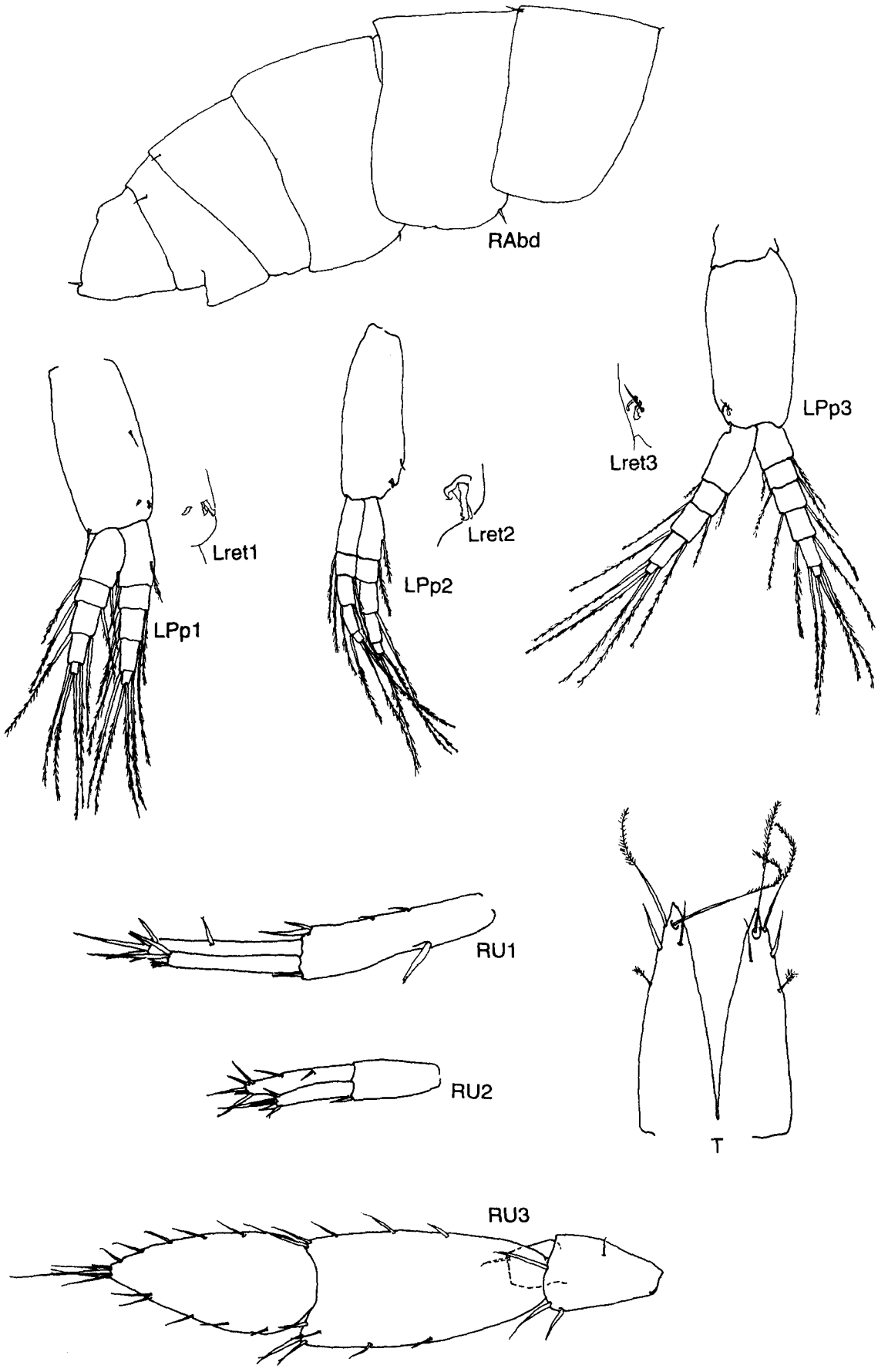

Fig. 5. *Nedsia straskraba* holotype male "a" 2.7 mm. Abdomen, pleopods, uropods, telson.

with few marginal setae, 2 apicomedial setae, 3 apicolateral setae and 1 subapical submarginal lateral seta, article-2 shorter (80:100), similarly armed, terminating in a cluster of 5 spines; inner ramus scale like, subquadrate, length 0.13× outer, bearing a single apicomedial spine. *Telson* (Fig. 5): length 1.5× width, widest at base, subequal in length to urosomite 3 (45:50), cleft 100%; apices slightly notched laterally female), apex of right lobe notched minutely medially; subapices with 2 long plumose setae, 1 submarginal medial seta and 1 lateral seta at M0.8, no other dorsal setae except for single penicillate setules on both lobes laterally at M0.7.

Description of other material. Specimen "b", male, length 2.5 mm. *Pleonite 6* with a single dorsolateral spine. *First antenna*: flagellum of 20 articles, aesthetascs present on articles 8,9,10,12,13,14,16. *Mandibles*: ratio of length of palp articles 1–2 = 15:12; setae of terminal article = 2E; interraker plumose setae present between accessory blades. *Left mandible*: palp article-2 shorter than in type; 15:12, setae = 2E; distal plumose seta present on both molars. *Maxillae*: spines of palp of left first maxilla not plumose *Maxilliped*: palp article-3 with rows of setae basal to dactyl; nail of dactyl short. *First gnathopod*: coxal plate without posteroventral seta. *Pleopods*: accessory spines adjacent to retinaculae = 1,0,0. accessory spine present adjacent retinacula of pleopod 1 only. *Uropod*: lengths relative to uropod 1; uropod 2 0.7×, uropod 3 2×; peduncle of uropod 1 1.9× length of inner ramus, of uropod 2 equal to ramus; uropod 2 inner ramus 1.3× outer; peduncle of uropod 3 0.27× length of outer ramus (longer than in type; 0.14×), second article of outer ramus relatively longer than in type (90:102).

Relationship. *Nedsia straskraba* varies from *N. douglasi* in that pleonites lack dorsal spines, the second peduncular article of the first antenna is relatively shorter, the mandibular palp is similar being 2-articulate, with reduced terminal setation, the inner plate of the second maxilla has fewer medial setae, coxae 1–2 are longer than broad versus broader than long, the palmar spines of the first gnathopod are apically dentate, not asymmetrically bifid, there are no setae along the palm and the inner edge is finely serrate, the second gnathopod is weakly enlarged, melitid, the carpus less lobate, the palm more strongly oblique with few spines or setae and palmar corner poorly defined, the fifth and sixth coxal gills are reduced slightly compared with *N. douglasi*. The principle feature separating this species from all but *N. fragilis* and *N. humphreysi* is the absence of marginal pubescence on both plates of the second maxilla, and from *N. macrosculptilis, N. sculptilis, N. fragilis* and *N. humphreysi* the absence of dorsal spines or sculpturing of the pleon and of facial spines on the epimera. *Nedsia straskraba* is unlike *N. fragilis* in that the palmar corner of the gnathopod 1 is subquadrate and unlike *N. hurlberti* in lacking a spine-like extension of the first urosomite.

Distribution. Barrow Island, Western Australia.

Nedsia hurlberti n.sp.

Figs 6–8

Etymology. Named for S.H. Hurlbert, noted biostatistician and salt lake limnologist.

Type locality. Western Australia, Barrow Island, Western Australian Museum, Western Australian Museum sample site BES545.

Material examined. HOLOTYPE (Western Australian Museum WAM 2-96) female 4.5 mm, unique specimen.

Diagnosis. *Pleonite 6*: small dorsal spines, displaced laterally. *First antenna*: ratio of peduncular articles 45:40:15. *Second antenna*: very short. *Upper lip*: symmetrical, not excavate. *Mandible*: palp 2-articulate, article-1 not setose, article-2 linear, setae = 2E; plumose interraker setae present between each main raker; no additional serrations beyond rakers. *Maxillae*: well setose medially. *First maxilla*: inner plate with 7 plumose medial setae; palps symmetric with 7 thin apical spines. *Second maxilla*: inner plate with a row of medial setae barely extending onto face apically, no other medial setae. *Maxilliped*: outer plate large, with 2 stout plumose setae distally and a single naked tooth-spine; paired submarginal medial setae of the outer plate blunt, apically curved; palp articles 2–3 with single lateral setae, article-3 naked basally, moderately setose distally, with rows of short setae adjacent the base of the dactyl, the apex not produced. *Coxae*: coxae 1–4 lacking posterior spines. *First gnathopod*: palm slightly oblique, palmar spines apically dentate. *Second gnathopod*: defining corner with 2 spines. *Epimera*: without setae, each with some facial spines adjacent ventral and posterior margins. *Pleopods*: peduncles of pleopods 1–2 without setae, of pleopod 3 with 2 lateral setae; basomedial setae of inner rami bifid, no accessory retinaculae. *Telson*: cleft 100%.

Description of holotype (female). *Body* 4.5 mm. *Head* (Fig. 6): rostrum obsolescent; eyes absent. *First antenna* (Fig. 6): length 0.5× body (broken at article-17), longer than antenna-2, flagellum much longer than peduncle; peduncle article-1 longest, 3 shortest, setae sparse; flagellum of many articles (17+), without calceoli or aesthetascs; accessory flagellum of 2 articles, article-2 tiny, extending to M0.7 of article-1 of the primary flagellum; articles of primary flagellum variable in length. *Second antenna* (Fig. 6): short, length 0.27× body; peduncle very much longer than flagellum, articles 4–5 equally long, articles 3–5 with weak ventral setation of 0-2-7 naked setae and 1-2-1 plumose setae, article-3 without dorsomedial spines; flagellum 4-articulate, without calceoli. *Upper lip* (Fig. 6): without excavation of the apical margin, connection to the epistome symmetrical. *Left mandible* (Fig. 6): palp article-1 shorter than 2 (11:35), setae

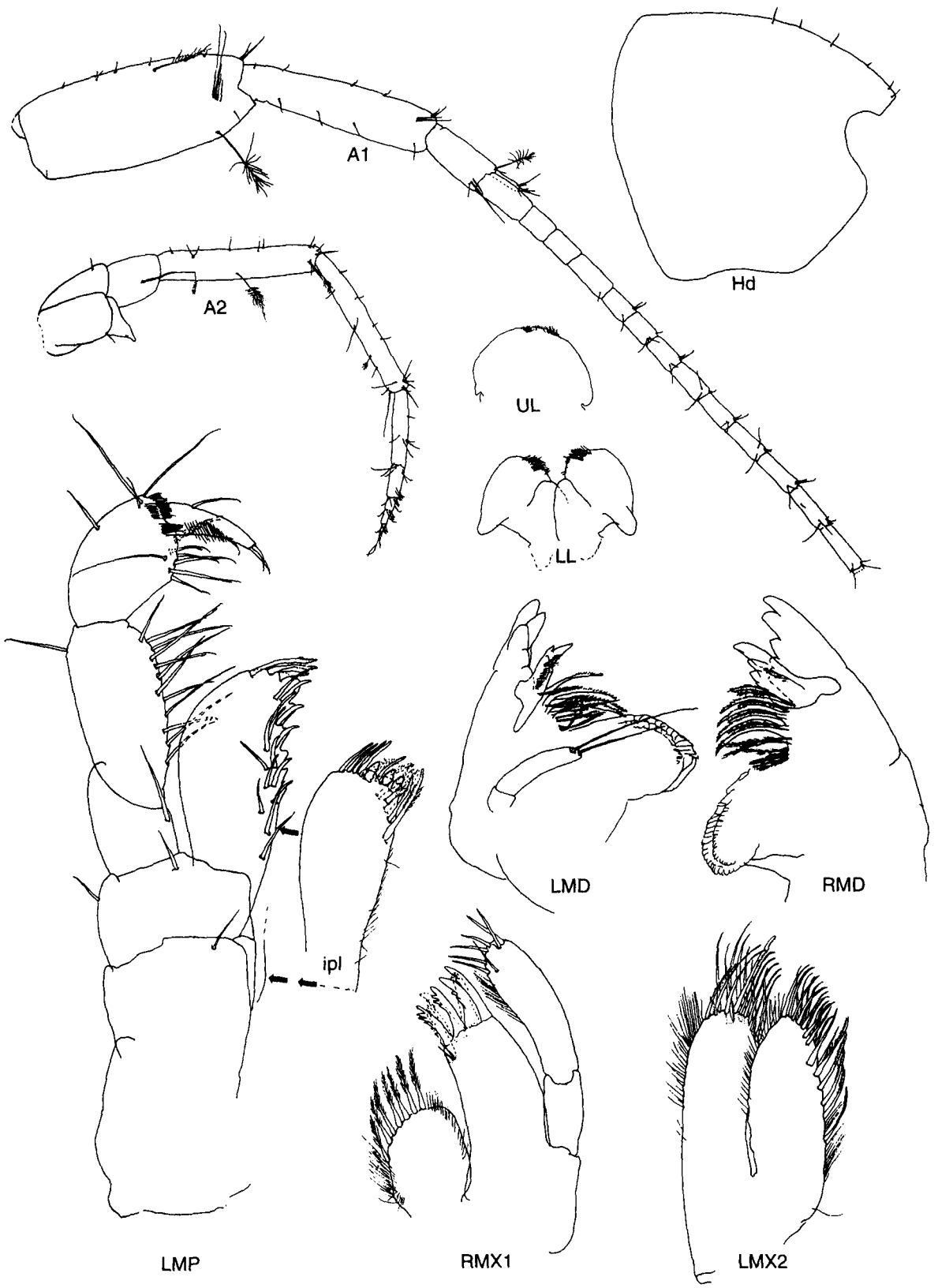

Fig. 6. *Nedsia hurlberti* holotype female 4.5 mm. Head, antennae, mouthparts.

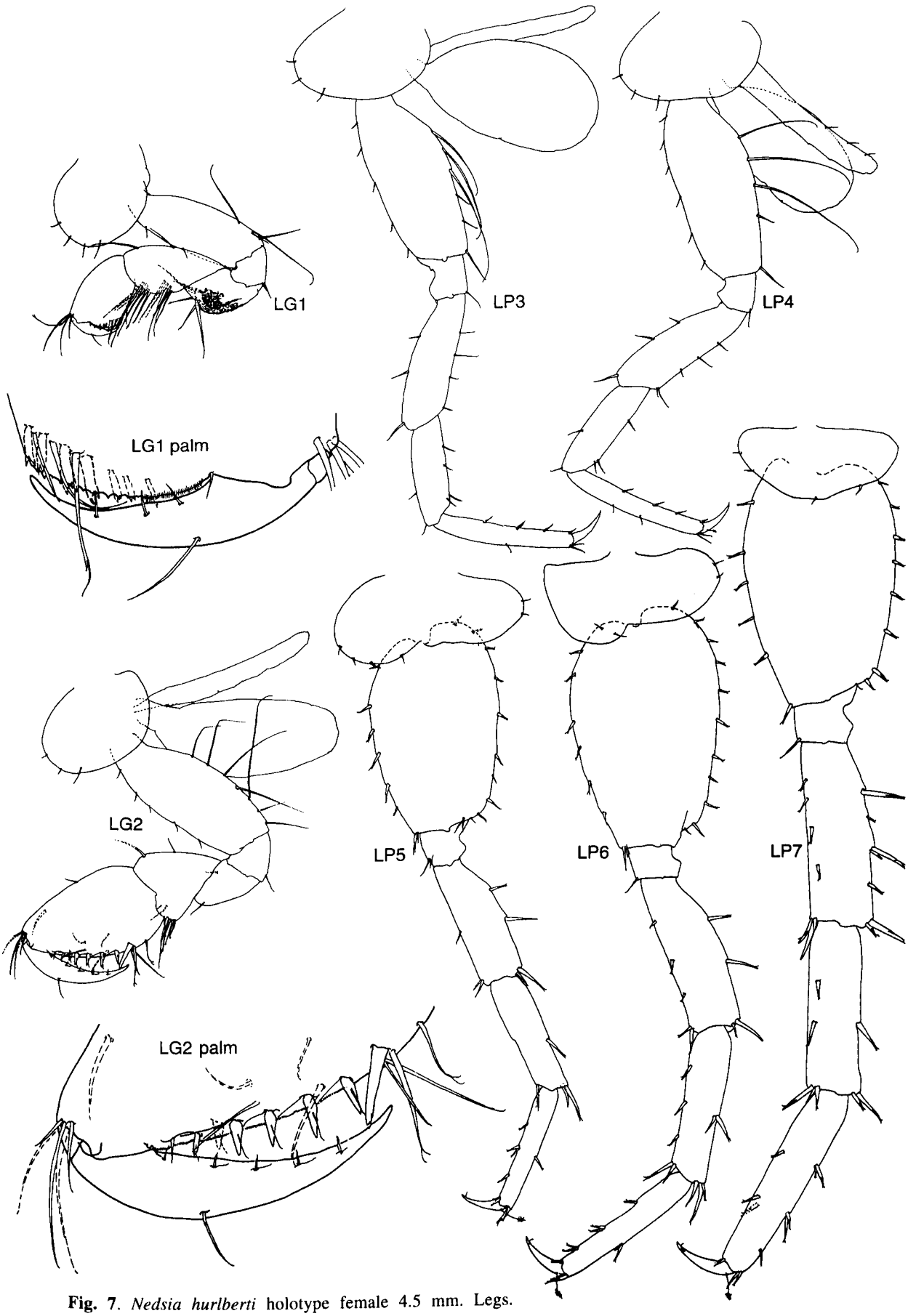

Fig. 7. *Nedsia hurlberti* holotype female 4.5 mm. Legs.

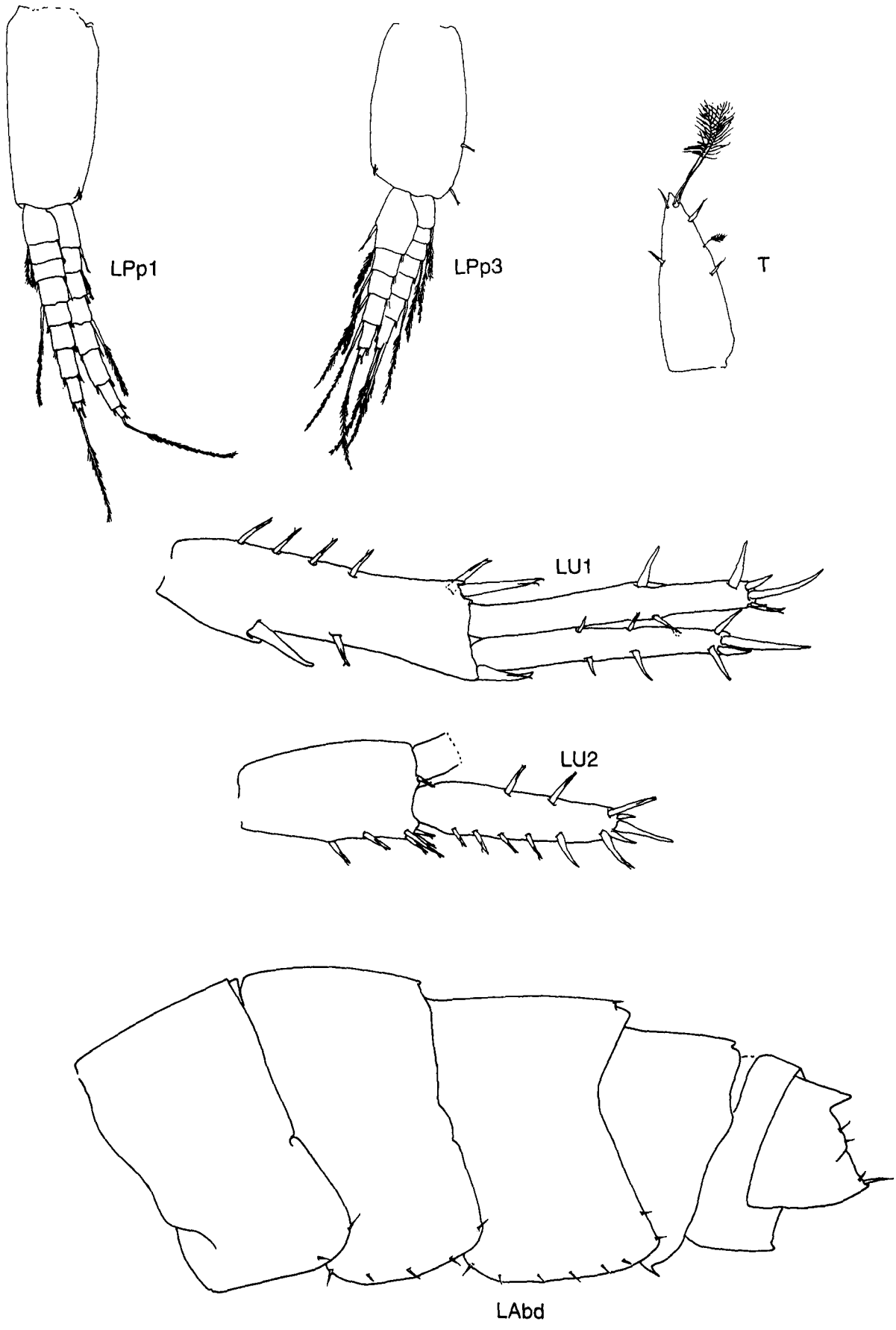

Fig. 8. *Nedsia hurlberti* holotype female 4.5 mm. Abdomen, pleopods, uropods, telson.

of article-2 = 2E: incisor 4 toothed; 4 setose accessory blades; lacinia mobilis bearing a row of short facial setae; plumose setae lying between each raker extend to the base of the molar; molar lacking distal plumose seta, without pubescence. *Right mandible*: incisor 5 toothed; lacinia mobilis 4 toothed and bearing facial setae; accessory blades of 5 plumose spines. *Maxillae* (Fig. 6): *first maxilla* palps of both sides bearing 7 thin apical and subapical spines; outer plate with 7 denticulate spines, the inner plate 7 medial setae; second maxilla, medial and apicomedial margin of both plates pubescent as is basomedial margin of inner plate. *Maxilliped* (Fig. 6): palp article-3 with moderate setae on the inner edge, dactyl bearing a row of mid-facial setae and terminal accessory spine slightly longer than the nail. *First gnathopod* (Fig. 7): coxal plate bearing 4 short setae apically, without posteroventral spines; article-4 posteriorly bulbous and facially pubescent; carpus not lobate; propodus trapezoidal, expanding slightly apically, longer than wide, the posterior edge naked, corner of the palm almost square marked laterally by 2 moderate unarmed spines and 1 long trigger spine, and medially by 4 stout trigger spines, palm convex, dactylus reaching the palmar corner, bearing 3 small spines submarginal to the inner edge. *Second gnathopod* (Fig. 7): coxal plate broader than coxa 1, poorly setose, with 3 anterior setae; propodus 2× that of gnathopod 1, palm bearing 5 lateral trigger spines, single unarmed distal spine, single medial trigger spine at M0.5 and a single long seta at M0.2 from the palmar corner; the palmar edge is finely serrated, the corner defined by a single long slender trigger spine, 1 long, stout trigger spine and 2 long setae. *Pereopods* (Fig. 7): coxa 3 slightly larger than coxa 2, coxa 4 more irregular, both with similar setae = 3 anterior, none posterior, coxae 5–7 with few setae on the ventral margin of posterior lobes (0-0-2); pereopods 3–7 longer than gnathopod 2, progressively elongate; pereopods 3–4 posterior armament formula of article-6 = S-S-S-S and S-2S-S-S, thus both with a single locking spine; pereopods 5–7 each with 2 locking spines; article-6 of pereopod 7 without posterior keel like expansion; article-2 of pereopods 5–7 expanded, but not posteroventrally lobate, bearing small trigger spines; pereopods 3–7 dactyls simple, naked, with an outer basal penicillate setule and a short subterminal seta. *Gills*: flask shaped gills on coxae 2–6; gill of coxa 6 not reduced. *Oostegites*: thin, strap like and poorly setose, present on coxae 2–5. *Pleopods* (Fig. 8): 2 retinaculae per pleopod, without accessory retinaculae, peduncle 3 only bearing a single apicolateral seta, rami extending subequally, the inner rami bearing 9-9-8 articles, the outer 9-9-6; basal article setae of rami 1–2 = 1-1-1-1, of which the inner seta is bifid on each. *Epimera* (Fig. 8): epimera 1–2 posteroventrally curved; epimeron 3 subquadrate, the posteroventral corners with 1-1-2 setae; posterior margins smooth, barely setulose, ventrofacial spines present as 1-4-6. *Pleon* (Fig. 8): pleonite 3 with a tiny posterior dorsal seta, pleonite 6 with 2 distolateral and 2 distoventral spines; uropod 3 strongly extended beyond uropods 1–2 in entire animal. *Uropod*: lengths relative to uropod 1 = uropod 2 0.6×, (uropod 3 1.3×). *Urosome* (Fig. 8): ventrodistal spine at base of uropod 1 on urosomite 1 absent, although urosomite 1 extended ventrodistally in a spine like projection. *Uropods* (Fig. 8): uropod 1 peduncle length equal to medial ramus, the outer margin bearing a single apicodistal spine and row of 4 dorsal spines, the medial margin 2 apical spines; rami subequal, both with 2 sparse rows of marginal spines, spines of the apex = 4 and 5; uropod 2 peduncle 0.9× length of outer ramus, bearing, as well as 2 apicolateral spines, single lateral and dorsal subapical spines, 1 dorsolateral spine at M0.7, 1 lateral spine at M0.5 and 1 mid-apical dorsal spine; no apical spines of the medial margin; (outer ramus shorter than inner) (both) with 2 rows of marginal spines of the form 5-1,(1–3), spines of the apex = (4)–5; uropod 3 (lost; similar to others of genus i.e. peduncle much shorter than outer ramus, shorter than urosomite 3, with subdistal seta, an apicolateral cluster of 5 spines, the outer ramus proximal article with several irregular spine/seta ranks, article-2 shorter but similarly armed; inner ramus much shorter than outer (0.4×) with a single apical spine). *Telson* (Fig. 8): 1.3× longer than broad, shorter than urosomite 3 (0.75×); cleft 100% of length; apices barely notched, 2 long penicillate setules and 1 shorter naked seta subapically, dorsal setae at M0.5 and M0.8, single medial seta at M0.6, and a single penicillate setule dorsolateral at M0.6.

Relationship. *Nedsia hurlberti* varies from *N. douglasi* in the shorter relative length of the first antenna and the variable length of the articles of the primary flagellum, no excavation or asymmetry of the upper lip, reduced dentition of the left mandibular incisor, inner plate of the first maxilla with an extra seta, the inner plate of the second maxilla apically pubescent, palp and dactyl of maxilliped more spinose, as are the propodus and dactyl of the gnathopods, absence of a posterior keel like extension of the sixth article of the seventh pereopod, the posterior margins of the epimera sinuous and epimeron 2 bearing an additional ventral seta, pleopods bearing an accessory retinaculum, the telson longer and more slender. *Nedsia hurlberti* differs from *N. straskraba, N. fragilis* and *N. humphreysi* in that the margins of both plates of the second maxilla bear pubescence, from *N. macrosculptilis* and *N. sculptilis* in that the pleon is not sculpted, nor the epimera bearing facial spines, and from *N. urifimbriata* in the presence of few ventrofacial spines on the second and third epimera, a spine like extension of the first urosome at the base of the first uropod, less than six articles of the pleopodal rami, and in the absence of organised comb rows of setae at the base of the dactylus of the maxillipedal palp.

Distribution. Barrow Island, Western Australia.

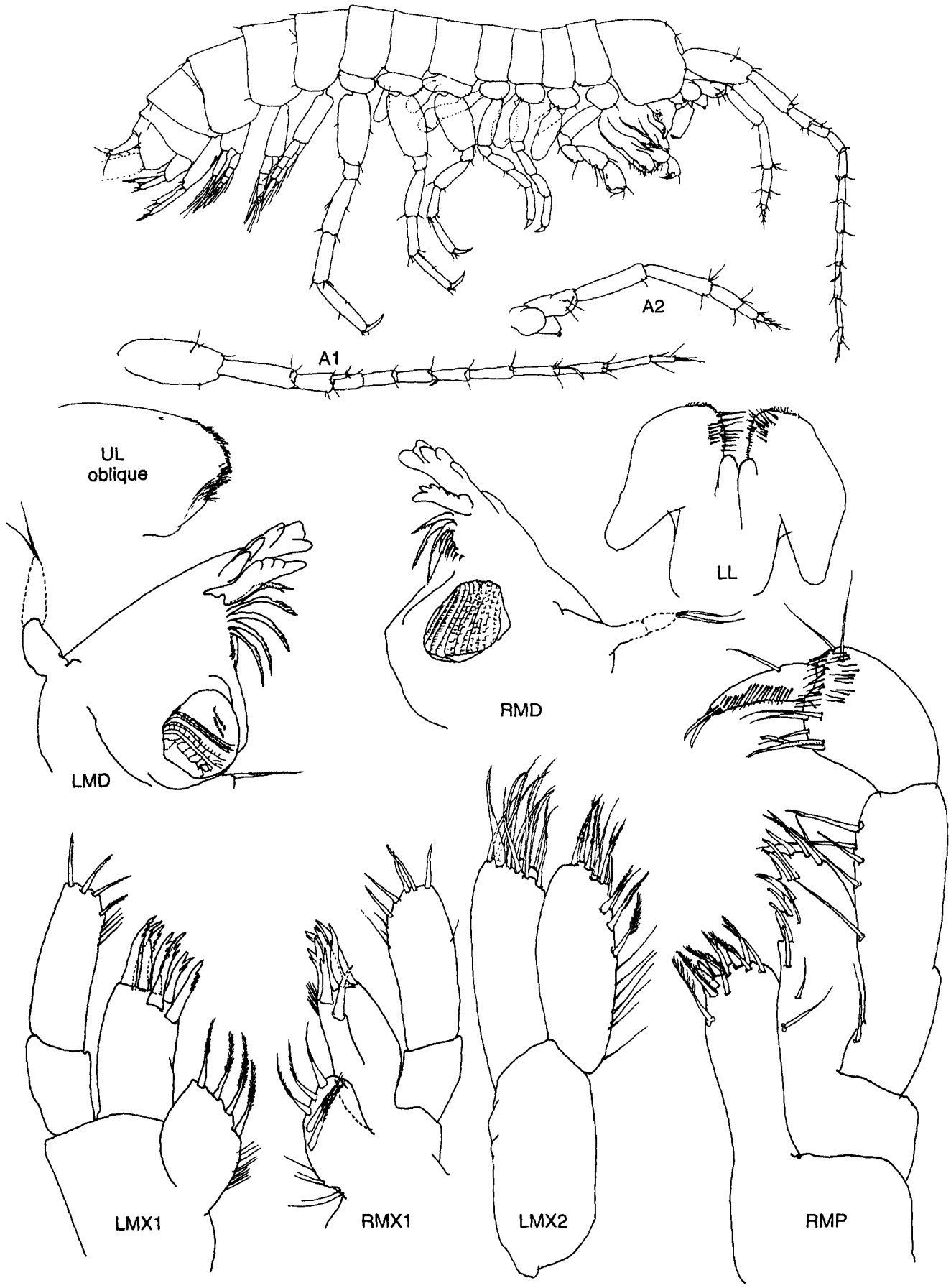

Fig. 9. *Nedsia humphreysi* holotype male 2 mm. Body, antennae, mouthparts.

Nedsia humphreysi n.sp.

Figs 9, 10

Etymology. Named for W.F. Humphreys, biologist, instrumental in the collection of Western Australian cave specimens.

Type locality. Barrow Island, Western Australia, Western Australian Museum sampling site BES710.

Material examined. HOLOTYPE (Western Australian Museum WAM 3-96) male 2 mm.

Diagnosis. Dorsal spines absent from pleonites 4–6. *Head*: lateral cephalic lobes slightly projecting. *Upper lip*: symmetrical, slightly excavate below. *Mandibular palp*: 2-articulate, 2E-setae only; lacking interraker plumose setae *Maxillae*: without pubescence, sparse to moderately setose medially. *First maxilla*: palps asymmetric with thin apical plumose or serrate spines. *Second maxilla*: medial margins sparsely setulate, without pubescence. *Maxilliped*: apex of third article of palp slightly produced, dactyls with moderate nail and accessory spine of almost equal length. *Gnathopods*: (diverse, gnathopod 2 dominant); gnathopod 1 palmar spines bifid, spines at corner of palm submarginal = 2 lateral, 3 medial; palmar margin serrate, with submarginal row of fine setae. *Pereopods*: pereopods 3–4 lacking posterior spine sets on article-6. *Coxal gills*: gills 5–6 smaller but not substantially reduced. Sternal gills absent. *Epimera*: epimera 1–2 with 1, epimeron 3 with 2, posterior spines at the corner, ventrofacial spines absent. *Pleopods*: peduncles without setae, retinaculae = 2-3-2, accessory retinaculae absent. *Uropods*: apicolateral corner of peduncles on uropods 1–2 without spines, dorsal margins spineless, medial margins of both with 1 apical spine; rami of uropods 1–2 without spine rows except for inner ramus of uropod 1. *Telson*: cleft 100%; lobes with a small mid-lateral concavity.

Description of holotype, (male). *Body* (Fig. 9) 2 mm. *Head*: rostrum obsolescent; eyes absent. *First antenna* (Fig. 9): length 0.6× body, 2× antenna-2, flagellum 1.6× peduncle, peduncular article-1 longest without mediodistal spines or setae, article-3 shortest, setae sparse, flagellum of 9 articles, sparsely setulate, no aesthetascs or calceoli; accessory flagellum 2-articulate, article-2 tiny, total length 0.6× article-1 of the primary flagellum; length of articles of primary flagellum variable, article-7 longest. *Second antenna* (Fig. 9): length 0.3× body, peduncle longer than (3×) flagellum, articles 4–5 equally long, articles 3-4-5 with sparse ventral setation, article-3 with apicodorsal setae, no dorsomedial spines. Flagellum 4-articulate, no calceoli. *Upper lip* (Fig. 9): apical margin rounded, symmetrical. *Mandibles* (Fig. 9): left mandibular palp (2-articulate), article-1 very reduced, bud like, naked; incisor 5 toothed; lacinia mobilis with 4 teeth and 6 setose accessory blades; molar triturative with a short distal plumose seta, lacking other setae or pubescence; right mandible palp 2-articulate, article-1 naked, short, bud-like, article-2 reduced, tapered, 2E-setae only; incisor with 5 teeth; lacinia mobilis with 7 denticles their size increasing distally; accessory blades of 3 plumose spines; a line of setae extending onto the base of the molar. *Maxillae* (Fig. 9): *first maxilla,* left palp 2nd article with 5 serrate apical spines, terminally rounded with 3 small to moderate apicomedial setae; right palp article-2 with 4 plumose apical spines, terminally subquadrate, 4 apicomedial setae; outer plate of both sides with 7 terminal spines, some of the left without denticles; left inner plate with 4 apicomedial and apical plumose setae, moderately setose basally; right inner plate with 4 apicomedial and apical plumose setae, moderately setose medially. *Second maxilla,* inner and outer plates devoid of pubescence. *Maxilliped* (Fig. 9): palp article-3 with apical pair of slender setae, 1 marginal, 1 submarginal; medial face with 5 slender setae, the basal pair denticulate. Inner plate without ventrofacial spine. *First gnathopod* (Fig. 10): coxal plate with 1 short seta apically, without posteroventral spines; article-4 posteriorly bulbous, carpus not lobate, propodus trapezoidal, expanding apically, longer than wide, posterior edge almost naked, corner of palm almost square, with 2 lateral and 3 medial spines and several lateral and medial setae set back from the corner; palm convex and serrate; dactylus reaching slightly beyond the corner of the palm. *Second gnathopod* (Fig. 10): coxal plate equal to coxa 1, with a single ventral spine. *Pereopods* (Fig. 10): coxa 3 with 1 anterior and 1 posterior ventral setae only; coxa 4 similar; pereopods 3-4-5 longer than gnathopod 1; pereopods consecutively elongate from pereopods 3–7; ratio of lengths = 137:–:140:155:185:220:270; all pereopods sparsely setose, posterior armaments of article-6 of pereopods 3–4 = 1–0, thus only pereopod 3 with 1 locking spine; pereopods 5–7 significantly longer than pereopods 3–4 with locking spines; 1,2,2; single anterior spines on article 6 of pereopods 6–7, one posterior spine on pereopod 7 only; no keel like expansion of article 6 of pereopod 7; coxae 5 and 7 bearing 1 anterior and 1 posteroventral seta and coxa 6 one anterior seta only; article-2 of pereopods 5–7 weakly expanded posteriorly, each with only 2 setae; dactyls of pereopods 3–7 simple, naked except for outer basal penicillate setule evident on pereopods 4–7 only. *Gills*: of coxae 2–6 flask shaped, of coxae 5–6, smaller, but not reduced. *Pleopods* (Fig. 10): retinaculae present on each pair, arranged 2-3-2, accessory retinaculae absent; peduncles without setae; rami extending equally, outer rami of 4-4-3 articles, inner 4-3-5. No setae bifid. *Epimera* (Fig. 10): each posteroventrally rounded, posterior margins slightly convex, smooth, without setae except for a single seta marking the posterior corner of epimera 1–2 and two on epimeron 3; ventrofacial spines absent; lacking oblique lateral ridge. *Pleon* (Fig. 10): pleonites with few posterior dorsal or lateral setae; pleonite 1 with 1 dorsal, 2 lateral; pleonite 2 with 1 submarginal and 1 marginal dorsal; pleonite 3 with 2 lateral; pleonites 4 and 5 with 1 lateral; pleonite 6 with

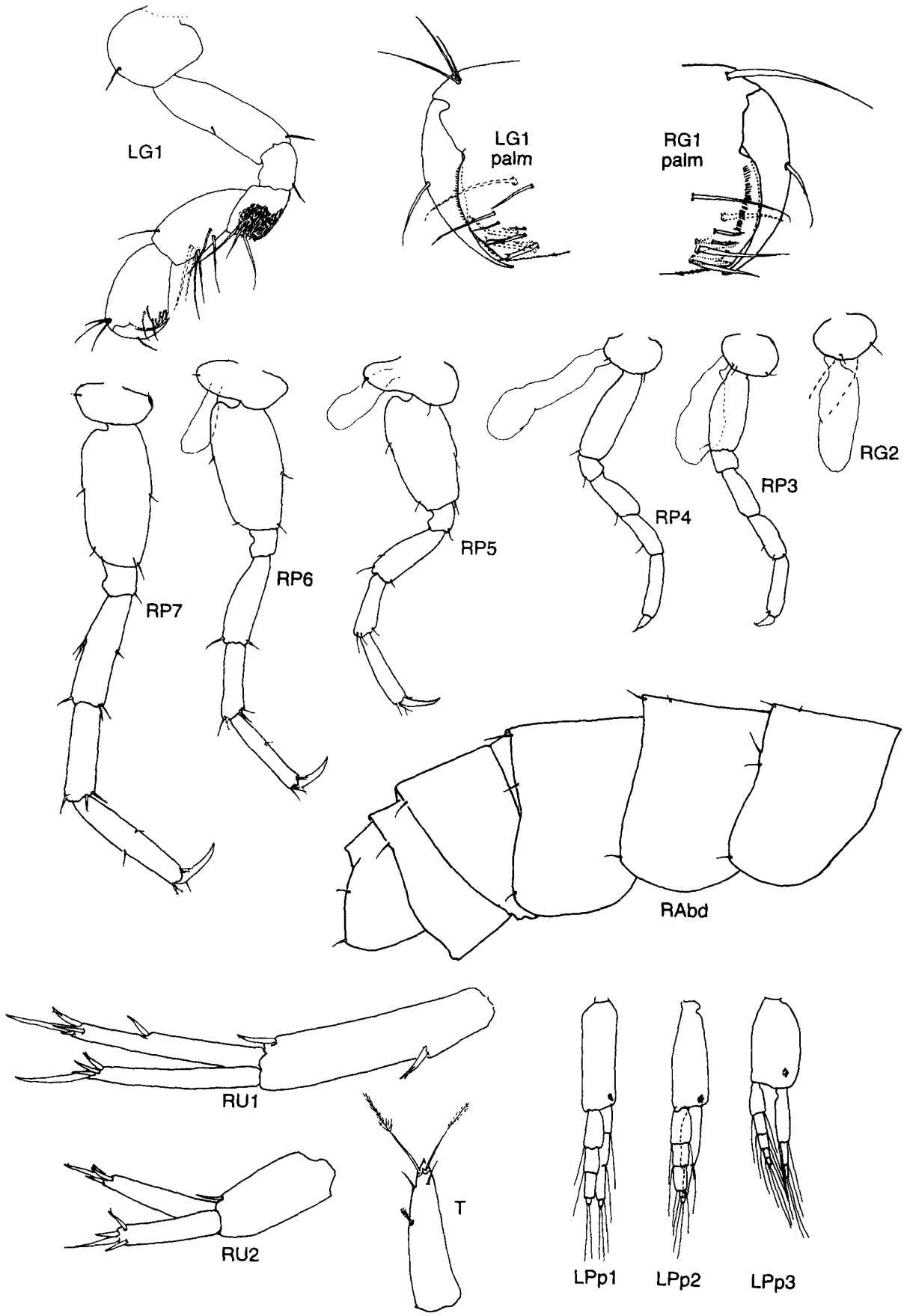

Fig. 10. *Nedsia humphreysi* holotype male 2 mm. Legs, abdomen, pleopods, uropods, telson.

1 mid-lateral and 1 distoventral seta. *Uropods* (Fig. 10): uropod 1 peduncle length 1.4× outer ramus, 1.2× inner ramus, apicodistal spines absent, bearing a single medial subapical spine, and basofacial spine at M0.3; inner ramus only with a mid-medial spine; both rami with 4 terminal spines; uropod 2 peduncle subequal to length of inner ramus, 1 apicodorsal spine slightly subdistal; other spines and setae absent; outer ramus shorter than inner (0.8×), both rami without spines, except 3–4 terminal spines. *Telson* (Fig. 10): longer than broad (1.8×), as long as urosomite 3; cleft 100%; apices pointed, not notched, each with 2 long plumose subapical setae, 2 apical setae, and a single lateral penicillate setule at M0.6.

Relationship. *Nedsia humphreysi* differs from *N. douglasi* in the reduced number of articles of variable lengths of the first antenna and relatively longer second antenna, a symmetrical and non-excavate upper lip, greater number of mandibular setose accessory blades and presence of a plumose molarial seta and basal molarial setae, palps of first maxilla asymmetrical, the inner plate with an extra seta, the second maxilla devoid of pubescence, the inner plate of the maxilliped without a ventrofacial spine, palmar corner of the first gnathopod with fewer armaments, the palm serrate and the dactyl reaching beyond the corner. The coxal plate of the second gnathopod is narrower, posteroventral margins of epimera rounded, epimera lacking ventrofacial spines, first uropod lacking apicodistal spines, second uropod peduncle les spinous, relatively shorter with only a single apicodorsal spine, the telson more slender, the apices pointed, not notched. *Nedsia humphreysi* is similar to *N. straskraba* and *N. fragilis*, but distinct from *N. hurlberti, N. urifimbriata, N. macrosculptilis* and *N. sculptilis*, in that marginal pubescence is not present on both plates of the second maxilla. *Nedsia humphreysi* differs from *N. straskraba* in that the pleonites bear dorsal spines, and from *N. fragilis* in that the first epimeron lacks distolateral spines, the peduncle of the first uropod is without a row of facial spines, the palmar corner of the first gnathopod is subquadrate rather than rounded, and the outer plate of the maxilliped is not tapering and is armed with distinct medial cusps.

Distribution. Barrow Island, Western Australia.

Nedsia urifimbriata n.sp.

Figs 11–13

Etymology. Named for the presence of marginal pubescence on the third uropod.

Type locality. Barrow Island, Western Australia. Western Australian Museum sampling site BES733.

Material examined. HOLOTYPE (Western Australian Museum WAM 4-96) male 2.5 mm. ALLOTYPE female 3 mm.

Diagnosis. *Mandibular palp*: 2-articulate, setae = 2E. *Second maxilla*: inner plate with submarginal mediodistal row of plumose setae barely extending onto the face apically, without medial setae, without pubescence. *Maxilliped*: inner plate with a reduced medial row of 1 faciodistal and 1 barely facial (submarginal) ventral seta; outer plate lacking a blunt naked tooth spine contiguous with distal plumose setae, an additional submarginal facial group of 4 setae at M0.3; palp article-3 with comb rows at the base of the dactyl, the apex weakly produced, dactylar nail moderately long, with a subequal accessory seta. *First gnathopod*: carpus equal to propodus in male, palmar spines symmetrically bifid. *Pereopods*: posterior spine sets of article-6 evenly spaced. *Pleopods*: peduncle 3 with 1 apicolateral seta, basomedial seta of inner rami not bifid; each with 2 retinaculae, no accessory retinaculum. *Epimera*: posteroventral tooth of epimera 1–3 present, posterior margins without setae, without facial spines. *Uropods*: uropods 1–2 apicolateral corners of peduncles with 2 and 1 spines, both rami of both uropods with only a single, poorly represented spine row; uropod 3 without subdistal peduncular setae. *Telson*: cleft 100%, lobes weakly convex laterally and medially; setation subapical, lacking lateral setal spines, single lateral penicillate setules at M0.3–0.5.

Description of holotype (male "x"). *Body* (Fig. 11) 2.5 mm. *Urosome*: poorly armed dorsally. *Head* (Fig. 11): rostrum obsolescent; eyes absent. *First antenna* (Fig. 11): elongate, longer than antenna-2, broken at article-6 of flagellum—broken length 0.6× body, (length > 2× antenna-2); flagellum longer than peduncle, peduncular article-1 longest and bearing a strong mediodistal spine at M0.85, article-3 shortest, ratio of lengths 90:70:30, setae sparse; flagellum of many articles (broken at article-6), uniform, sparsely setulate; calceoli absent, no aesthetascs; accessory flagellum 2-articulate, reaching M0.5 article-1 of primary flagellum, second article tiny. *Second antenna* (Fig. 11): with weak ventral setation, article-3 without dorsomedial spines; flagellum 5-articulate, lacking calceoli. *Upper lip* (Fig. 11): (asymmetrical, weakly excavate below). *Left mandible* (Fig. 11): palp 2-articulate, article-1 shorter than 2 (35:47), article-2 bearing 2 apical E-setae; incisor 5 toothed, lacinia mobilis 5 toothed bearing on the medial face a row of short spines, 4 setose accessory blades and 3 inter-raker plumose setae; molar triturative, with a moderately long distal plumose seta. *Right mandible*: palp absent, incisor 5 toothed and lacinia mobilis 5 toothed with mediofacial spine row as on left side, 4 setose accessory blades and 2 inter-raker plumose setae; molar triturative, without distal plumose seta. *Maxillae* (Fig. 11): first maxilla palp article-2 bearing thin apical and subapical spines, configuration of the left side being; 4 naked, 1 denticulate, and 1 setate, the right side having one less naked spine, the outer plate of both sides with 7 denticulate spines; inner plate with 4 plumose mediodistal setae and 1 subdistal naked seta; second maxilla outer plate apicolateral margin pubescent, inner

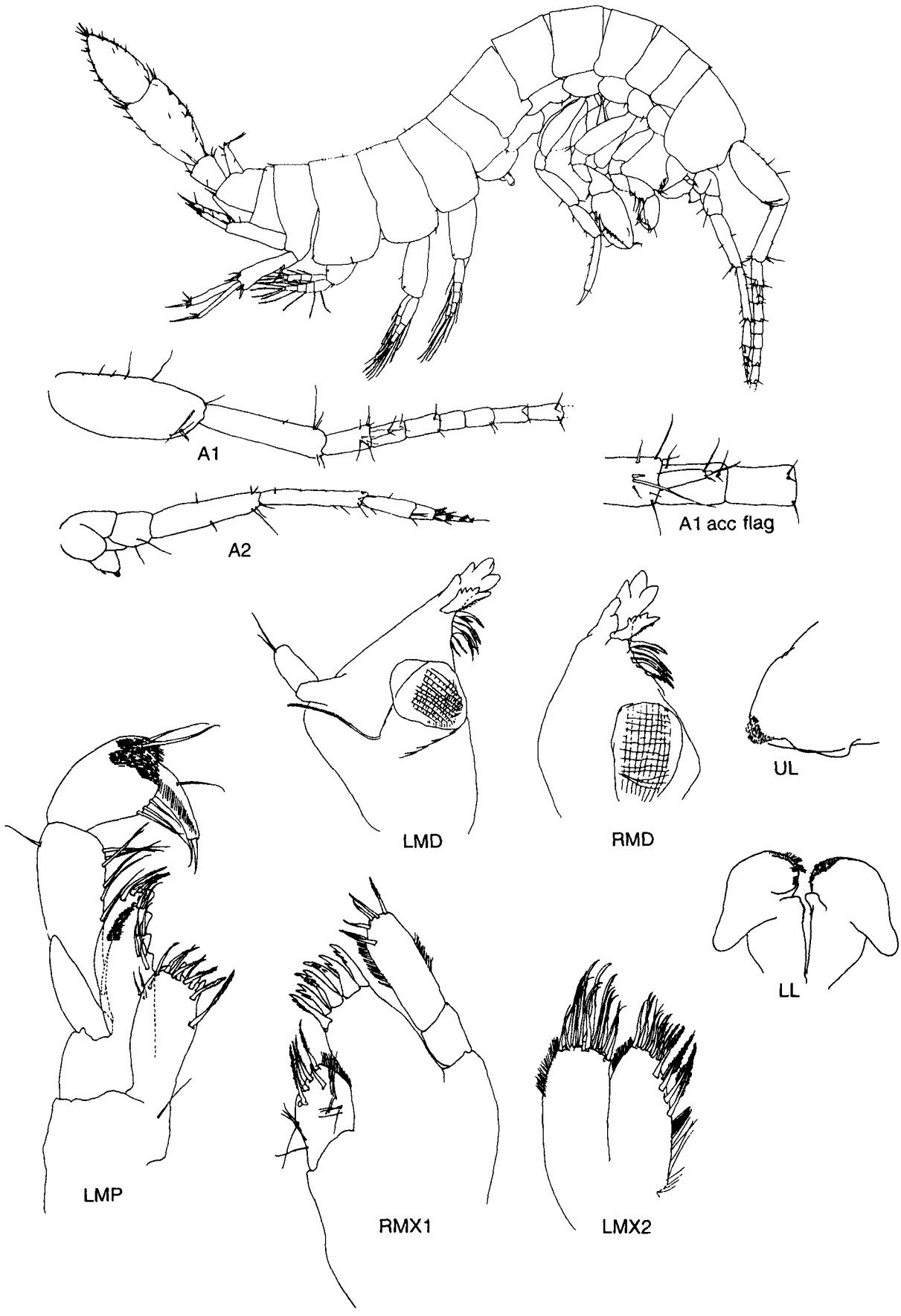

Fig. 11. *Nedsia urifimbriata* holotype male 2.5 mm. Body, antennae, mouthparts.

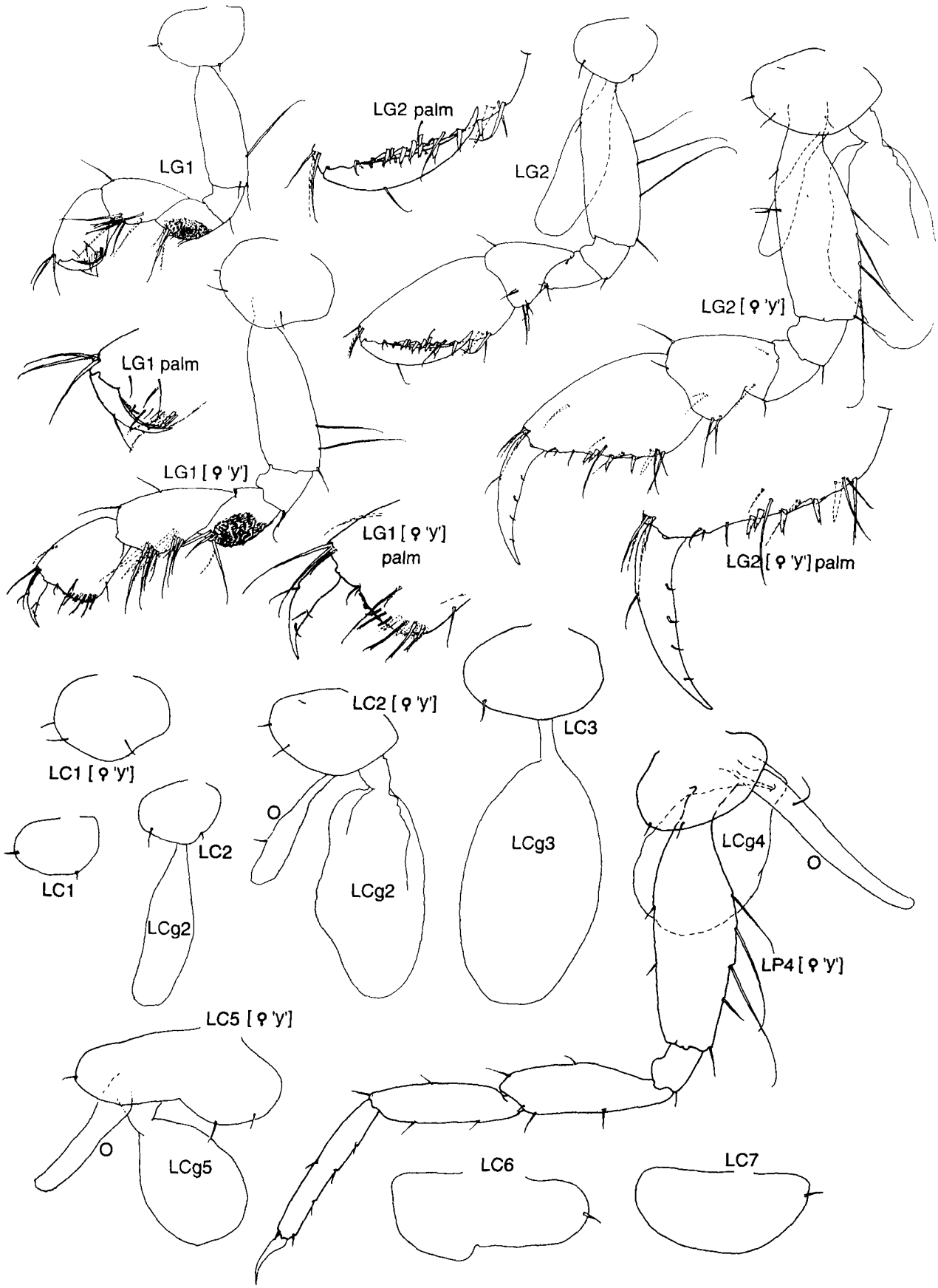

Fig. 12. *Nedsia urifimbriata* holotype male 2.5 mm: all drawings except those indicated as female "y". Legs.

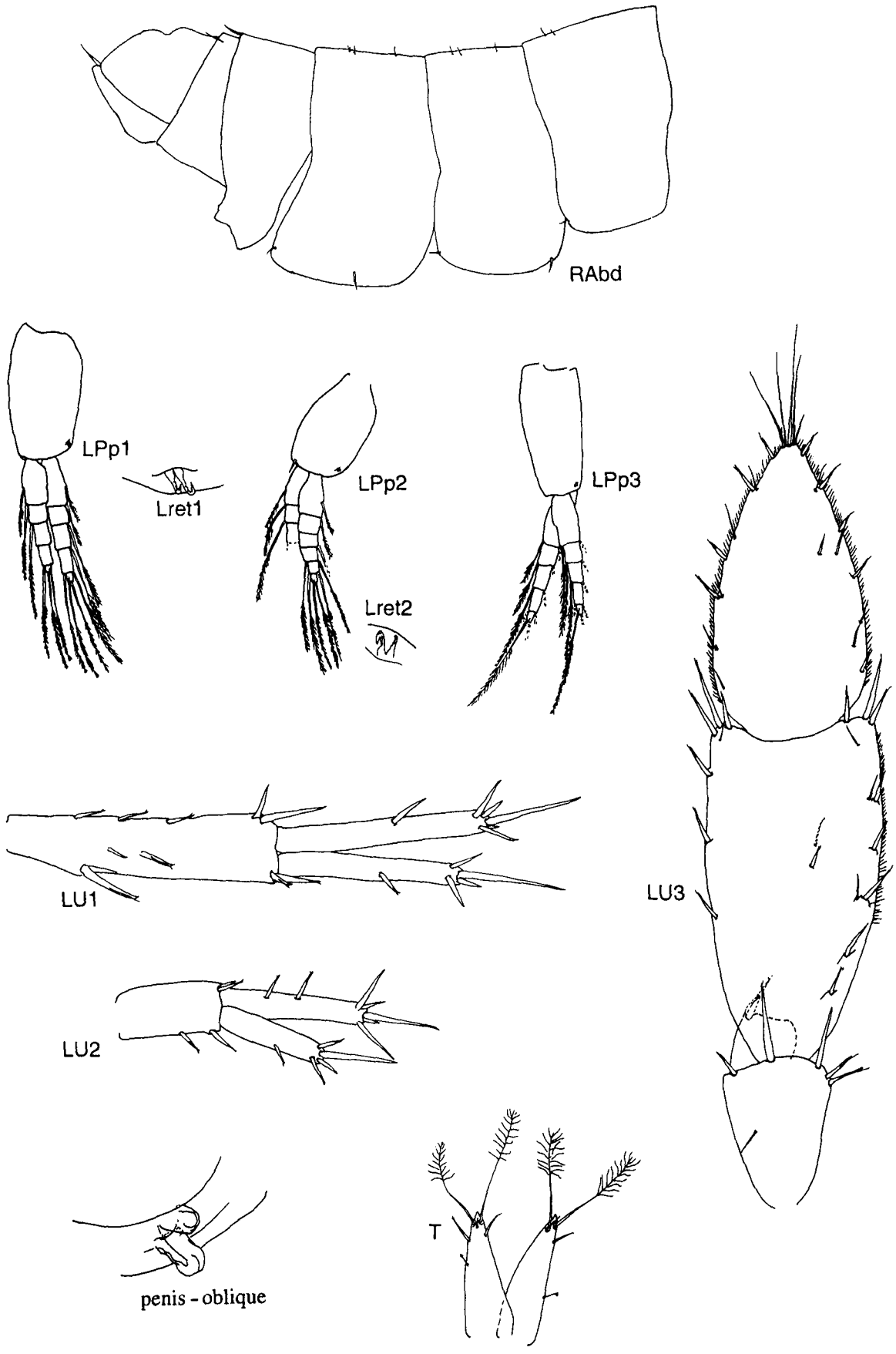

Fig. 13. *Nedsia urifimbriata* holotype male 2.5 mm. Abdomen, pleopods, uropods, telson, penis.

plate basomedial margin pubescent; apical spines of both plates mostly setate, but some naked. *Maxilliped* (Fig. 11): palp article-3 with 3 thin setae on the inner edge, no other facial setae; inner plate with a single mid-medial submarginal plumose spine. *First gnathopod* (Fig. 12): coxal plate bearing 1 or 2 short setae apically and 1 posteroventral spine; article-4 posteriorly bulbous and pubescent; carpus not lobate, propodus trapezoidal, expanding apically, length greater than width, the posterior edge naked; palmar corner rounded, marked by 2 lateral setae and 3 stout, bifid medial spines; palm convex, transverse, lined with fine setules; dactylus reaching slightly beyond the corner of the palm. *Second gnathopod* (Fig. 12): palm bearing 3 lateral and 6 medial spines, the spine at the palmar corner medial; coxal plate no broader than coxa 1, poorly setose. *Pereopods* (Fig. 12): coxa 3 bearing 1 anterior seta only, coxa 4 similar but with 1 small posterior seta; pereopods (3)–4 longer than gnathopod 2, pereopod (3) approximately equal to pereopod 4; articles 4–5 of pereopod 4 sparsely setulose posteriorly; posterior margin of article-6 of pereopods (3)–4 armament formula 1-1-1-1-1, i.e. with 1 locking spine; pereopods 5–7 absent; coxae 5–7 bearing few (1) setae on the ventral margin of posterior lobes; dactyls (3–7) simple as in pereopod 4, but without any basal penicillate setule. *Gills* (Fig. 12): coxal gills of limbs 2–4 flask shaped, none present on coxae 5–6(7); sternal gills absent. *Pleopods* (Fig. 13): peduncle of pleopod 3 only with an apicolateral seta; two retinaculae on each peduncle, without accessory spines; rami extending subequally, all with 5 articles; setae on basal articles = 3 for all rami, none bifid. *Epimera* (Fig. 13): epimera 1 and 3 posteriorly quadrate, epimeron 2 more rounded; posterior margins of epimera 1–2 weakly convex, of epimeron 3 linear; smooth, not setulose with no ventrofacial spines, lacking an oblique ridge. *Pleon* (Fig. 13): pleonites 4 and 5 with distolateral posterior seta, pleonite 6 with distoventral spine. *Uropods* (Fig. 13): uropod lengths relative to uropod 1 (300)—uropod 2 (165) = 0.55×, uropod 3 (485) = 1.6×; uropod 1 peduncle length 1.3× inner ramus, outer margin without an apicodistal spine, with 2 apicomedial and 2 apicolateral spines, bearing a short row of 2 dorsal and 3 medial spines; rami of subequal length (lateral : medial = 116:130), both rami bear a single mid-dorsal spine, medial ramus with 5 terminal spines, the lateral with 4; uropod 2 peduncle 0.7× length of inner ramus, no apicodorsal spines, 1 mid-lateral spine, 1 sub-apicolateral spine, and 2 apicomedial spines; outer ramus shorter than inner (70:95), both with marginal spines; lateral ramus with 1 mid-lateral spine, medial ramus with 2 medial spines; apices of rami with 4 (lateral) and 5 (medial) terminal spines; uropod 3 peduncle length 0.24× outer ramus, shorter than urosomite 3 (47:52), with no subdistal setae, an apicolateral group of 3 spines, single mid-distal spine, single apicomedial spine, and single small mid facial spine; outer ramus lateral margins of both articles and medial margin of distal article, bearing short, marginal pubescent fringe; proximal article with several irregular spine-seta ranks, these submarginal laterally, a pair of mid-facial setae, sparse medial setae, 3 apicolateral and 3 apicomedial setae, terminal article shorter (190:200), similarly armed, distally with a group of 4 long and 2 short setae. *Telson* (Fig. 13): 1.5× longer than broad, as long as urosomite 3, cleft 100%; apices minutely notched, subapices each with 2 long distal plumose setae, 2 or 3 distal and marginal setae, each lobe bearing a single penicillate setule at M0.3 or 0.5. Small penial processes borne on sternum of thoracic article-7 (Fig. 13).

Description of allotype (female "y"). *Body* 3 mm. *First gnathopod* (Fig. 12): coxa with 2 anterior setae, article-2 with 2 long posterior setal spines and 1 distal seta, merus with elongate seta of the pubescent posterior lobe and short setae anterodistally; carpus bearing 12 rather than 9 long spines, propodus and dactyl more spinous than male. *Second gnathopod* (Fig. 12): more setose and spinous than male; coxa without posterior seta, bearing 3 (rather than 1) anterior setae. *Oostegites* (Fig. 12): gnathopod 2–pereopod 5 each bearing a simple strap like oostegite with few setae or spines.

Relationship. *Nedsia urifimbriata* differs from *N. douglasi* in that the peduncle of the first antenna bears a strong mediodistal spine, the second antenna is slightly longer, the molar is triturative with a moderately long distal plumose seta, the palps of the first maxilla are symmetrical, the maxillipedal palp bears an extra medial seta, the inner plate a single mid-medial, submarginal plumose spine, the first gnathopod bears fewer palmar spines, the dactyl reaches beyond the palmar corner, the palm of the second gnathopod bears more spines, apical setae of the peduncles of the pleopods are present on pleopod 3 only, the first uropod lacks an apicodistal spine, and the rami with single mid-dorsal spines each, the peduncle of the second uropod is relatively short, without apicodorsal spines, and the telson longer than wide, as long as urosomite 3. *Nedsia urifimbriata* differs from *N. straskraba, N. fragilis* and *N. humphreysi* in the presence of marginal pubescence on both pates of the second maxilla, from *N. hurlberti* in the presence of ventral submarginal spines on the second and third epimera, of organised comb rows of setae at the base of the maxillipedal dactyl, and of more than six flagellar articles on the pleopods, and in the absence of a spine like extension of the first urosome at the base of the first uropod. *Nedsia urifimbriata* differs from *N. macrosculptilis* and *N. sculptilis* in the presence of anterior spines, but absence of setae, on the first coxal plate, the absence of dorsal setae on the telson and of sculpturing of the pleon, and in possessing a long outer plate on the maxilliped.

Distribution. Barrow Island, Western Australia.

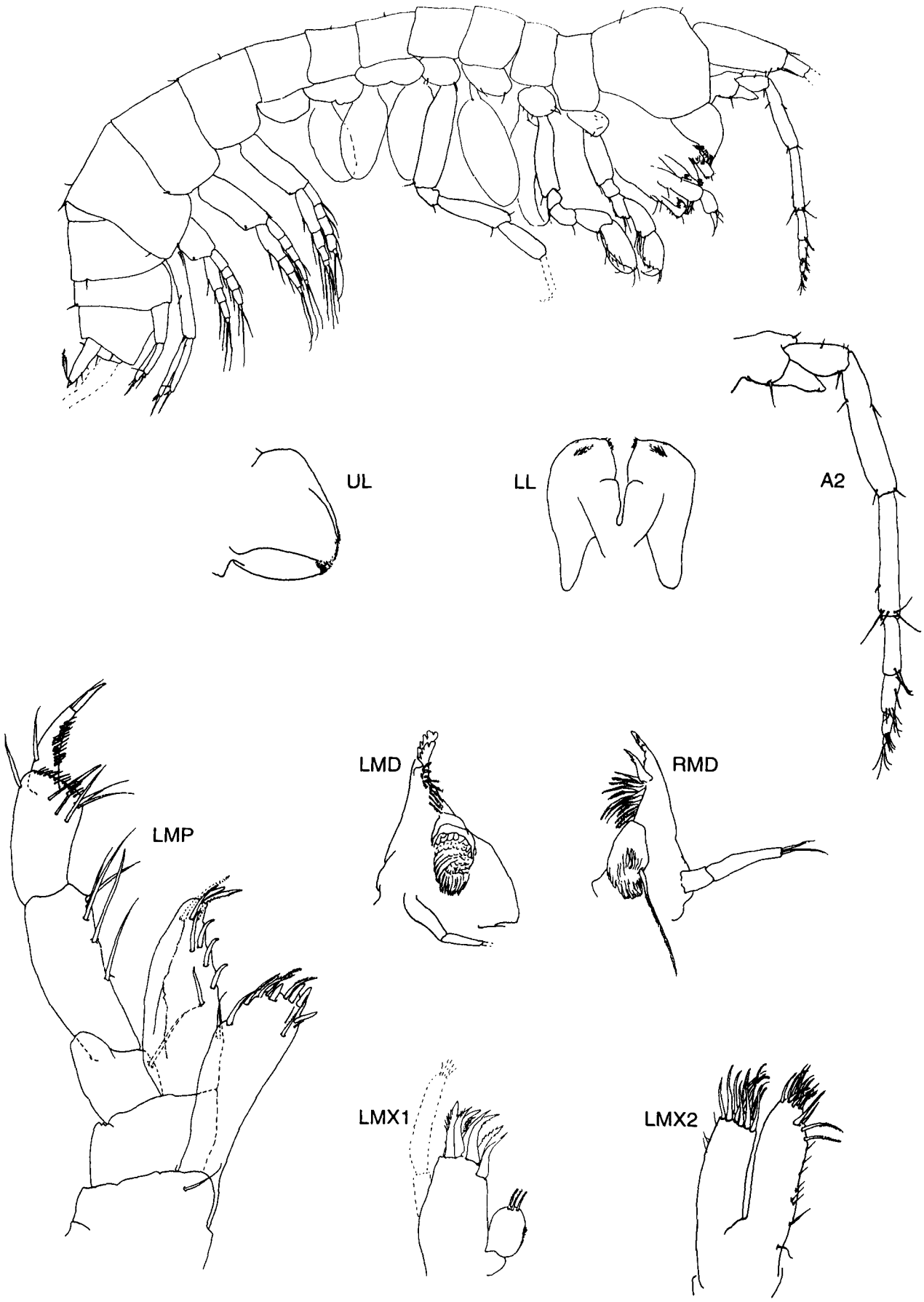

Fig. 14. *Nedsia fragilis* holotype male 2.4 mm. Body, antenna, mouthparts.

Nedsia fragilis n.sp.

Figs 14, 15

Etymology. Named for the fragile nature of the appendages.

Type locality. Barrow Island, Western Australia., Western Australian Museum sampling site BES738.

Material examined. HOLOTYPE (Western Australian Museum WAM 5-96), male 2.4 mm.

Diagnosis. *First antenna* (broken in type specimen): ratio of peduncular articles = 82:23:–. *Upper lip*: symmetrical, not excavate below. *Right mandible*: bearing inter-raker plumose setae, *left mandible* without; palp 2-articulate, article-1 reduced, subtruncate; article-2 linear, subtruncate, setae = 2E. *Maxillae*: inner plate of both maxillae without pubescence of medial or lateral margins; outer plate of first maxilla bearing 5 denticulate and 2 naked terminal spines. *Coxae*: coxa 1 longer than broad, slightly expanded below, coxa 2 lacking posterior marginal spines, coxae 3–4 with posterior spines. *Maxilliped*: inner plate with distal row of 4 plumose setae, lacking medial plumose setae; outer plate medial margin barely sinuous, paired submarginal setae curved and blunt, reduced in number; apex of palp article-3 not produced, setae not organised into combs; dactyl bearing a row of comb setae, single dorsal spine seta, moderate nail and equally long accessory spine. *First gnathopod*: palmar spines curved, not bifid except at palmar corner where spines = 3 lateral, 2 medial. *Second gnathopod*: defining corner of palm bearing 1 long lateral seta and 1 slender medial trigger spine. *Epimera*: posteroventral tooth present on epimera 2–3, epimeron 3 with small ventromarginal spine at M0.6. *Pleopods*: peduncles without setae, basomedial setae of inner rami not bifid, 2 retinaculae on each peduncle, without accessory retinaculum. *Uropods*: dorsal margins of peduncles of uropod 2 not spinous, spine rows of rami reduced to 0 or 1 spine each. *Telson*: cleft 100%; single distolateral spine at M0.8; single lateral penicillate setule at M0.7 on either lobe.

Description of holotype (male). *Body* 2.4 mm. *Urosome*: poorly armed dorsally. *Head* (Fig. 14): rostrum obsolescent; eyes absent. *First antenna* (Fig. 14): ratio of peduncle articles = 82:23:–. Setae of peduncular article-1 limited to single dorsal and ventral sub marginal setae, one submarginal ventral and one long mediodistal setae; article two naked. *Second antenna* (Fig. 14): length 0.3× body, peduncle longer than flagellum, article-4 longer than article-5 (63:52), articles 3-4-5 with weak ventral setation, article-3 with 1 dorsomedial spine, flagellum of 4 articles, without calceoli. *Upper lip* (Fig. 14): apical margin rounded, not excavate, connection to epistome symmetrical. *Mandibles* (Fig. 14): left mandibular palp of 2 articles (broken), incisor 5 toothed, lacinia mobilis 5 toothed, 6 barely setose accessory blades, no inter-raker plumose setae; molar triturative, lacking distal plumose seta, slight pubescence around base of accessory blades; right mandible incisor 5 toothed, lacinia mobilis denticulate, accessory blades of 6 plumose spines; molar triturative, with distal plumose seta; palp 2-articulate, reduced, ratio of articles 2:16, articles truncate, naked, terminal article with 2 E-setae only. *Maxillae* (Fig. 14): first maxilla palp article-2 bearing (5 spines), outer plate with 7 spines; 2 naked, 5 denticulate, inner plate (bearing fine medial setae); second maxilla outer plate, outer apical margin lacking pubescence with few fine setae; inner plate lacking pubescence; terminal spines of both plates half rastellate, half finely setulate. *Maxilliped* (Fig. 14): palp article-3 with a pair of long subterminal setae medially, diagonal distal row of 3 facial setae, apex with subterminal transverse row of unorganised comb setae; nail of moderate length with an accessory spinule of equal length; palp article-2 bearing mid-medial serrations; inner plate with a pair of plumose facial spines and two distal submarginal medial spines, one small and sharp the other moderate, stout and blunt. *First gnathopod* (Fig. 15): coxal plate with 1 moderate apical seta, several (3) anterior and posterior (2) facial setae, without a posteroventral spine; article-4 posteriorly bulbous and pubescent; carpus not lobate; propodus trapezoidal, slightly expanded apically, longer than wide; posterior edge naked except for an apical pair of long setae basal to the dactyl; palmar corner rounded, marked by 3 naked lateral spines and 2 stout bifid medial spines; palm convex, finely serrated, dactylus reaching the end of the palm. *Second gnathopod* (Fig. 15): palm with 4 setae; 2 lateral, 2 medial, the fourth marking the corner medially, along with a strong elongate lateral spine; palm finely serrate along most of its length; dactyl bearing a single dorsal spinule at M0.3, and small bent spinule laterofacial at M0.6; coxal plate 2 broader than coxa 1, poorly setose with 1 posteroventral marginal spine and a ventrofacial spine both at M0.6, as well as a single anteroventral spine at M0.1. *Pereopods* (Fig. 15): coxa 3 with 1 anteroventral spine, 1 posteroventral submarginal seta-spine; coxa 4 similar; pereopods (3)–4 longer than gnathopod 2, pereopod (3) equal to pereopod 4; pereopod 4 articles 4–5 sparsely setose posteriorly, (pereopods 5–7 similar, consecutively elongate, with 2 locking spines, pereopod 7 article-6 anterior spines displaced by an anterior keel); coxae 5–7 bearing no setae on ventral margins of the posterior lobes, article-2 weakly expanded, (not lobate but extended posteriorly, with thin, short posterior setae); coxae 3–7 dactyls simple, with no accessory spinules. *Gills*: coxal gills of limbs 2–6 flask shaped, simple, gill 6 not reduced, gill coxa 2 largest, gill coxae 5–6 smallest but not significantly reduced. *Pleopods* (Fig. 15): two retinaculae per pleopod, with no accessory retinaculae; peduncle 2 only with apicolateral seta; rami extend subequally, outer rami with 5 articles each, the inner with 5-4-4; setae of the basal articles = 1-1-1-1-, none are bifid. *Epimera* (Fig. 15): each posteroventrally quadrate, though epimeron 2 barely so; posterior margins scarcely convex, smooth, and barely setulose; epimeron 3 with 1 ventrofacial spine, lacking lateral oblique ridge.

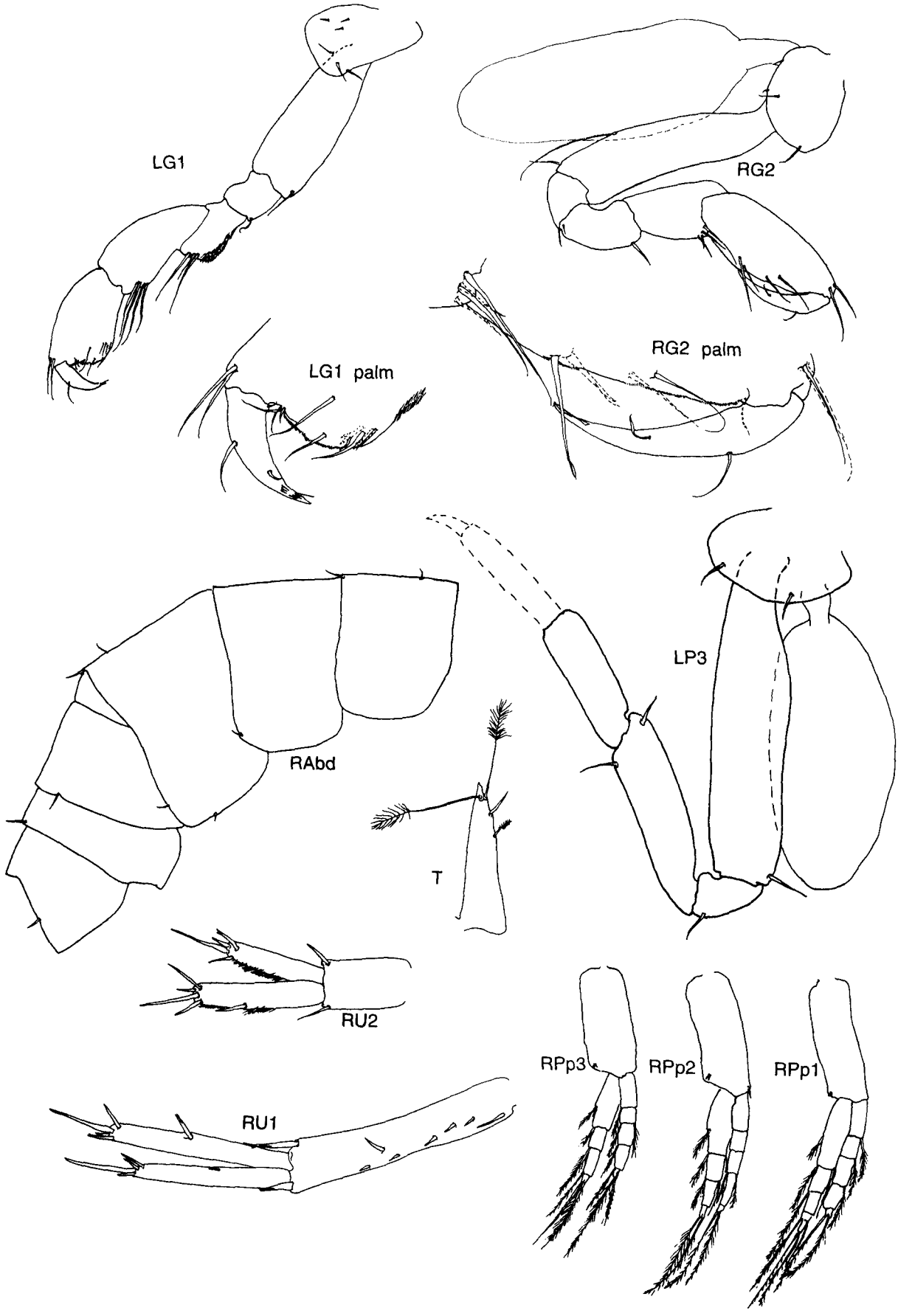

Fig. 15. *Nedsia fragilis* holotype male 2.4 mm. Legs, pleopods, uropods, telson, abdomen.

Pleon (Fig. 15): pleonite 2 only without dorsal or dorsolateral posterior setae; pleonite 6, no dorsolateral or distoventral spines. *Uropods* (Fig. 15): lengths relative to uropod 1—uropod 2 = 0.5, uropod 3 absent; uropod 1 peduncle length 1.3× medial ramus, outer margin with a row of 5 small submarginal spines and 1 moderate laterofacial spine at M0.6, single apicomedial and apicolateral trigger spines, basofacial spine weak, the medial ramus longer than the lateral; both rami with sparse setation, terminating in 4 spines; peduncle of second uropod 0.6× length of inner ramus, single apicomedial and apicolateral spines; medial margin of both rami pubescent; outer ramus shorter than inner (62:81), both bearing few marginal spines and 4 terminal spines; uropod 3 absent. *Telson* (Fig. 15): length 1.6× width, as long as urosomite 3, cleft 100%; apices notched, subapices with 2 long plumose setae; 1 marginal seta at M0.8, each lobe bearing a single penicillate setule marginal at M0.7.

Relationship. *Nedsia fragilis* varies from *N. douglasi* in the relative length of the second antenna, the greater length of the second peduncular article, the presence on the third article of a dorsomedial spine, a round and symmetrical upper lip, mandible bearing additional accessory blades, the molar bearing a distal plumose seta, palp of right mandible with elongate first article, second maxilla lacking pubescence, terminal spines of both plates either rastellate or terminally setulate, first gnathopod palmar corner rounded not square, with fewer medial spines, palm of second gnathopod with fewer spines, retinaculae of pleopods not associated with an accessory, rami of pleopods with fewer articles, epimera 2–3 without ventrofacial spines, pleonite 6 without dorsolateral or distoventral spinules or spines, basofacial spine weak, peduncle of the second uropod short and less spinous, rami marginally pubescent with fewer terminal spines, telson more slender. *Nedsia fragilis* differs from others of the genus in lacking marginal pubescence on both plates of the second maxilla, except for *N. straskraba*, from which it differs in possessing dorsal pleonal spines, and from *N. humphreysi* in lacking distolateral spines on the first epimeron, possessing a row of facial spines on the peduncle of the first uropod, the outer plate of the maxilliped tapers apically and is weakly cuspidate, and the palmar corner of the first gnathopod is rounded.

Distribution. Barrow Island, Western Australia.

Nedsia macrosculptilis n.sp.

Figs 16–18

Etymology. Named for the deep sculpturing of the pleon.

Type locality. Barrow Island, Western Australia, Western Australian Museum sampling site BES786.

Material examined. HOLOTYPE (Western Australian Museum WAM 6-96) female 5.5 mm Barrow Island, Western Australia.

Diagnosis. *Pleonites 5–6*: with 3 pairs of small dorsolateral spines. *Head*: rostrum absent, lateral cephalic lobes moderately projecting. *First antenna*: ratio of peduncular articles about 3:3.5:1. *Upper lip*: symmetrical, apically rounded. *Mandible*: palp of 2 small articles, truncate, cone like, setae of article 2 = 2E; accessory blades (rakers) = 5 right or 6 left with 3 right and 4 left interraker plumose setae between each main raker. *Maxillae*: first maxilla inner plate facially pubescent with 8 plumose medial setae, both plates of the second maxilla with distolateral fine pubescence, outer plate with fine pubescence medially. *Maxilliped*: medial setae of inner plate submarginal to facial, with 1 short, naked, submarginal spine at the base of the first of these, medial margin of face of outer plate scalloped and bearing rugosities; palp third article apex setae not organised to comb rows, apex not produced; dactyl facially setose with 2 medial and 1 terminal accessory spines, the latter as long as the moderate nail. *Coxae*: coxae 1–4 lacking posterior spines. *First gnathopod*: palmar spines symmetrically bifid, and without triggers, spines at corner of palm = lateral 4 long and medially a continuous row of 5 bifid and 2 naked spines, palmar edge finely serrated anteriorly. *Second gnathopod*: enlarged, 2× gnathopod 1, carpus moderate, shorter than propodus; defining corner of palm with 1 enlarged spine. *Epimera*: posterior margin of epimeron 3 sculptured; epimera with facial and ventral submarginal spines. *Coxal gills*: 5–6 reduced slightly. *Uropods*: rami of uropods 1–2 with 2 spine rows; uropod 3 medial setae of outer ramus moderately long; spines of peduncle apical and mid-lateral. *Telson*: cleft 100%.

Description of holotype (female). *Body* (Fig. 16) 5.5 mm. *Pleon*: pleonite 6 with 3 dorsolateral spines and 2 distoventral spines; pleonite 5 with 4 dorsolateral spines. *Head*: rostrum obsolescent; eyes absent. *First antenna* (Fig. 16): length about 1.5× body, 2.9× antenna-2, flagellum longer than peduncle, peduncle article-2 longest, 3 shortest, article-1 bearing a strong mediodistal spine; setae moderate, flagellum of many articles (44), and a few aesthetascs; accessory flagellum 2-articulate, 2nd article tiny; article-1 of primary flagellum fused, other articles shortest proximally, longest distally. *Second antenna* (Fig. 16): moderately short, length 0.4× body; peduncle longer than flagellum, articles 4–5 equally long, with weak ventral setation, article-3 without dorsomedial spines; flagellum 5-articulate, lacking calceoli. *Upper lip* (Fig. 16): apical margin convex, slightly extended, spinose and pilose, connection to epistome symmetrical. *Left mandible* (Fig. 16): left mandible palp missing, incisor 5 toothed, lacinia mobilis 5 toothed and very broad; 6 setose accessory blades; molar with distal plumose seta, triturative, an area of pubescence leading from accessory blades to the base of the molar. *Right mandible*: palp 2-articulate, reduced,

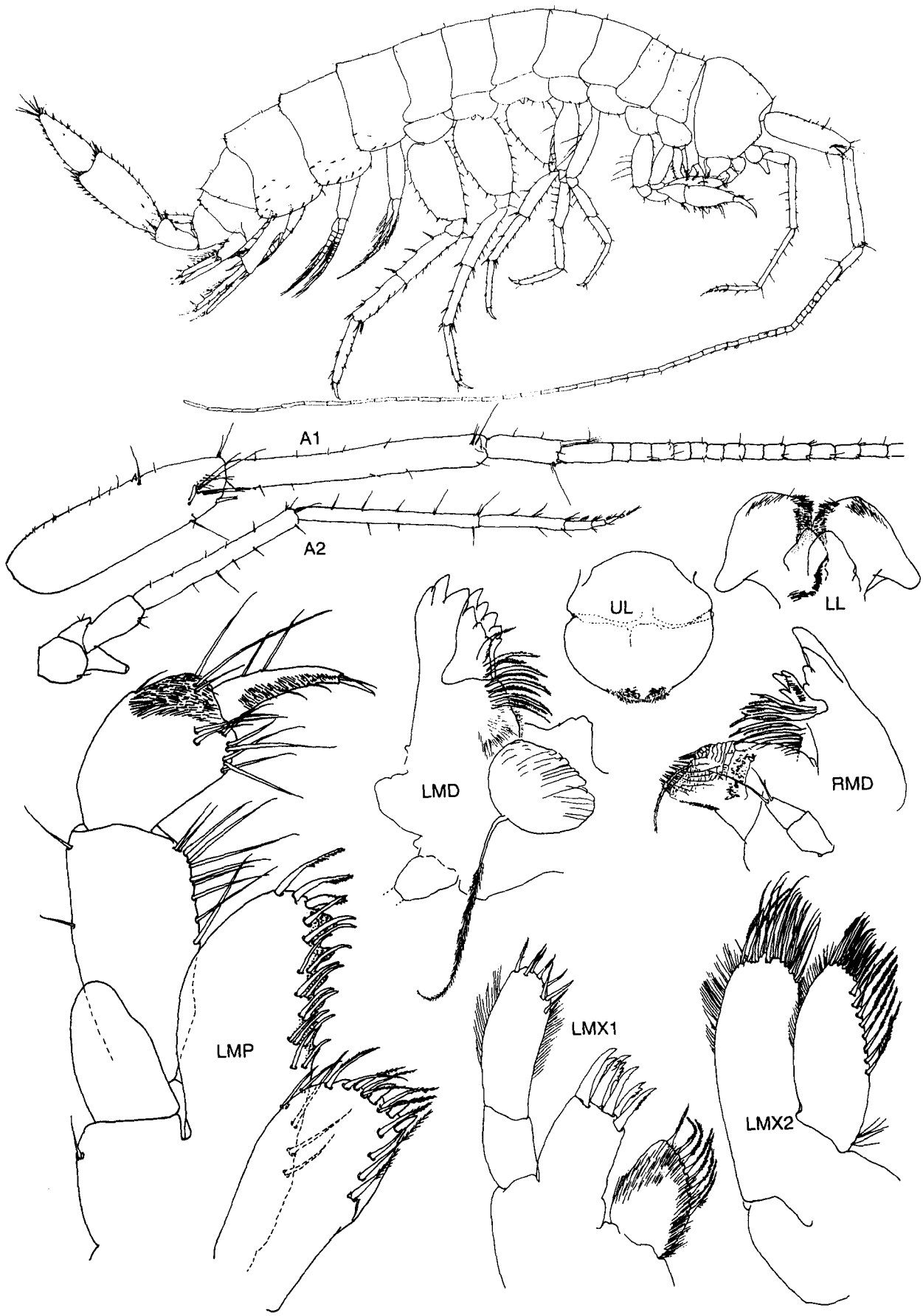

Fig. 16. *Nedsia macrosculptilis* holotype female 5.5 mm. Body, antennae, mouthparts.

article-1 short, naked, second article tapered, setae = 2E; lacinia mobilis with 3 smooth teeth and small denticle medial between 1st and last tooth, 5 setose accessory blades and 3 plumose interraker setae; line of pubescence leading to edge of molar. *Lower lip* (Fig. 16): bearing prominent inner lobes, outer lobes apically pilose and spinose. *First maxilla* (Fig. 16): right and left palp article-2 bearing 4 naked thin apical setae, 3 with fine distal setulate rugosities, and 1 plumose thin apical seta; outer plate with 6 denticulate, and 1 naked spines; inner plate ovate and pubescent, with 8 medial plumose setae. *Second maxilla*: both plates with the outer margin pubescent, as well as the median distal margin of the outer plate; basomedial margin of the inner plate with 5 fine setae grouped 2,3. *Maxilliped* (Fig. 16): palp article-3 with 2 thin, moderately long setae subdactylar on the inner face, and a longer pair on the outer face; article-3 moderately setose distally leading to the base of the dactyl. *First gnathopod* (Fig. 17): coxal plate with 5 short setae apically, without posterior ventral spines; article-4 posteriorly bulbous, marginally pubescent, but without a hyaline lobe; carpus not lobate, propodus trapezoidal, slightly expanded apically, longer than wide, posterior margin almost naked with 2 setae only; corner of palm rounded, not clearly defined, with row of 4 lateral setae, medially 2 naked spines and 5 bifid spines; palm convex, dactyl not reaching corner. *Second gnathopod* (Fig. 17): palm strongly oblique with 5 lateral and 2 medial spines all unevenly bifid with triggers; defining spine near corner medial, dactyl reaching spine, but not corner of palm; coxal plate broader than long, 4 anterior, 1 posterior setae. *Pereopods* (Fig. 17): coxa 3 with 3 anteroventral setae, similar; coxa 4 with 4 similar setae; pereopods 3–4 longer than gnathopod 2 (287,250:215), pereopod 3 shorter than pereopod 4, articles 4,5 sparsely setose posteriorly; posterior armament formulae of pereopods 3–4; S,S,S,S,S,0 and S,S,sS,S,S,S thus with a single locking spine on pereopod 4 only; pereopods 5–7 similar but consecutively elongate, each with 3 locking spines; slight inward expansion of the anterior spines of article-6 of pereopod 7 revealing a slight keel; coxae 5–7 bearing single posteroventral setae on posterior lobes; article-2 of pereopods 5–7 moderately expanded, not lobate, but extended posteriorly, bearing short but moderately stout posterior setae; dactyls of pereopods 3–7 simple with single basal outer penicillate setule, and no accessory setules. *Gills*: of coxae 2–6 flask shaped, gills 5–6 smaller but not significantly reduced; gill 4 largest, gills 5–6 smallest. *Oostegites* (Fig. 17): of coxae 2 small, 3–5 thin, strap like, only those of coxa 5 with a few small setae. *Pleopods* (Fig. 18): retinaculae 2 each, no accessory retinaculae; peduncle of the first pleopod with no setae, of the second with 1 seta, of the third with 4; setae unevenly bifid with triggers; rami extending equally, the inner with 10,10,9 articles, the outer with 11,11, 10 articles. Setae on basal articles of rami = 1-1,1-1,1-0. *Epimera* (Fig. 18): epimera 1–2 posteroventrally subquadrate, epimeron 3 slightly lobate; posterior margins slightly convex, of epimeron 1 smooth, of epimeron 2 sculptured at the posteroventral corner and posteriorly sinuous, of epimeron 3 finely sculptured posteriorly; epimera with facial and submarginal spines, posterior corners marked with 2-2-1 spines, each lacking an oblique ridge, but with an incomplete row of facial spines. *Pleon* (Fig. 18): pleonites 1–4 bearing dorsal and dorsolateral posterior setae, and posterior margins sculptured into sharp serrations; pleonites 4–6 with lateral and/or dorsolateral posterior spines—pleonite 4 with 2 lateral, pleonite 5 with 4 dorsolateral, pleonite 6 with 3 dorsolateral as well as 2 blunt ventrolateral spines. *Uropods* (Fig. 18): uropod 3 strongly extended in entire animal; uropod lengths relative to uropod 1—uropod 2 = 0.6×, uropod 3 = 1.3×; uropod 1 peduncle length subequal to inner, longer ramus (175:165), outer margin with 1 long apicodistal spine besides a row of 6 dorsal spines (the 6th spine subapical), one apicomedial spine and a medial row of 7 spines (the 7th spine subapical); rami of uropod 1 subequal in length, the medial ramus being the longer (155:165); both rami with two rows of marginal spines, and 5 terminal spines, distal margins of the inner ramus finely pubescent; uropod 2 peduncle 0.85× length of inner (longer) ramus, outer margin with 1 apicodorsal and 1 apicoventral spines, dorsolateral row of 5 unevenly spaced spines, medial margin with 2 apicoventral spines and 2 subdistal apicodorsal spines, 1 mid submarginal spine and a single basomarginal spine at M0.3; outer ramus shorter than inner, both with 2 rows of marginal spines in formulae 4,3 and 3,7; distolateral and medial margins of the outer ramus and both margins of the inner ramus finely pubescent; both rami terminating in 4 apical spines; uropod 3 peduncle length 0.24× outer ramus, longer than urosomite 3 (50:40), bearing an apical cluster of 4 dorsolateral spines, 1 mid-lateral spine; all spines marginal; outer ramus proximal article long, 2.3× peduncle, with lateral and medial marginal trigger spines, regularly spaced, an irregular, medial submarginal row of 4 small spines, one displaced toward the mid line, the medial and lateral apices each with a cluster of 4 spines extending partially across the distal margin; article-2 shorter, 0.8× article-1, margins bearing regularly spaced trigger spines, paired distally, the mediodistal and apical margins setate, setae increasing in length distally and with a single apical plumose seta; inner ramus scale like, of 1 article, length 0.1× the length of the proximal article of the outer ramus (16:117), bearing 1 short and 1 medium length apicolateral trigger spines and 1 postero-mid-lateral, submarginal medium-length trigger spine. *Telson* (Fig. 18): length 2.9× width, longer than urosomite 3 (47:40), cleft 100% of its length; subapices with sinuous lateral notch, long, paired, plumose setae arising subapically, a short row of 2 distal medial setae, 3 lateral trigger spines and weak dorsal setation; single small submarginal lateral penicillate setule at M0.6 on either lobe.

Relationship. *Nedsia macrosculptilis* varies from *N. douglasi* in that the pleon is more spinous and setous, the posterior margins of pleosome 1–4 finely sculpted and setate and of 5–6 dorsolaterally spinous, the flagellum of the first antenna extremely long bearing aesthetascs, the second peduncular article is longest, the first article

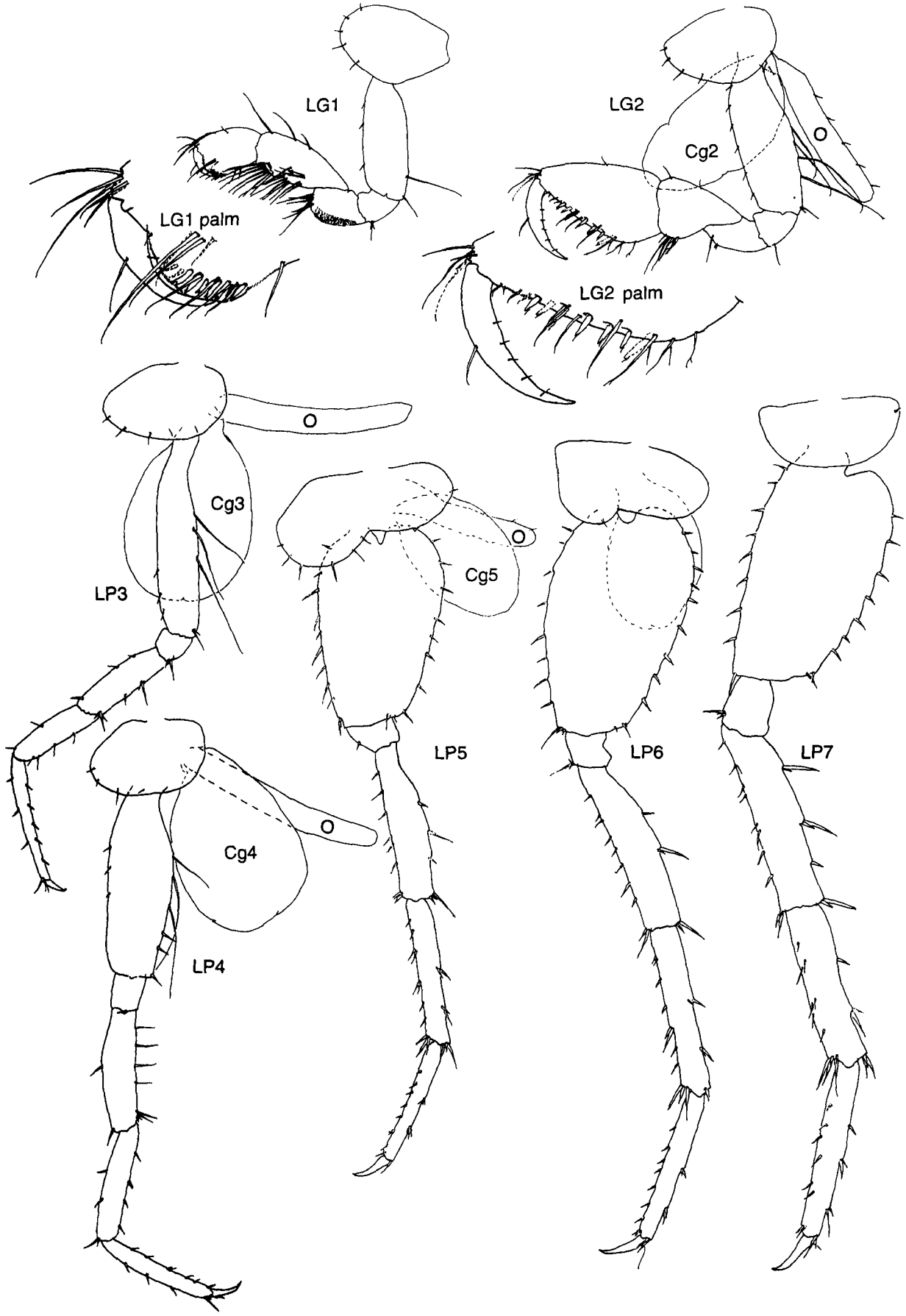

Fig. 17. *Nedsia macrosculptilis* holotype female 5.5 mm. Legs.

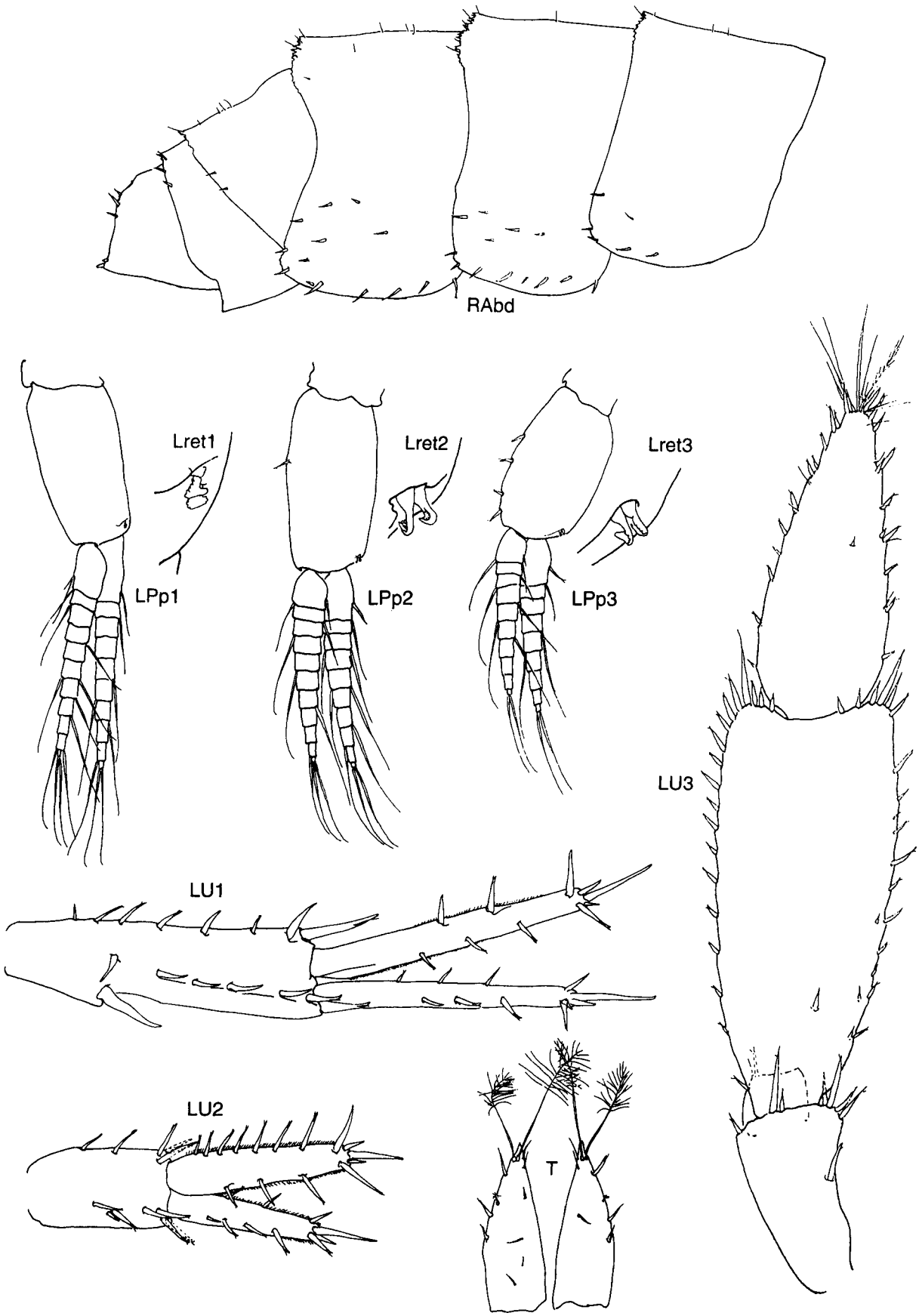

Fig. 18. *Nedsia macrosculptilis* holotype female 5.5 mm. Abdomen, pleopods, uropods, telson.

bearing a strong mediodistal spine, and moderately setate, the first article of the primary flagellum is fused and subsequent articles increase in length distally. The second antenna is proportionally longer, the flagellum 5-articulate, the upper lip is slightly convex apically, extended and symmetrical. Left molar bearing long plumose distal seta, is pubescent from the accessory blades to the base of the molar. Right mandibular palp 2-articulate, with a medium length plumose molarial seta, and pubescence. Palp of first maxilla bearing 8 thin apical setae, symmetrical, inner plate with 8 medial plumose setae, second maxilla basomedial margin of inner plate bearing 5 fine setae in 2 groups, maxillipedal palp article-3 with moderate distal setae leading to the base of the dactyl, gnathopod 1 palmar corner rounded, not clearly defined with more setae and spines, The second gnathopod is more spinous in the palm, epimera with facial and submarginal spines and posterior corners with 2-2-1 spines, pleon sculptured to sharp serrations, and bearing setae and dorsolateral spines on pleon 5–6, peduncle of uropod 1 shorter than in *N. douglasi*, distal margins of inner ramus finely pubescent, uropod 2 shorter, outer ramus shorter than inner, distolateral and medial margins of outer ramus and all of inner ramus covered in fine pubescence, uropod 3 peduncle longer than urosomite 3, all spines marginal, article-2 0.8× article-1, inner ramus relatively longer than in *N. douglasi*, telson much longer than wide, subapical notch broader, telson more spinous. *Nedsia macrosculptilis* differs from *N.sculptilis* in the absences of spines on the posterolateral margins of the fourth pleonite and of rugosity on the medial face of the maxillipedal outer plate, and in reduced scalloping of the medial margin of that plate. *Nedsia macrosculptilis* differs from all the other *Nedsia* in the presence of deep sculpturing of the pleonic posterior margins and of facial spines on the epimera. The species differs from *N. straskraba, N. fragilis* and *N. humphreysi* in bearing marginal pubescence on both plates of the second maxilla.

Distribution. Barrow Island, Western Australia.

Nedsia sculptilis n.sp.

Figs 19–21

Etymology. Named for the sculpturing of the pleon.

Type locality. Barrow Island, Western Australia. Western Australian Museum sampling site BES787.

Material examined. HOLOTYPE (Western Australian Museum WAM 7-96) male 4.0 mm.

Diagnosis. *Pleonites*: without dorsal spines. *Head*: rostrum obsolescent, lateral cephalic lobes moderately projecting. *First antenna*: bearing aesthetascs, *Second antenna*: short. *Upper lip*: symmetrical, not excavate. *Mandibular palp*: 2-articulate, articles equal in length, terminal article tapered terminating in 2 E-setae; accessory blades on rakers = 6 left, 4 R, with one interraker plumose seta on the right and one additional seta beyond the left rakers. *Maxillae*: without medial setae or pubescence except for the lateral margins of the second maxilla; inner plate of the first maxilla ovato-triangular with six mid-medial to mediodistal plumose setae; palps symmetric; inner plate of the second maxilla with a row of medial setae barely extending onto the face apically with few other medial setae. *Coxae*: short, broader than long with few posterior spines. *Maxilliped*: inner plate bearing three distal plumose setae and three blunt naked terminal spines, without plumose medial setae, the outer plate bearing two distal plumose setae contiguous with a blunt naked tooth spine; palp articles 2–3 weakly setate laterally, setae at the dactylar base not organised into comb rows, the palp apex weakly produced, the dactyl with a moderately long nail. *First gnathopod*: palmar corner marked with one long lateral spine, moderate numbers of setae along palm. *Second gnathopod*: carpus barely lobate. *Pereopods*: 3–6 without accessory spinules on dactyls, posterior spine sets on article-6 of pereopod 3 evenly spaced, those on pereopod 4 uneven; dactyl of pereopod 7 with an extra terminal spinule. *Gills*: present on coxae 2–6. *Pleopods*: peduncles with 0,2,2 setae, 2 retinaculae and no accessory retinaculae. *Epimera*: epimeron 3 only with a small posteroventral tooth. *Uropods*: apicolateral corners of peduncles of uropods 1–2 with 3 and 2 spines respectively, the dorsal margins bearing few spines, the medial margin of uropod 1 with 2 apical spines. *Telson*: longer than broad, cleft 85%, bearing some medial spines.

Description of holotype (male). *Body* 4 mm. *Pleon*: pleonite 6 without dorsal spines, bearing two laterodistal and single ventrodistal spines; pleonite 5 with distal dorsolateral spines. *Head* (Fig. 19): rostrum obsolescent; eyes absent. *First antenna* (Fig. 19): longer than second (broken at article-11); flagellum longer than peduncle; peduncular articles 1–2 equal in length, 2.7× article-3, the first article bearing a cluster of ventral subdistal spines and setae, a row of small ventral spines, a dorsal row of three strong spines and a weak distal seta; flagellum moderately setate, bearing aesthetascs on some articles, article-1 of the primary flagellum fused, accessory flagellum 2-articulate, second article tiny, extending to M0.8 of the first article of the primary flagellum. *Second antenna* (Fig. 19): moderately short, 0.3× body length; peduncle longer than flagellum, articles 4–5 subequal with weak setation, article-3 bearing a single dorsomedial spine and 4 ventrodistal spines; flagellum of 5 articles of diminishing dimension, lacking calceoli or aesthetascs. *Upper lip* (Fig. 19): apically convex, pilose and spinose; symmetrical. *Left mandible* (Fig. 19): without palp (broken), incisor 5 toothed, lacinia mobilis 5 toothed and elongate, extending to the apex of the incisor; mandible bearing 6 large setose and 1 small naked accessory blades between the incisor and molar, without interraker plumose setae or pubescence; molar triturative, without

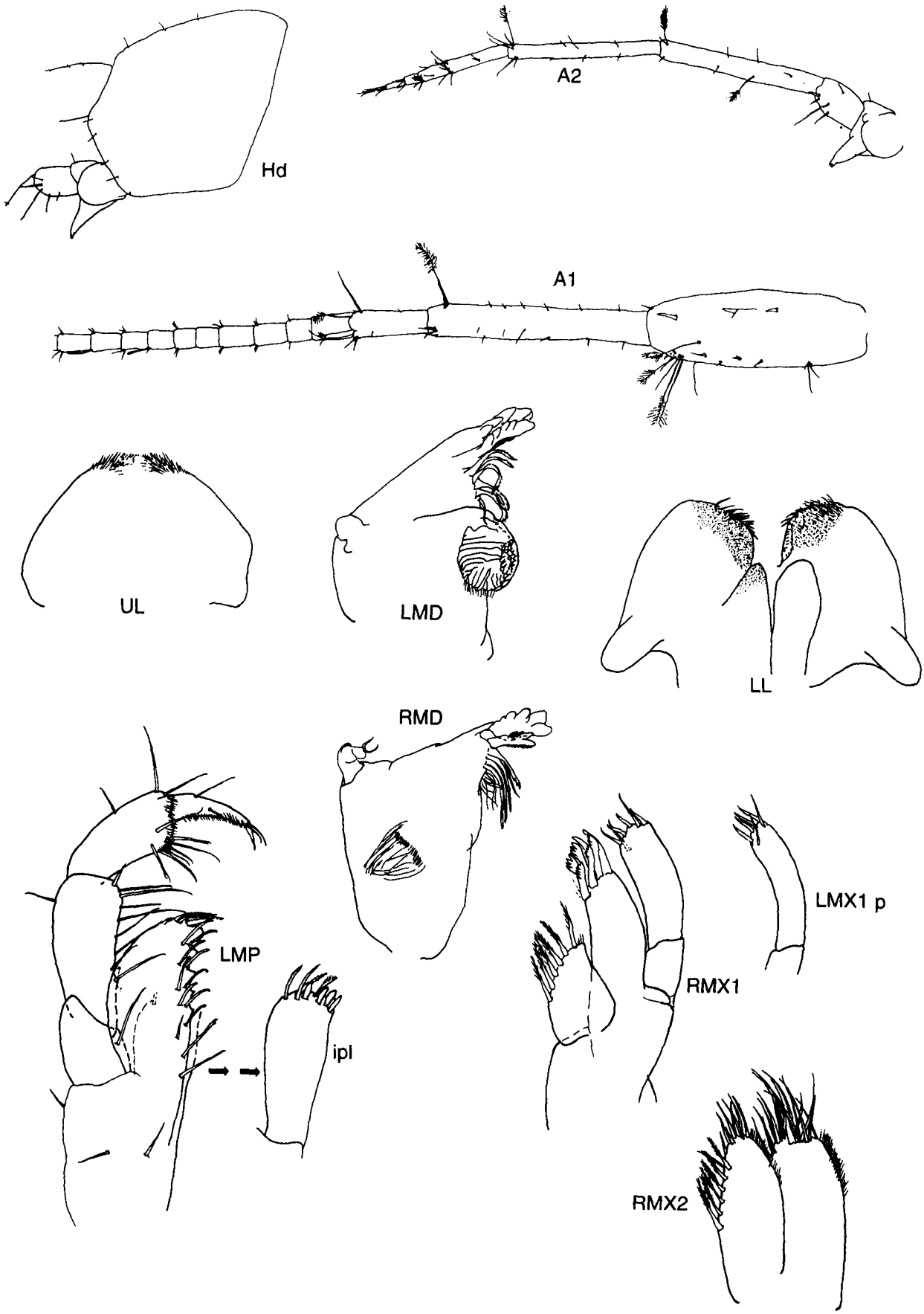

Fig. 19. *Nedsia sculptilis* holotype male 4 mm. Head, antennae, mouthparts.

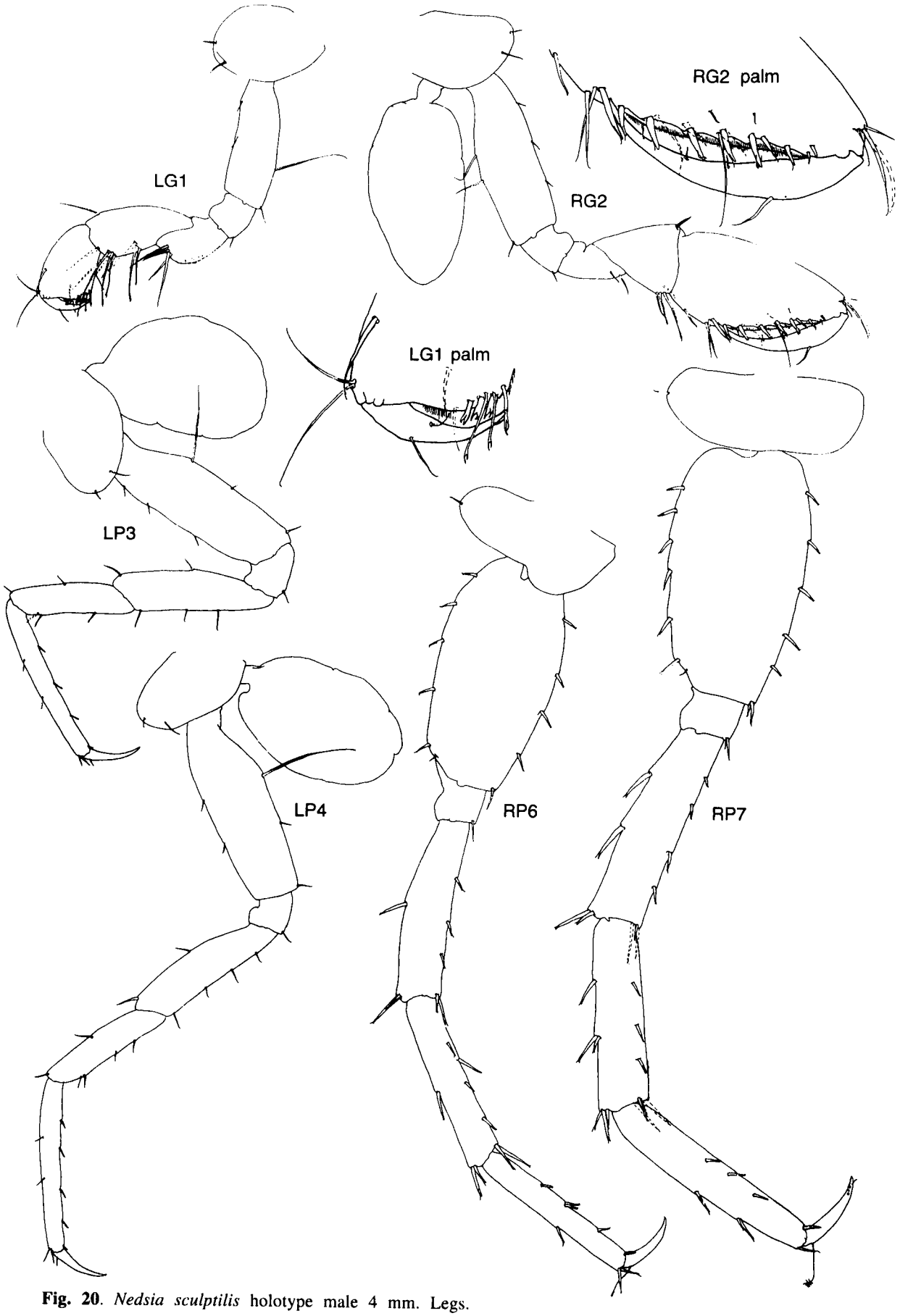

Fig. 20. *Nedsia sculptilis* holotype male 4 mm. Legs.

distal seta. *Right mandible* (Fig. 19): bearing a short palp of two subequal articles, the first truncate and naked, the second cone like bearing 2 short apical E-setae; incisor of 5 teeth; lacinia mobilis shorter than incisor, bifid, bearing anteriorly a median row of short spines, posteriorly a marginal row of setae; mandible bearing 4 accessory blades, the first denticulate, the remainder setose, with a single interraker seta lying between first and second blades, and a row of setae extending posteriorly; molar triturative, without a distal seta. *Lower lip* (Fig. 19): bearing prominent inner lobes extending to M0.7 of the outer lobes; anterior surfaces of both lobes rugose, inner lobes naked, outer lobes bearing apicomedial spines and setae. *First maxilla* (Fig. 19): palps of two articles, almost symmetrical, the left side more slender than the right, possibly regenerent, each with 5 apical and 1 subapical slender naked spines; inner plate ovatotriangular, without pubescence except for a small lateral terminal cluster, bearing on the medial margin to the apex 6 plumose setae; outer plate bearing two naked and five denticulate terminal spines. *Second maxilla* (Fig. 19): outer distal margin of both plates pubescent, facial and medial regions lacking pubescence, outer plate bearing a single distal spine additional to the terminal setae; both plates without other setae. *Maxilliped* (Fig. 19): palp third article with medial setae confined to the margin of the apex, bearing a single facial spine adjacent the dactylar base; apical setae marginal, not organised to comb rows; dactyl with two accessory spines arising adjacent the base of the nail and as long as the nail; medial margin of the outer plate carved into 4 sinuous indentations, without marginal spines, but associated with each a pair of long submarginal, curved, blunt spines. *First gnathopod* (Fig. 20): coxal plate bearing 2 apical setae, the fourth article posteriorly bulbous and pubescent, carpus not lobate; propodus trapezoidal and slightly expanded apically, longer than wide, posterior margin naked but for a single submarginal spine and a pair of long apical spines; margin of the palm lined with fine setae anteriorly, posteriorly the palmar corner rounded, marked by a single long lateral bifid spine, the posterior margin of the hand pubescent; adjacent the palmar corner three stout bifid spines and two long terminally bifid spines; dactyl bearing a subterminal accessory spinule extending to the nail-less apex, which reaches to the palmar corner. *Second gnathopod* (Fig. 20): coxa bearing 2 anterior setae, the palm strongly oblique, bearing 7 lateral and 2 medial stout trigger spines and marginally bordered with short setae, the palmar corner defined by a long lateral trigger spine; dactyl bearing 3 small spines along the inner margin, and extending to a point slightly short of the palmar corner. *Pereopods* (Fig. 20): coxae 3–4 with 2 anterior setae only, pereopods 3–4 longer than gnathopod 2, pereopod 3 < pereopod 4, both sparsely armed, pereopod 6–7 similar, pereopod 6 < pereopod 7, articles 5 of pereopod 6 and 5–6 of pereopod 7 bearing a slight anterior keel, the anterior spines consequently slightly submarginal; coxae 6–7 bearing single posterior spines, articles 2 of pereopods 6–7 posteriorly expanded but not lobate and bearing stout trigger spines; dactyls of pereopods 3–6 without accessory spinules, pereopod 7 bearing a single subterminal spinule on the dactyl. *Gills*: flask shaped, present on coxae 2–6, gill 6 not reduced. *Sternal gills* absent. *Pleopods* (Fig. 21): each with 2 retinaculae, without accessory retinaculae, peduncles bearing 0,1,1 setae and 0,1,1 spines, all distal, the lateral spine of peduncle 3 bearing a trigger; rami extending subequally, of 7,6,6 inner and 8,8,7 outer articles; setae of basal articles of rami = 3-2,3-2,3-2. *Epimera* (Fig. 21): first epimera posteroventrally rounded, second posteroventrally quadrate, third slightly extended posteriorly and bearing a small posteroventral tooth, otherwise posterior margins smooth; epimera 1–3 bearing facial and submarginal ventral spines, the posterior corners marked by 2-1-1 spines, epimeron 2 bearing a single anteroventral marginal spine. *Pleon* (Fig. 21): pleonites 1–4 bearing dorsal and dorsolateral posterior setae, the posterior margins sculptured, with many serrations, less so on pleonite 4; without spines except for pleonite 5 which bears 3 dorsal and dorsolateral spines of moderate length, and pleonite 6 with 2 lateral and 1 ventrolateral posterior spines. *Uropods* (Fig. 21): first uropod 1.9× length of second, peduncle length greater than rami, outer margin bearing a strong basofacial spine and row of 4 dorsolateral spines, the last subapical, the medial margin bearing 2 anterior and 1 subapical dorsal spines; distal apices of peduncle bearing 1 medial and 1 lateral spines; inner ramus longer than outer, with single marginal spine at M0.6, and terminating in 5 spines, the outer ramus with 2 lateral spines at M0.4 and M0.6, terminating in an apical cluster of 4 spines; second uropod peduncle subequal to outer ramus, outer margin with 3 apical spines, inner margin with 1 mid-marginal and 3 apical spines; outer ramus bearing 1 mid-medial and 2 lateral spines at M0.5 and M0.7, and 4 terminal spines; inner ramus with 1 lateral spine at M0.7, a row of 4 medial spines and 4 terminal spines. Uropod 3 absent. *Telson* (Fig. 21): length equal to width, as long as urosomite 3; cleft 85% of its length, the subapex notched around an apical spine like extension, the notches bearing long plumose setae; left lobe bearing small lateral spines at M0.6 and M0.8, medial spines at M0.7 and M0.9, and a single penicillate facial setule at M0.5; right lobe bearing small lateral spines at M0.6 and M0.8, facial spines at M0.85, and single lateral penicillate spinule at M0.7.

Relationship. *Nedsia sculptilis* in the form of the pleonites which are setate and complexly sculptured, and the epimera which are facially and submarginally spinous is similar to *N. macrosculptilis* and differs from other *Nedsia* in these ways. *N. sculptilis* is distinguishable from *N. macrosculptilis* in that the posterior margins of the fourth pleonite are without spines, and the medial margin of the outer plate of the maxilliped is without facial rugosity and is carved into 4 rather than 5 indentations.

Distribution. Barrow Island, Western Australia.

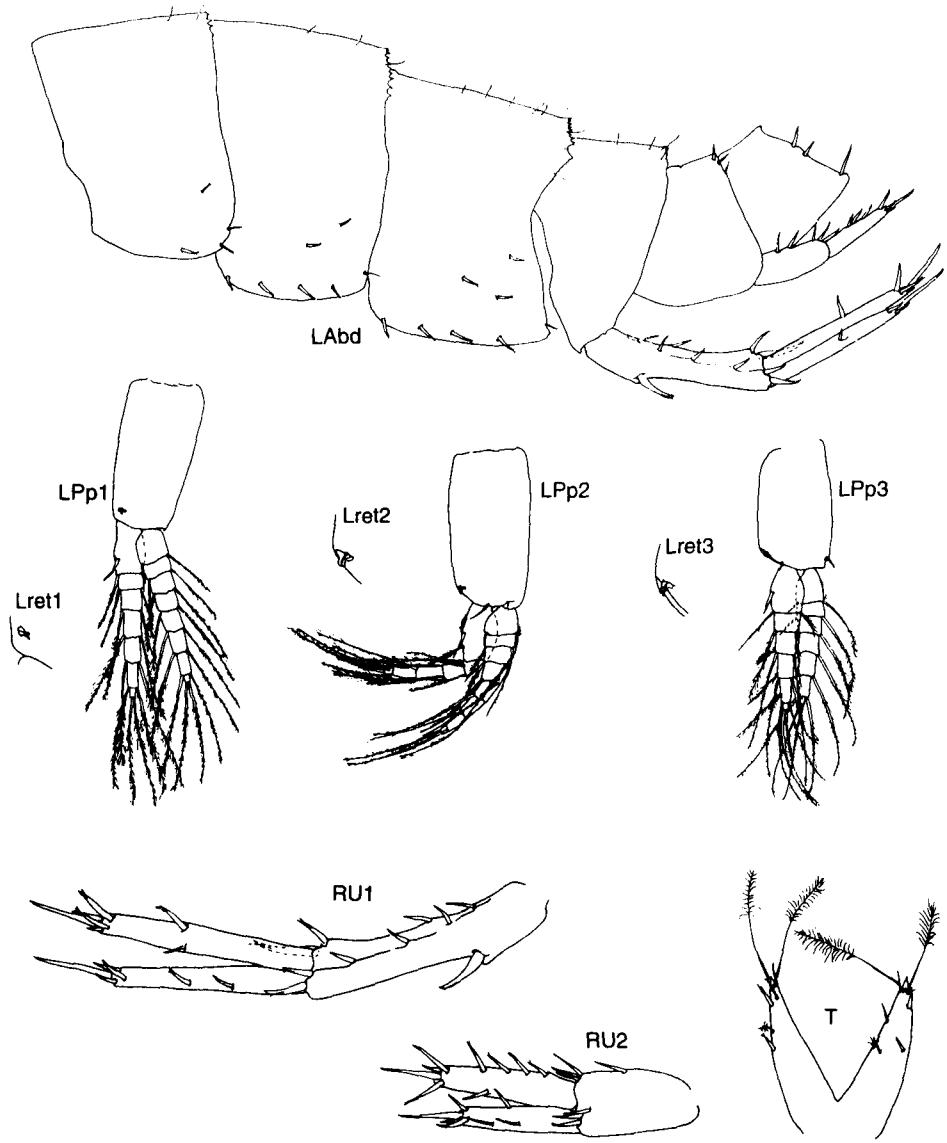

Fig. 21. *Nedsia sculptilis* holotype male 4 mm. Abdomen, pleopods, uropods, telson.

Family Bogidiellidae

A species of this family is recorded from a single Barrow Island site described as cave WL8. This record of a bogidiellid from Western Australia is unique. While Stock (1984) recorded *Bogidiella (Xystriogidiella) capricornea* from Heron Island on the Great Barrier Reef, the nearest record is of *Bogidiella (Medigidiella) sarawacensis* Stock, 1983 from Sarawak.

All Bogidiellids are hypogean or interstitial stygobionts of marine and fresh waters. Holsinger (1993) records 86 subterranean species of 16 genera.

The species recorded here possesses Bogidiellid characteristics of vermiform body, absence of sternal gills, restriction of coxal gills to coxae 4-5-6 without reduction of the sixth gill, free urosomites, gnathopods not mittenform and the first gnathopod dominant, palmar spines simple, rami of uropod three equal and extended beyond the first and second in the entire animal and without article-2 of the outer ramus, the telson uncleft and scarcely emarginate, pleopods uniramous, the lower lip broadly spread by forward extension of the inner lobes, setae of the terminal article of the mandible reduced, the maxillae reduced and without medial setae, and the maxilliped reduced (Barnard & Barnard, 1983).

Bogidomma n.gen.

Etymology. Named for the presence of eyes, unique among the family.

Type species. *Bogidomma australis* n.sp.

Diagnosis. *Body*: pleonite 6 naked, rostrum obsolescent, lateral cephalic lobes strongly projecting, broad, with slight antennal sinus present; tending vermiform. Urosome without armaments. *Head*: first antenna moderately elongate, longer than antenna-2, ratio of peduncular articles 2:2:1, accessory flagellum 2-articulate; second

antenna, shorter than A1, flagellum much shorter than peduncle, calceoli absent. *Mandibles*: palp 3-articulate, ratio of articles 4:11:6, article-1 not setose, article-2 with few setae, article-3 with 2 E-setae only. *Lower lip*: broad, inner lobes elongate. *Maxillae*: without pubescence or peripheral setae except a single mid-medial seta on the inner plate of the second maxilla; inner plate of the first maxilla ovato-rectangular to subrectangular, without setae or pubescence, bearing 6 or 7 terminal spines, palp of two articles, with thin apical spines. *Coxae*: 1–7 short, longer than broad, coxae 1–2 lacking posterior spines, coxa 1 not expanded below, coxa 4 not excavate posteriorly, subquadrate, coxae 4–5 of approximately equal length. coxae 3–7 each with single posterior spines, coxae 1–4,6 each with single anterior spines. *Gnathopods*: similar. *First gnathopod*: dominant, hand ovate, carpus much shorter than propodus, strongly lobate, merus posteriorly extended but without hyaline lobe, palm strongly oblique, palmar spines not symmetrically bifid but with small trigger like extensions, spines at corner of palm; 2 long, lateral, 1 moderate medial; few simple setae along the palm; dactyl not reaching the end of the palm. *Second gnathopod*: smaller than gnathopod 1; carpus short, weakly lobate; hand moderately enlarged, ovate, palm acutely oblique, sparsely setulose, irregularly spinose; palm without distinct corner, bearing single slender medial and lateral trigger spines at point of intersection of dactyl. *Pereopods*: 6–7 moderately elongate, pereopod 7 longer than pereopod 6, pereopod 7 article-2 moderately expanded and posteriorly extended but lacking a posteroventral lobe; dactyls of pereopods 3–7 with 1 or 2 accessory spinules. *Gills*: coxae 4–6 each with a flask shaped gill; gill 6 not reduced; sternal gills absent. *Oostegites*: coxae 2–5 each with an elongate, thin, poorly setose oostegite. *Uropods*: uropod 3 extended beyond uropods 1–2 in entire animal, outer ramus with 1 article only, inner rami of equal length. *Telson*: broader than long, uncleft, laterally convex and terminally concave, subapical spines and paired penicillate setules on either lobule at M0.85.

Additional description. *Upper lip*: symmetrical, laterally and distally setose, weakly excavate below. *Mandibles*: accessory blades (rakers) few (3), with no inter-raker plumose setae, but a few additional plumose setae basal to the molar. *Maxilliped*: both plates short, inner plate bearing 3 long distal setae and 2 blunt naked tooth spines, but no other setae or pubescence; outer plate bearing 4 distal setae and a single medial seta at M0.5, medial margin otherwise without sinuosities, setae or pubescence; palp long, articles 2–3 weakly setose medially, naked laterally, article-3 with a single comb row of fine setae at base of dactyl, few distomedial setal-spines, apex not produced; dactyl unguiform with an oblique row of comb setae, a slender, elongate nail and pair of terminal spines one of which is equal to the nail. *Gnathopods*: dactyls of gnathopods 1–2 without recumbent inner tooth spine, lacking nail; gnathopod 1 without rastellate seta of article-4. *Pereopods*: 3–4 smaller than pereopods 5–7; posterior spine sets of article-6 of pereopods 3–4 evenly spaced. *Pleopods*: similar, peduncles devoid of setae, each with a single outer ramus, no setae bifid; each peduncle with 2 retinaculae, no accessory retinaculae. *Epimera*: Post-ventral tooth of epimera 1–3 absent, posterior margins without spines or setae, smooth, slightly convex. *Uropods*: apicolateral corners of peduncles of uropods 1–2 with small single spines, dorsal margins without spines except for 1 medium size mid-dorsal spine at M0.85 on uropod 1; medial margin of uropods 1–2 with 1 apical spine; rami of uropods 1–2 subequal, without spine rows; uropod 1 without basofacial spine; uropod 3; medial setae of outer ramus absent; peduncle with 1 medial subdistal and 1 apicolateral spine. *Urosome*: ventrodistal spine on urosomite 1 at base of uropod 1 absent.

Relationship. This genus is unique among recorded bogidiellids in possessing well-developed eyes. All previously recorded bogidiellids are without eyes (Stock, 1984). Except in the presence of eyes *Bogidomma* is unequivocally a bogidiellid. Absence of inner rami of the pleopods suggests it is closest to either *Bollegidia* or *Bogidiella*.

Bogidiellids are categorised by Barnard & Barnard (1983) as probably a mixture of descendents from various Crangonyctoids. Barnard & Karaman (1980) discussed and dismissed Bousfield's (1977) elevation of the Bogidiellidae to superfamily status pointing out that the only consistent characteristic of the group is the dominant first gnathopod, a common occurrence among many groups, and therefore no basis for allocation to superfamily. Stock (1981) and subsequent authors have retained family status for this loose group characterised by a number of features which, however, do not all occur in all genera. Stock's (1981) cladistic analysis of the then known genera and species of the family translates into a position for *Bogidomma australis* somewhere within the *Bogidiella* group of subgenera, or possibly, though more remotely, on the basis of configuration of the lobes of the maxilliped, with *Marigidiella* (split from *Bogidiella*), although the new genus is unlike it in possessing two elements to the palp of the first maxilla, as well as a naked inner lobe and reduced setal cover of the second maxilla. Using the keys of Barnard & Barnard (1983), the new genus fits closely to *Bogidiella* except for the presence of eyes, ratio of the lengths of peduncular articles of the first antenna and of the length of the primary flagellum of the first antenna.

Geographically bogidiellids have been regarded as primarily Neotropical. They have, however, been reported from all the major continents, except Antarctica. The only record of a bogidiellid from Australia is of *Bogidiella (Xystriogidiella) capricornea* Stock, 1984, from the tropical marine atoll Heron Island, situated off the Pacific coast, a first recording of the family from the Pacific Ocean. *Bogidiella* is Palaearctic and Palaeotropical (Oriental) as well as Neotropical (Hertzog, 1933; Stock, 1983). Stock (1983) considered the distribution of the Bogidiellidae can be explained as the result of the break up of Pangea in the Mesozoic and

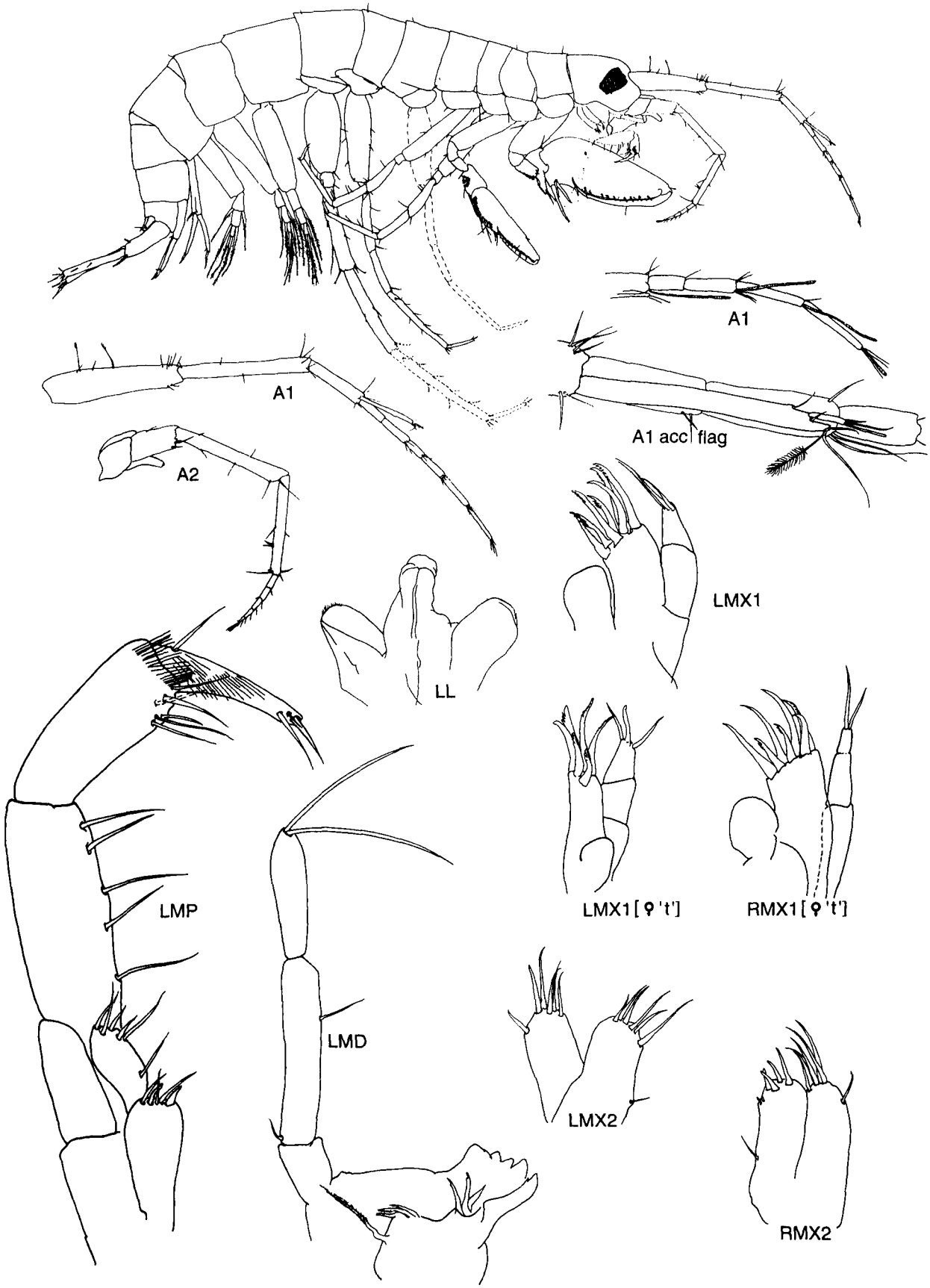

Fig. 22. *Bogidomma australis* holotype female 2.8 mm: all drawings except those indicated as female "t". Body, antennae, mouthparts.

isolation of populations in the Tertiary, and that the limited distributions and low fecundities of many species indicates their poor dispersive abilities.

Bogidomma australis n.sp.

Figs 22–24

Etymology. The name refers to the type locality region.

Type locality. Cave number WL8, Barrow Island, Western Australia.

Material examined. HOLOTYPE (Western Australian Museum WAM 8-96) Barrow Island, Western Australian Museum collection BES799, female 2.8 mm collected 2 December 1992. Other specimen: BES716 female "t" 2.5 mm (broken) collected 28 November 1992.

Diagnosis. As in the genus.

Description of holotype (male). *Body* (Fig. 22) 2.8 mm; urosome without armaments, length 2.5–3 mm. *Head*: rostrum absent; eyes present, large, about 0.3× head, ovate, pale and indistinct in the preserved specimen; antennal sinus absent except for a small concavity of the ventral lateral cephalic lobes. *First antenna* (Fig. 22): length 0.4× body, 1.5× antenna-2; primary flagellum of 6 articles, shorter than peduncle (120:200); peduncular articles 1 and 2 equal, article-3 shortest, setae sparse; primary flagellum with aesthetascs but without calceoli, article-3 smallest, remainder of uniform length, sparsely setulate; accessory flagellum 2-articulate, (Fig. 22) extending to M0.1 of the third article of the primary flagellum; second article tiny (1:8), articulated subdistally and extending only 0.4 of its length beyond the terminus of the first. *Second antenna* (Fig. 22): short, length 0.3× body, peduncle much longer than flagellum (195:35), articles 4–5 longest, articles 3–5 with weak ventral setation and a weak single mid-dorsal seta; article-4 with proximal and mid-dorsal setae; flagellum of 5 articles of progressively reduced length, all articles with weak dorsal setation; calceoli absent. *Upper lip* (Fig. 22): symmetrical, laterally and distally setose. *Mandibles* (Fig. 22): similar; palp 3-articulate, article-1 short, ratio of article lengths 4:11:6, article-3 with 2 apical setae (2E) only, incisor 4 toothed, lacinia mobilis bifid, with 3 setose accessory blades, and a short row of 3 plumose setae leading to the molar; molar indistinct, weakly or non-triturative, bearing distal plumose seta; no other pubescence. *Lower lip* (Fig. 22): outer lobes finely pilose apically, spread broadly by forward intrusion of elongate inner lobes; inner lobes naked, projecting beyond outer lobes, relative lengths; 33:23. *First maxilla* (Fig. 22): first maxilla asymmetric; palps of two articles, left palp with 3 apical spines, right palp with 2; left outer plate with 5 denticulate spines and 1 or 2 naked spines all of approximately equal length, right outer plate with 3 short denticulate spines, 1 short and 3 long curved, naked spines. *Second maxilla*: both plates without pubescence, asymmetric; left inner plate bearing 4 blunt apical spines and 2 short distomedial spines; right inner plate bearing 3 apical and 2 subapical slender, sharp spines, and an elongate slender distomedial spine which extends as far as the longest apical spines. *Maxilliped* (Fig. 22): palp article-3 with 3 distal and 3 apical spine-setae, nail of dactyl slender, with 2 subterminal setae, the longer extending as far as the nail itself; article-3 with a transverse comb-row of setae basal to the dactyl, the dactyl with basal setae and an oblique row of similar setae, as well as a single dorsal setule at M0.2. *First gnathopod* (Fig. 23): dominant, 1.5× gnathopod 2; article-4 posteriorly linear, carpus strongly lobate, propodus ovate, much longer than broad, tapering apically, posterior edge naked except for a single distal submarginal spine at M0.7; corner of palm recurved with 2 lateral and 1 medial spines, palm convex, finely serrated, spines and setae all submarginal, dactylus not reaching end of palm. *Second gnathopod* (Fig. 23): smaller than gnathopod 1; hand ovate, elongate, width 0.3× length; palm finely serrated, convex except at the posterior end where it is broadly sinuous, palmar spines and setae all submarginal, spines not symmetrically bifid but with triggers; dactyl not reaching palmar corner, which is marked by a pair of slender trigger spines with a further slender spine posteriorly; hand facially and posteroventrally pubescent; carpus posteriorly pubescent; coxal plate subequal to coxa 1 with a single anteroventral spine. *Pereopods* (Fig. 23): pereopods 3–4 shorter than gnathopod 1, pereopod 3 longer than gnathopod 2, pereopod 4 subequal to gnathopod 2, pereopod 3 longer than pereopod 4, pereopods 3–4 articles 1–5 sparsely setose posteriorly and anteriorly, posterior margin of article-6 on pereopods 3–4 with armament formula S-S-S-Ss and S-S-S-S, thus with only 1 locking spine; pereopods 6–7 similar but consecutively elongate, with 2 locking spines on pereopod 6; article-2 of pereopod 7 weakly expanded, but not posteriorly lobate, without posterior setae; article-2 of pereopod 6 not expanded with few posterior setae; dactyls of pereopods 3,4,6 bearing 2,2,1 accessory spinules. *Gills* (Fig. 24): of coxae 4–6 flask shaped, of coxa 6 not reduced. *Oostegites* (Fig. 24): strap like, length 0.5× article-2 of pereopods, bearing few distal setae. *Pleopods* (Fig. 24): similar. Retinaculae 2 per pleopod without accessory, peduncles without setae, each uniramous, the outer ramus only present, of 3 articles, each article with 2 plumose setae, none bifid. *Epimera* (Fig. 24): epimera 2–3 post ventrally quadrate, epimeron 3 slightly extended, epimeron 1 more rounded, subquadrate; posterior margins slightly convex, smooth, without setae or spines, without a lateral ridge. *Pleon* (Fig. 24): only pleonites 2–3 with a single posterior dorsolateral seta on either side; posterior margins of 1–3 convex, remainder linear, all smooth, without setae or teeth except as above. *Uropods* (Fig. 24): uropod 3 longest, extending beyond uropods 1–2 in the entire animal; uropod lengths relative to uropod 1—uropod 2 = 0.75, uropod 3 = 1.3; peduncle length

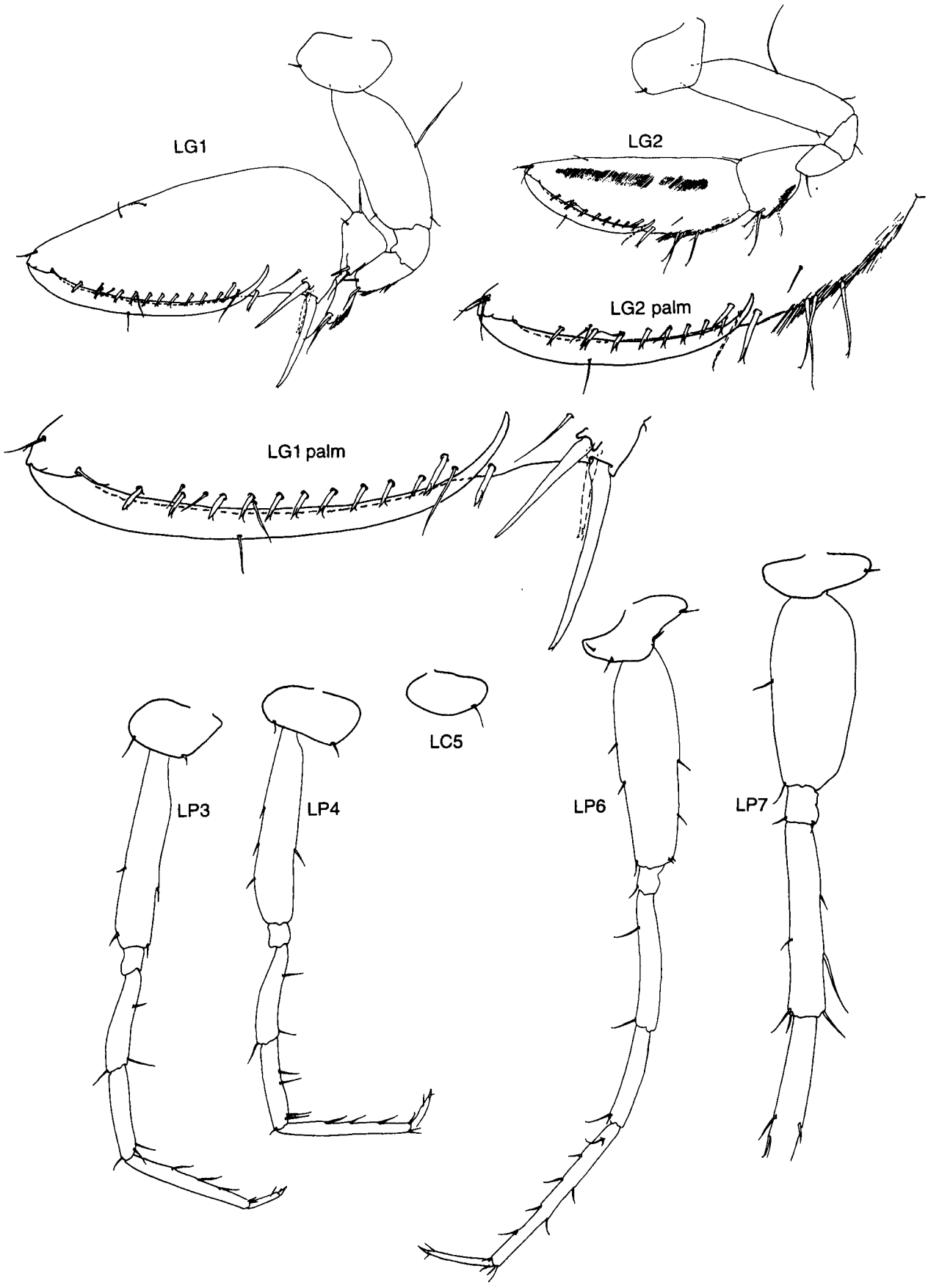

Fig. 23. *Bogidomma australis* holotype female 2.8 mm. Legs.

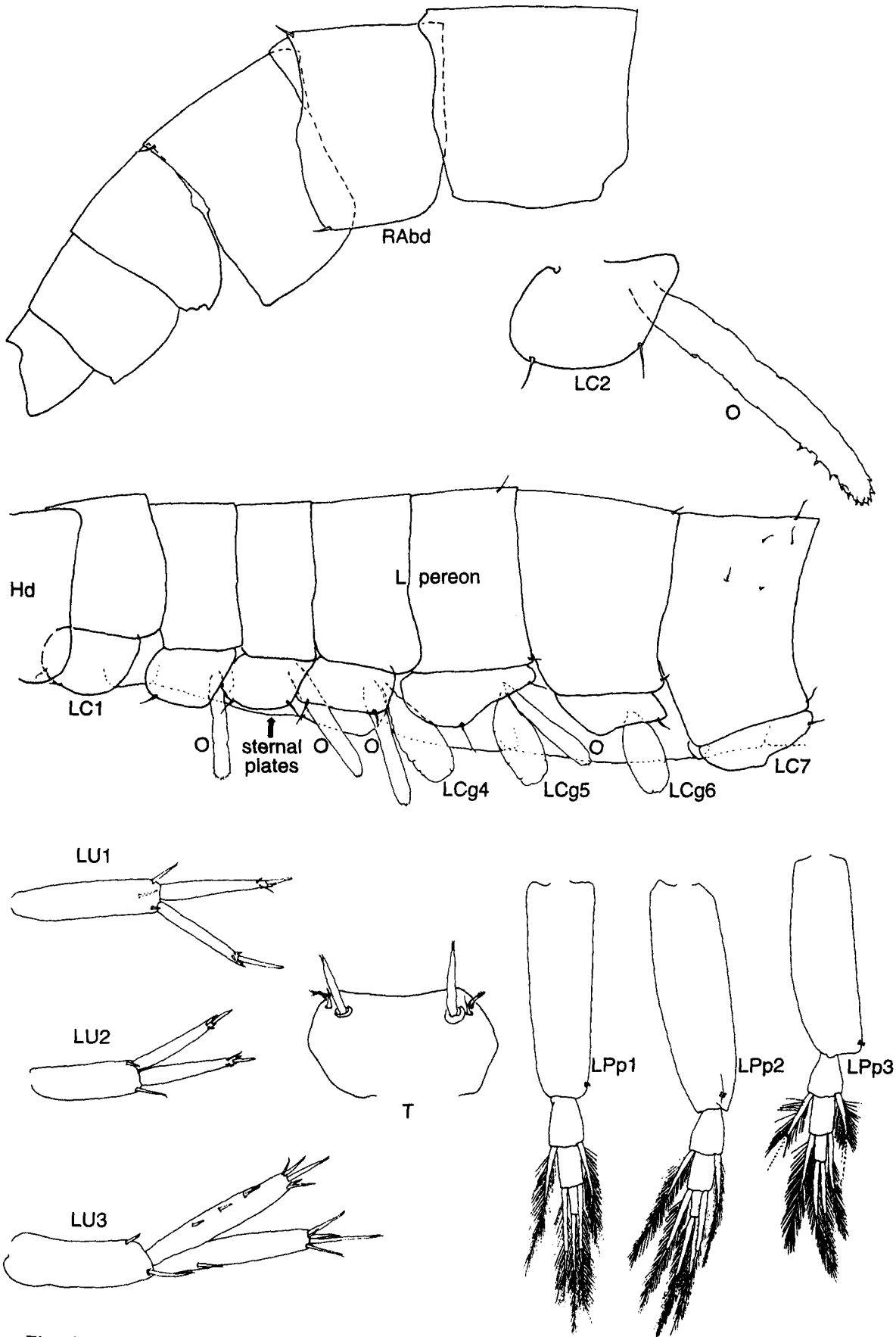

Fig. 24. *Bogidomma australis* holotype female 2.8 mm. Abdomen, gills and oostegites, pleopods, uropods, telson.

of uropod 1 = 1.3× inner ramus, outer margin with 1 small apicodistal spine, inner apical margin with a single, longer spine, without dorsal spine rows except for a single mid-dorsal spine at M0.85; rami of subequal length, lacking marginal spines; terminal spines = 5 lateral, 4 medial, the basal pair on each displaced subapically: uropod 2 peduncle length equal to length of inner ramus; peduncle naked except for a single apicomedial and a smaller apicolateral spine; outer ramus 0.9× inner; both rami without marginal spines, terminal spines = 4 lateral, 5 medial, several displaced subapically; uropod 3 rami equal in length; peduncle length 0.85× rami, 3× urosomite 3, bearing a single long apicolateral spine, and single smaller, apicomedial spine (the medial apex rounded, not subquadrate as is the lateral, thus displacing the apical spine subapically); outer ramus bearing a single laterofacial spine at M0.3 and 5 terminal spines; inner ramus bearing a row of 3 dorsomedial spines and 5 terminal spines. *Telson* (Fig. 24): width 1.8× length, approximately equal to, urosomite 3, not cleft, the apex concave to M0.9; 1 large trigger spine and 1 smaller spine submarginal, subapical on either lobe; paired penicillate setules at M0.85 on either side, submarginal on the left side.

Distribution. Barrow Island, Western Australia, in cave.

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References

Barnard, J.L. & C.M. Barnard, 1983. Freshwater amphipods of the world. 2 vols., 830 pp. Hayfield Associates, Mount Vernon, Virginia.

Barnard, J.L. & G.S. Karaman, 1980. Classification of gammarid Amphipoda. Crustaceana, Supplement 6: 5–16.

Barnard, J.L. & W.D. Williams, 1995. The taxonomy of Amphipoda (Crustacea) from Australian fresh waters: part 2. Records of the Australian Museum 47(2): 161–201.

Bousfield, E.L., 1977. A new look at the systematics of Gammaroidean amphipods of the world. Crustaceana, Supplement 4: 282–316.

Bradbury, J.H. & W.D. Williams, 1996. Two new species of anchialine amphipod (Crustacea: Hadziidae: *Liagoceradocus*) from Western Australia. Records of the Western Australian Museum 17: 395–409.

Costa, A. 1851. **In** Gugl. Hope's "Catalogo dei Crostacei Italiani e di Molti Altri del Mediterraneo, Napoli, Azzolino."

Eberhard, S.M., A.M.M. Richardson & R. Swain, 1991. The invertebrate cave fauna of Tasmania. Zoology Department, University of Tasmania, 174 pp.

Hertzog, L., 1933. *Bogidiella albertimagni* sp. nov., ein neuer Grundwasseramphipode aus der Rheinebene bei Strassburg. Zoologischer Anzeiger 102: 225–227.

Holsinger, J.R., 1993. Biodiversity of subterranean amphipod crustaceans: global patterns and zoogeographic implications. Journal of Natural History 27: 821–835.

Holsinger, J.R., 1994. Amphipoda in Encyclopaedia Biospeologica, Tome 1. C. Juberthie & V. Decou (eds). Société Biospéologie.

Horwitz, P., 1988. The faunal assemblage (or pholeteros) of some freshwater crayfish burrows in Southwest Tasmania. Bulletin of the Australian Society of Limnology 12: 29–36.

Humphreys, W.F. & M. Adams, 1991. The subterranean aquatic fauna of the North West Cape peninsula, Western Australia. Records of the Western Australian Museum 15(2): 383–411.

Karaman, G.S., 1969. XXII Beitrag zur Kenntnis der Amphipoden. Über einige neue Formen des Genus *Sarothrogammarus* (Gammaridae) aus Afghanistan. Acta Musei Macedonici scientiarum Naturalium, Skopje 11(11): 195–208.

Karaman, G.S., 1984. Revision of *Eriopisa*-complex of genera (Gammaridea) (Contribution to the knowledge of the Amphipoda 139) Poljoprivreda I šumarstvo, 30(4): 39–72.

Karaman, S., 1955. Uber einige Amphipoden des Grundwassers der Jugoslavischen Meereskuste. Acta Musei Macedonici scientiarum Naturalium, Skopje, 2: 223–242.

Knott, B., 1993. Stygofauna from Cape Range Peninsula, Western Australia: Tethyan relicts. Records of the Western Australian Museum, Supplement 45: 109–127.

Lowry, J.K. & H.E. Stoddart, 1993. Crustacea Amphipoda: Lysianassoids from Philippine and Indonesian waters. **In** A. Crosnier (ed.). Resultata des Campagnes MUSORSTOM, Volume 10. Mémoirs Museum national d'Histoire naturelle, Paris (n.s.) 156: 55–109.

Stock, J.H., 1981. The taxonomy and zoogeography of the family Bogidiellidae (Crustacea, Amphipoda), with an emphasis on the West Indian taxa. Bijdragen tot de Dierkunde 51(2): 345–374.

Stock, J.H., 1983. Discovery of a Bogidiellid Amphipod Crustacean in inland waters of the East Indian Archipelago: *Bogidiella (Medigidiella) sarawacensis* n.sp. Crustaceana 44(2): 198–204.

Stock, J.H., 1984. First record of Bogidiellidae (Crustacea, Amphipoda) from the Pacific: *Bogidiella (Xystriogidiella* n. subgen.) *capricornea* new species from the Great Barrier Reef. Bulletin of Marine Science 34(3): 380–385.

Williams, W.D., 1986. Amphipoda on land masses derived from Gondwana, in Stygofauna Mundi. Pp. 553–559. L. Botosaneanu (ed.). E.J. Brill, Leiden.

Williams, W.D. & J.L. Barnard, 1988. The taxonomy of crangonyctoid Amphipoda (Crustacea) from Australian fresh waters: foundation studies. Records of the Australian Museum, Supplement 10: 1–180.

Accepted 11 December 1995.

Bradbury, J.H. & Williams, W.D. (1996) Two new species of anchialine amphipod (Crustacea: Hadziidae: Liagoceradocus) from Western Australai.
Records of the Western Australian Museum, 17, pp. 395-409

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Memoirs of the Museum of Victoria 56(2):513–519 (1997)

AMPHIPOD (CRUSTACEA) DIVERSITY IN UNDERGROUND WATERS IN AUSTRALIA: AN ALADDIN'S CAVE

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Abstract

Bradbury, J.H. and Williams, W.D., 1997. Amphipod (Crustacea) diversity in underground waters in Australia: an Aladdin's cave. *Memoirs of the Museum of Victoria* 56(2): 513–519.

The presently known troglobitic and troglophilic (stygobiont) species of Australian aquatic amphipods are listed and discussed, and their geographical distributions are indicated. The 26 species known are predominantly in crangonyctoid and hadzioid families. Further undescribed species are referred to. The diversity is high and confirms Australia as a centre of stygobiont amphipod speciation. Explanations for the diversity include the considerable extent of karst, the frequent occurrence and extensive areas of former marine transgressions, and palaeoclimatic fluctuations. Attention is drawn to the usefulness of stygobiont amphipods as biogeographical tools, and to the need for their diversity in Australia to be noted in discussions, legislation and actions to conserve Australian biodiversity.

Introduction

Until relatively recently, our knowledge of the taxonomy of Australian freshwater amphipods (Crustacea: Amphipoda) was limited. Few species had been described, the extent of diversity was unrecognized, and most available species descriptions were in need of revision. Williams and Barnard (1988) began the initial revision needed with redescriptions of all known species and added descriptions of a few new species. Their efforts were continued in a second paper (Barnard and Williams, 1995). Both papers referred to subsurface as well as surface forms.

Taxonomic studies of the Australian freshwater amphipods are a long way from completion but the papers of Barnard and Williams and other recent studies have pointed to the existence of much greater diversity amongst surface forms than had been realised. They also point to the existence of greater biodiversity amongst subsurface forms than had been realised (Williams, 1986). The diversity of subsurface forms is confirmed by the studies of Knott (1983) and Bradbury and Williams (1995, 1996 a, b) and unpublished work on recent collections from caves and other underground waters in Western Australia, New South Wales and Tasmania. This diversity amongst subsurface forms is not surprising given both the paucity of previous studies and, more importantly, the fact that amphipods are known worldwide to be amongst the most widespread, abundant and diverse of subsurface aquatic invertebrates (Holsinger, 1991).

In this paper, our immediate intentions are to summarize the present status of our knowledge of the taxonomy of hypogean amphipods in Australia on the basis of described species, to provide some indication of the extent of diversity based on described species and undescribed material, and to offer some explanation for this diversity. Thus this paper provides a basis for discussion and should help achieve two, more general aims, namely:

1. to focus attention upon the usefulness of hypogean amphipods as biogeographical tools (given the nature of their ecology and environments) within an Australian context, and
2. to draw attention to the significant diversity of Australian hypogean amphipods at a time when considerable discussion is taking place at a variety of levels — State, Federal and international — on the conservation of biodiversity.

In these discussions, the diversity of hypogean amphipods should not be forgotten; whilst caves and other subsurface waters do not have the faunal diversity of surface waters, and of course lack plants, within the animal groups that do occur there (see, for example, Culver, 1982, and Barr and Holsinger, 1985), much speciation has taken place. Holsinger (1991, 1994a) has previously noted the global importance of hypogean amphipods for biogeographical studies, and Knott (1985) has noted their interest in Australia. Australian speleologists have long recognized the need for caves to be conserved and their fauna protected on the basis of both bio-

logical and geomorphological criteria. Governments have generally acted sympathetically to this need for cave protection and conservation.

In passing, we also mention the recent recognition of much higher diversity than expected in other bodies of inland water in Australia that — like underground waters — have generally received less attention from biologists than permanent fresh waters near major metropolises. These waters include salt lakes, temporary streams and freshwater lakes, and other bodies of surface water in arid and semi-arid regions. Recent work has indicated that considerable biodiversity occurs within such localities (e.g., see Frey, 1991; Timms, 1993; Comin and Williams, 1994). Their fauna, however, does not usually involve amphipods as these crustaceans are more or less confined to permanent, fresh waters. It does involve a comprehensive range of other invertebrate groups.

Present status of the hypogean (stygobiont) amphipod fauna

Table 1 lists all described species recorded thus far from either underground waters (caves, boreholes) or springs near their source. It lists two principal sorts of taxa: those which have been recorded from underground waters (including springs) and nowhere else (obligate stygobionts or troglobites *sensu* Barr and Holsinger, 1985); and those recorded from both underground and surface waters (facultative stygobionts or troglophiles). In total, the table lists over 30 species of which half can be regarded as troglobites and half, troglophiles. All are endemic. On the basis of described species, therefore, approximately 60 per cent of the total amphipod diversity of Australian inland waters can be found in subsurface waters. This figure is far higher than the global figure of 13 per cent given by Holsinger (1993) for the approximate fraction of all described amphipod species that are stygobionts. Our percentage is undoubtedly inflated by our concentration on stygobionts during recent studies. It seems likely that more balanced and comprehensive studies of both hypogean and epigean species will lead to some correction of this high figure towards a lower value.

With regard to the systematic positions of the species listed in the table, it is immediately obvious that most belong to the three groups identified by Holsinger (1993) as those of most importance so far as hypogean amphipod diversity is concerned worldwide, namely, the crangonyctoids, the hadzioids *s. l.* and the bogidiellids.

The geographical distribution of the species listed in Table 1 is indicated in Fig. 1. An obvious point to emerge from this figure is the large number of stygobiont species recorded from Western Australia. Of particular note in this respect is the extraordinarily large number described from Barrow Island, a relatively small offshore island. Species recorded from this island comprise those collected from boreholes (species of *Nedsia* and *Bogadomma australis*), and two species from an anchialine cave — that is, a coastal cave under marine influence — (*Liagoceradocus* spp.). None of the *Nedsia* species was found co-existing with another (but note paucity of specimens available), and all at present are known only from one locality each, the type locality. Apart from the facultatively subterranean *Austrochiltonia australis*, which is also a common and widespread surface form, other species listed in the table and figured in the map are likewise recorded from either a single locality or a restricted area. An absence of sympatry appears to be generally characteristic of stygobiont amphipods elsewhere too.

A less obvious point shown by Fig. 1 is that the distributions of hypogean amphipods extend more to the north in Australia than do those of

Figure 1. Geographical distribution of stygobiont amphipods in Australia. 1–12, hadzioids; 13, *Bogadomma*; 14–28, crangonyctoids. *Austrochiltonia australis*, *Phreatochiltonia anapthalma* and *Pseudomoera fontana* omitted.

Table 1. Systematic position and geographic distribution of Australian subterranean amphipods. The index numbers relate to Fig. 1.

Taxon	Distribution	Habit	Index no.
HADZIOIDS			
Melitidae			
Nedsia straskraba Bradbury & Williams	Barrow Island	troglobite	1
N. fragilis Bradbury & Williams	Barrow Island	troglobite	2
N.humphreysi Bradbury & Williams	Barrow Island	troglobite	3
N.hurlberti Bradbury & Williams	Barrow Island	troglobite	4
N.urifimbriata Bradbury & Williams	Barrow Island	troglobite	5
N.macrosculptilis Bradbury & Williams	Barrow Island	troglobite	6
N.sculptilis Bradbury & Williams	Barrow Island	troglobite	7
Liagoceradocus subthalassicus Bradbury & Williams	Barrow Island	anchialine troglobite	8
Liagoceradocus branchialis Bradbury & Williams	North West Cape	anchialine troglobite	9
Nedsia douglasi Barnard & Williams	North West Cape	troglobite	10
Brachina invasa Barnard & Williams	Flinders Ranges	hyporheic interstitial	11
Nurinna Cave *Melita* like	Nullabor Plain	troglobite	12
BOGIDIELLIDS			
Bogidiellidae			
Bogadomma australis Bradbury & Williams	Barrow Island	troglobite	13
CRANGONYCTOIDS			
Paramelitidae			
Hurleya kalamundae Straskraba	SW Australia	troglobite	14
Protocrangonyx fontinalis Nicholls	Darling Range, WA	troglophile	15
Uroctena westralis (Chilton)	nr Perth W A	troglophile	16
Totgammarus eximius Bradbury & Williams	SW Australia	troglophile	17
Chillagoe thea Barnard & Williams	N Queensland	troglobite	18
Giniphargus pulchellus Karaman & Barnard	Gippsland Vic	troglobite	19
Austrogammarus species Barnard & Karaman	Tasmania	troglophile	20
Austrogammarus smithi Williams & Barnard	Tasmania	troglophile	24
Antipodeus antipodeus (G.W.Smith)	Tasmania	troglophile	21
Antipodeus wellingtoni (G.W.Smith)	Tasmania	troglophile	22
Antipodeus franklini Williams & Barnard	Tasmania	troglophile	23
Uronyctus longicaudus Stock & Iliffe	SE South Australia	troglobite	25
Perthiidae			
Perthia acutitelson Straskraba	SW Australia	troglophile	26
Neoniphargidae			
Neoniphargus obrieni Nicholls	Mt Buffalo, Vic.	possible troglophile	27
Neoniphargus spp. Stebbing	Tasmania	troglophile	28
CEINIDS			
Ceinidae			
Phreatochiltonia anapthalma Zeidler	Mound spring, SA	poss troglobite	29
Austrochiltonia australis (Sayce)	cosmopolitan	troglophile	30
EUSIRIDS			
Eusiridae			
Pseudomoera fontana (Sayce)	SE Australia	troglophile	31

any surface aquatic amphipod. Thus, those from Barrow Island in Western Australia and *Chillagoe thea* in Queensland lie many hundreds of kilometres north of areas where surface amphipods occur. It is not difficult to provide an explanation of this; freshwater amphipods are not common in subtropical and tropical waters and only subterranean waters in these regions provide the lower temperatures and more stable environmental conditions required to support amphipod populations. It may be noted that not all northern and apparently suitable subtropical subsurface waters in Australia contain amphipods. The Cutta Cutta caves near Katherine, Northern Territory, for example, do not appear to be inhabited by amphipods; a recent and diligent search for them by one of us (WDW) failed to locate any specimens although considerable material of the atyid shrimp which do inhabit the caves was collected (*Parisia* spp.; see Williams, 1964). Perhaps the water in this cave system is too warm, the atyids too powerful a competitor, or there was no available ancestral surface form. No amphipods, likewise, have been collected from caves in the Kimberly region of Western Australia (Humphreys, 1995).

As for geographical patterns, three are obvious and accord with the broad biogeographical patterns postulated by Holsinger (1994a) for all subterranean amphipods and perhaps other malacostracans. These patterns are:

1. that shown by stygobionts derived from old freshwater ancestors (limnostygobionts);
2. that shown by stygobionts derived from marine ancestors, and
3. that shown by stygobionts inhabiting coastal waters with marine affinities and clearly derived from closely allied marine ancestors (thalassostygobionts or 'crawl-outs').

The process involved in pattern 3 is often referred to as 'stranding'. Crangonyctoid species clearly exhibit pattern 1, hadzioid species, pattern 2, and *Liagoceradocus* species, pattern 3. Other Australian stygobionts are less easily assigned to a particular pattern, but *Pseudomoera fontana* at least, given its marine taxonomic affinities and despite its entirely freshwater distribution, would appear to exhibit pattern 3. Fig. 2 indicates how close the correlation between distribution of stygobiont amphipods derived from hadziid ancestors is with areas of marine transgression and, conversely, of those with crangonyctoid ancestors and areas not inundated before or during the Cretaceous.

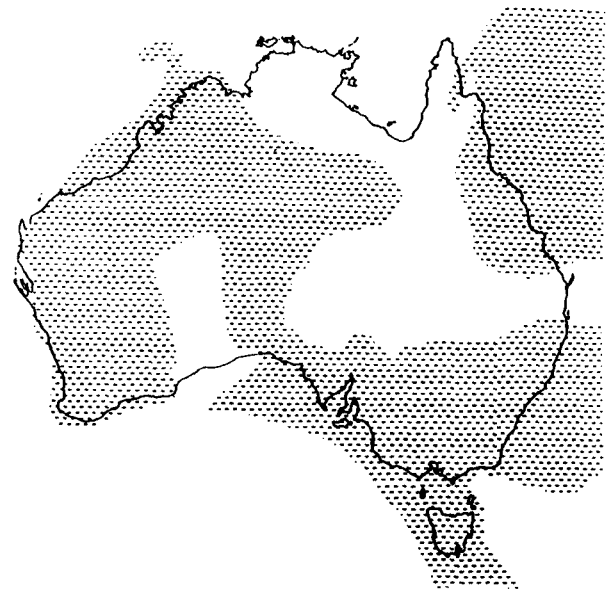

Figure 2. Marine transgressions in Australia during the Cretaceous (119–114 million years ago). Redrawn from Paine (1990). Areas free of inundation shaded.

The ecological nature of subsurface waters inhabited by species here considered as stygobionts covers a considerable range in type. Avoiding the plethora of technical terms that have been applied to subsurface waters, included are freshwater streams and lakes in inland caves in calcareous karst, coastal anchialine caves containing marine or brackish water, springs, mud or plant detritus on the bottom of surface waters which are in obvious continuity with the water table in unconsolidated substrata, and interstitial (hyporheic) water associated with streams. The collection of material from such a diversity of habitats itself demands diversity. For example, cave forms have been collected from open water by sweep nets or by baiting, forms in interstitial waters by pumping, and spring species by placing nets over surface outlets for extended periods (collections of *Brachina invasa* were made by placing a collecting net over the outlet of a spring for 12 hr).

The diversity of the hypogean amphipod fauna

On the basis of described species alone (Table 1), it is obvious that significant diversity exists amongst amphipods found in subsurface waters in Australia. How much more diverse will this fauna prove to be when further investigations have taken place? We have reason to believe that the answer is that it will prove to be substantially more diverse. This response is based in part on

our possession of further undescribed material from underground waters and including at least three new species from Western Australia, two from Queensland, and three from New South Wales (see also Eberhard et al., 1991). We believe it doubtful, however, that the number of species of hypogean amphipods in Australia will ever reach the numbers found in the two most diverse regions of the world in so far as this group is concerned, that is, the central-southern European — Mediterranean region and the eastern and southern North American — West Indian region. Even so, it is already clear that our increased knowledge of the diversity of hypogean amphipods in Australia confirms, as indicated, Holsinger's (1993) view that southern Australia is a region of significant diversity for this group. However, unlike the genera:species ratios found in the two regions of highest diversity mentioned, where the usual pattern is one of many species per crangonyctoid genus and few species per hadzioid genus, the pattern in Australia appears to be different, with many species per genus an obvious pattern for at least some hadzioid genera, and few species per genus for most crangonyctoid genera.

The causes of diversity

Two issues are involved in considering this matter. First, the factors that have led to the evolution of styobiont amphipods in Australia, and second, those factors responsible for the high diversity.

The first set of factors are of relatively little interest in the present context; it may be presumed that the evolutionary routes followed by stygobiont amphipods in Australia are similar to those followed elsewhere by such organisms. Thus, all originated from surface forms by regressive evolution — irrespective of whether selection, the accumulation of neutral mutations, or genetic drift was the more important in this process (Culver, 1982) — after isolation from surface forms had occurred following sea-level change, the onset of climatic aridity, or a given geomorphological event. A number of evolutionary steps have been proposed through which populations pass as stygobiont species evolve. As a general rule, three broad ones can be recognized to accommodate the evolution of stygobionts from both inland and marine ancestors (Holsinger, 1994a). The first is inclusive of troglophiles with few if any troglomorphic features. *Neoniphargus obrieni* provides an example. The second also include troglophiles but these do exhibit some troglomorphic features. Various species of *Antipodeus* provide examples. The third step includes troglobites with clear troglomorphy. *Hurleya kalamundae, Nedsia* species, and *Protocrangonyx fontinalis* are some examples.

Of much greater interest are those factors responsible for the high diversity. In this connection it is instructive to determine those features held in common by the two regions of greatest stygobiont amphipod diversity, the central-southern European — circum Mediterranean region and the eastern and southern North American — West Indian region. In both regions, the following features are both held in common and regarded as significant in promoting the development of high diversity (Holsinger, 1994a): a former proximity to the Tethys Sea, the lack of extensive glaciation during the Pleistocene, large areas of karst, and widespread marine transgressions in the late Mesozoic and Cainozoic. To a not inconsiderable degree, *these features also characterise large parts of the Australian continent.* Over much of the Mesozoic, the Tethys Sea lay west of Australia; apart from the highlands of Tasmania and small areas of the highest mountains in the south-east of the mainland, the Australian continent was free of ice during the Pleistocene; and marine transgressions covered large areas of the Australian continent during the early Cretaceous (Fig. 2). The only difference, and one of degree not kind, is the extent of karst in Australia. Karst does occur widely in Australia (Jennings, 1985; Mathews, 1985), but continuously extensive areas are confined to the Nullabor Plain and the lower Murray Valley, with only relatively minor occurrences elsewhere (included here is the Fitzroy Basin of Western Australia, the Cooleman Plain, Jenolan and Wee Jasper areas of New South Wales, the Buchan caves area of Victoria, the Mole Creek area of northern Tasmania, and the Barkly Basin of Queensland).

The evolution of stygobionts does not depend entirely upon the presence of karst, but there is little doubt that it does promote their evolution and the development of diversity. In any event, we believe that the features listed above, including the occurrence of karst — albeit it to an extent more limited than in the southern Europe — Mediterranean and North American — West Indian regions — have been important in producing the observed diversity of the Australian stygobiont amphipod fauna. Also important, we believe, has been both:

1. *continental drift* during which Australia first broke free from Gondwana and then passed through a series of quite distinct climatic zones during the Cainozoic, and
2. *palaeoclimatic fluctuations* including periods of aridity which, in conjunction with allied sea-level changes for coastal populations, would have served to isolate surface and subsurface populations of a species and have led to the development of discrete drainage basins.

A succession of favourable (wetter and colder) and unfavourable (drier and warmer) climates could easily have provided mechanisms promoting stygobiont speciation as epigean populations were driven to seek subterranean refugia. It may also be that some troglomorphic forms (lacking eyes) now found in surface waters actually represent the return to epigean conditions of hypogean forms in the absence of surface competitors, the latter having become extinct during former unfavourable conditions. It is not possible, for eyes, once lost, to be regained.

Finally, some explanation should be offered for the extraordinary diversity of stygobionts on Barrow Island. The most likely one is that after stranding, ancestral populations were isolated in a series of small and discrete subterranean basins where genetic drift led to the evolution of separate species from the original founder population.

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References

Barnard, J.L., and Williams, W.D., 1995. The taxonomy of Amphipoda (Crustacea) from Australian fresh waters. Part 2. *Records of the Australian Museum* 47(2): 161–201.

Barr, T.C., and Holsinger, J.R., 1985. Speciation in cave faunas. *Annual Review of Ecology and Systematics* 16: 313–337.

Bradbury, J.H., and Williams, W.D., 1995. A new genus and species of crangonyctoid amphipod, (Crustacea) from Western Australian fresh waters. *Transactions of the Royal Society of South Australia* 119(2): 67–74.

Bradbury, J.H., and Williams, W.D., 1996a. Freshwater amphipods from Barrow Island, Western Australia. *Records of the Australian Museum* 48: 33–74

Bradbury, J.H. and Williams, W.D., 1996b. Two new species of anchialine amphipods (Crustacea, Hadziidae, *Liagoceradocus*) from Barrow Island, Western Australia. *Records of the Western Australian Museum* 17(4) in press.

Comin, F. and Williams, W.D., 1994. Parched continents: our common future? Pp 473–527 in: Margalef, R. (ed.), *Limnology now; a paradigm of planetary problems*. Elsevier: Amsterdam.

Culver, D.C., 1982. *Cave life. Evolution and ecology*. Harvard University Press: Cambridge, Mass.

Eberhard, S.M., Richardson, A.M.M. and Swain, R., 1991. *The invertebrate cave fauna of Tasmania*. Department of Zoology, University of Tasmania: Hobart.

Frey, D.G., 1991. A new genus of alonine chydorid cladocerans from athalassic saline waters of New South Wales, Australia. *Hydrobiologia* 224: 11–48.

Holsinger, J.R., 1991. What can vicariance biogeographic models tell us about the distributional history of subterranean amphipods? *Hydrobiologia* 223: 43–45.

Holsinger, J.R., 1993. Biodiversity of subterranean amphipod crustaceans: global patterns and zoogeographic implications. *Journal of Natural History* 27: 821–835

Holsinger, J.R., 1994a. Pattern and process in the biogeography of subterranean amphipods. *Hydrobiologia* 287: 131–145.

Holsinger, J.R., 1994b. Amphipoda. Pp. 147–163 in: Juberthie, C. and Decou, V.(eds), *Encyclopaedia Biospeologica* 1: Société de Biospéologie.

Humphreys, W.F., 1995. Limestone of the east Kimberly, Western Australia — karst and cave fauna. *Report to the Australian Heritage Commission and to the Western Australian Heritage Committee*. 190+ xix.pp. Unpublished.

Jennings, J.N., 1985. *Karst geomorphology*. Blackwell: Oxford.

Knott, B., 1983. Amphipods from Nurina Cave — Nullabor Plain. *Australian Speleological Federation Newsletter* 101: 3–4.

Knott, B., 1985. Australian aquatic cavernicolous amphipods. *Paper presented to the 15th biennial conference, Australian Speleological Federation, Hobart*. 11 pp.

Mathews, P.G. (ed.), 1985. *Australian karst index*. Australian Speleological Federation Inc.: Melbourne.

Paine, A.G.L. (ed.), 1990. *Australia. Evolution of a continent*. Australian Government Publishing Service: Canberra.

Timms, B.V., 1993. Saline lakes of the Paroo, inland New South Wales, Australia. *Hydrobiologia* 267: 269–289.

Williams, W.D., 1964. Subterranean freshwater prawns in Australia (Crustacea: Decapoda:

Atyidae). *Australian Journal of Marine and Freshwater Research* 15(1): 93–106.

Williams, W.D., 1986. Amphipoda on land masses derived from Gondwana. Pp. 551–559 in: Botosaneanu, L. (ed.), *Stygofauna Mundi*. Brill and Backhuys: Leiden.

Williams, W.D. and Barnard, J.L., 1988. The taxonomy of crangonyctoid Amphipoda (Crustacea) from Australian fresh waters: foundation studies. *Records of the Australian Museum, Supplement* 10: 1–180.

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The Amphipod (Crustacea) Stygofauna of Australia: Description of New Taxa (Melitidae, Neoniphargidae, Paramelitidae), and a Synopsis of Known Species

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ABSTRACT. Freshwater amphipods from Australian subterranean waters are discussed. Five new genera and fourteen new species are described; the genus *Wesniphargus* Williams & Barnard is rediagnosed and specimens assigned to *W. nichollsi* (Straškraba) are fully described; a synopsis of subterranean species is provided.

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Introduction

The diversity of Australian sub-surface (stygobiont) amphipods was, until recently, considered to be relatively low; only four or possibly five species were regarded as subterranean (Williams, 1986). However, in a separate footnote to the paper by Williams (1986: 556), Knott foreshadowed greater diversity and noted that a range of undescribed subterranean amphipods occurred in Western Australia. Without formal description of taxa, comments supporting this note were separately published (Knott, 1983, 1985). Descriptions of several subterranean species (Williams & Barnard, 1988; Stock & Iliffe, 1991; Barnard & Williams, 1995; Bradbury & Williams, 1995, 1996a,b, 1997) have provided substantive confirmation that a diversity of forms occur, a phenomenon which includes—as elsewhere—both troglobitic and troglophilic forms (i.e. obligate and facultative sub-surface forms). Bradbury & Williams (1997) discussed and drew attention to this diversity, listed all described sub-surface forms, and noted the occurrence of several further undescribed taxa.

The main aim of the present paper is to describe the further taxa referred to by Bradbury & Williams (1997). Given their number and diversity, the opportunity is taken to update the synopsis of described forms and discuss them briefly. The opportunity is also taken to revise the generic description of *Wesniphargus* Williams & Barnard, 1988, in the light of additional material of *W. nichollsi* collected from a stream flowing from a cave and from a temporary pool.

Although the taxa described herein significantly increase the already considerable known diversity of subterranean Australian amphipods, still further new taxa await description; material is in our possession or known to us which points to the likelihood of new stygobiont taxa from Queensland (*Chillagoe* sp.), New South Wales, South Australia (northwestern, east-central, and southeastern), Tasmania, and Western Australia (Barrow Island, Varanus Island, Ashburton River, Nullarbor Plain). However, given the pressing need to focus attention on surface forms of Australian amphipods, rather than provide an exhaustive study of sub-surface forms, this material will form the basis of a subsequent paper.

While the major aim of this paper is taxonomic, we recognise—together with an increasing number of others (see especially: Christiansen, 1992; Culver *et al.*, 1995; Holsinger, 1994a,b; Kane & Culver, 1992)—that cave faunas, amphipods in particular, are of considerable scientific interest beyond their taxonomy, but that taxonomic studies like ours nevertheless continue to dominate studies of cave faunas. Notwithstanding this recognition, given the only recent knowledge of the extensive diversity of sub-surface amphipods in Australia and its still indeterminate limits, we believe taxonomic studies essential prerequisites at this stage.

Methods of dissection and description

These follow Bradbury & Williams (1996a).

The notation **M**, with an appended number, indicates the position of an object as a fraction of the distance from the base to the apex of an appendage; **S**, large robust seta; **s**, small robust seta. Abbreviations used in the figures are as follows: **A**, antenna; **Abd**, abdomen; **acc**, accessory; **C**, coxa; **d**, dorsal; **dact**, dactylus; **E**, epimeron; **fl**, flake; **flag**, flagellum; **g**, gill; **G**, gnathopod; **Hd**, head; **i**, inner; **juv**, juvenile; **L**, left; **lac**, lacinia mobilis; **lat**, lateral; **LL**, lower lip; **MD**, mandible; **med**, medial; **mol**, molar; **MP**, maxilliped; **MX**, maxilla; **O**, oostegite; **opp**, opposite; **p**, palp; **P**, peraeopod; **pl**, plate; **Pp**, pleopod; **R**, right; **st**, sternal gill; **T**, telson; **U**, uropod; **UL**, upper lip; **UR**, urosome; **1, 2, 3 ...7**, first, second, third ...seventh article, segment, somite or epimeron (as appropriate).

Mandibular palp setae are described using the notation of Karaman (1969) and Barnard & Barnard (1983). Lowry & Stoddart (1993) proposed a modified notation which removed many discrepancies, but as the former notation was developed for freshwater crangonyctoids it has not been necessary to employ the more detailed ones of Lowry & Stoddard (1993).

Melitidae Bousfield, 1973

Norcapensis n.gen.

Type species. *Norcapensis mandibulis* n.sp.

Diagnosis. Pleonite six with two small dorsolateral robust setae, rostrum obsolescent, lateral cephalic lobes strongly projecting, broad, no antennal sinus, eyes absent. First antenna: elongate, longer than second antenna, ratio of peduncular articles 34:31:12, accessory flagellum 2-articulate, second article tiny. Second antenna: very short, flagellum much shorter than peduncle, calceoli absent. Upper lip: symmetrical, ovate. Mandible: palp three-articulate, articles reduced with few setae; accessory blades (rakers) on mandibles few with two plumose setae anteriorly; few small setae beyond rakers on to base of molar. Lower lip: with inner lobes. Maxillae: moderately to well setose medially; inner plate of first maxilla ovate with medial and distal plumose setae; outer plate with seven or more denticulate robust setae, palps symmetric, each with thin apical robust setae. Inner plate of second maxilla with row of plumose medial setae extending to the apex, some facial; both plates of second maxilla with plumose apical setae of medium to moderate length. Inner plate of first maxilla and medial and lateral margins of second poorly pubescent. Maxilliped: inner plate long with distofacial row of plumose setae extending apically, blunt naked tooth like robust setae terminally; outer plate large with apical plumose setae continuous with paired rows of curved facial setae extending medially and submarginally from the base; anteromedial margin carved into sinuosities without marginal robust setae; palp articles 2 and 3 with few lateral setae, moderately setose medially; article 3 without setae or comb rows at base of the dactyl, distolaterally and facially pubescent; apex not produced, dactyl unguiform, multispinous, facially pubescent with short nail and terminal accessory spinule. Coxae 1–7 short, broader than long; coxae 1–4 lacking posterior robust setae; coxa 1 not expanded below; coxa 4 not excavate posteriorly; coxa 5 as long as four. Gnathopods: diverse, dactyls lacking inner tooth like robust seta, lacking nail. First gnathopod: small, feeble, carpus equal to propodus, not lobate, merus lacking hyaline lobe, without rastellate seta, palm transverse, robust setae not symmetrically bifid, rather with small subapical trigger like extensions; armaments at corner of palm few lateral and medial robust setae, setae along palm sparse and simple. Second gnathopod: enlarged, 3.3× gnathopod 1; carpus short and lobate, hand enlarged and ovate, palm strongly oblique, spinose and irregularly setose, defining corner with strong lateral and medial robust setae. Peraeopods: three and four of proportions similar to peraeopods 5–7; posterior robust seta sets on article 6 of peraeopods 3 and 4 unevenly spaced; peraeopods 5–7 moderately long, peraeopods 6 and 7 subequal, longer than five, article 2 moderately expanded, ovatorectangular, posteroventrally extended, slightly lobate on peraeopod 6, lobate on peraeopod 7; dactyls of peraeopods lacking accessory spinules. Coxae 2–6 each with a single flask-shaped gill, that of coxa 6 not reduced. No sternal gills. Oostegites: present on coxae 2–5; thin, strap like, poorly setose. Epimera: posteroventral tooth of epimera 1 to three absent; posterior margins smooth to sinuous with few setae; epimera 2 and 3 with facial robust setae near the ventral margin. Pleopods: peduncles with few setae, rami extending equally, basomedial setae of inner rami not bifid; retinaculae two per pleopod, no accessory robust setae. Uropods: apicolateral corner of peduncles of uropods 1 and 2 with one or two robust setae; mediodorsal margin of peduncle of first uropod spinose, of second naked, mediodistal margin of first uropod with two robust setae; first uropod with basofacial robust seta; lateral rami of uropods 1 and 2 shorter than medial, rami of both uropods mostly with two robust seta rows; third uropod: strongly extended, peduncle short, outer ramus large, inner ramus short, scale like, medial setae of outer ramus sparse, peduncular robust setae few, medial and distal. Urosome: ventrodistal robust seta on urosomite 1 at base of uropod 1 absent. Telson: longer than broad, cleft 90%, laterally convex, bearing, short, marginally subapical setae with one or two long lateral penicillate setae and small, paired lateral penicillate setules.

Relationship. It is difficult to determine the relationship of *Norcapensis* to other melitids, and as an ongoing taxonomic review of the Melitidae is underway (Lowry, pers. com.) it would be premature to speculate on this. However, attention should be drawn to the presence of eriopisid characters, including: absence of eyes; medial setosity of the maxillae; symmetricity of the first maxilla palps; dissimilarity of the gnathopods; non-lobate fourth coxa; peduncular basofacial spine present on the first uropod; elongate third uropod; and deeply cleft, apically notched tapering telson bearing few setae. Among the three eriopisid genera, *Norcapensis* has several characters in common with *Victoriopisa* Karaman & Barnard, including: fusion of the basal articles of the flagellum of the second antenna; seven denticulate apical spines present on the outer plate of the first maxilla; elongate carpus and transverse, convex palm on the first gnathopod; broad, ovate coxal gills. The genus differs, however, from *Victoriopisa* in that: C setae are present and A setae absent from the mandibular palp; inner plate of the first maxilliped is ovate rather than ovatotriangular; fourth article of the seventh peraeopod is not dilated; outer ramus of uropods 1 and 2 are shorter than inner.

This genus appears related to *Nedsia* Barnard & Williams, a marine invader or "crawlout" from the lowland coastal plains of North West Cape and Barrow Island (Barnard & Williams, 1995; Bradbury & Williams, 1996a). *Norcapensis*, nevertheless, differs from *Nedsia* in several minor ways: relatively short first and third articles of the peduncle and the longer flagellum of the first antenna; the upper lip is not excavate below; there are three rather than two articles of the mandibular palp; a greater number of setae on the inner plate of the first maxilla; setae of the outer plate of the maxilliped are not blunt and are more numerous and the distal plumose setae are not accompanied by a bent naked medial robust seta, the apex of the maxillipedal palp is not produced even weakly and the dactyl bears additional accessory setules. The carpus of the first gnathopod is equal in length to the propodus rather than longer, with reduction in the length of the lateral setae at the palmar corner and greater numbers of setae and robust setae along the palm; the second gnathopod is enlarged with a strongly oblique and more setose palm, the palmar corner marked by two or three stout lateral and medial robust setae rather than a single robust seta; the sixth periopod is subequal to the seventh, article 2 of peraeopods 6 and 7 is progressively lobate rather than without lobes as found in *N. douglasi* Barnard & Williams. There are additional setae on the peduncle of the pleopods and

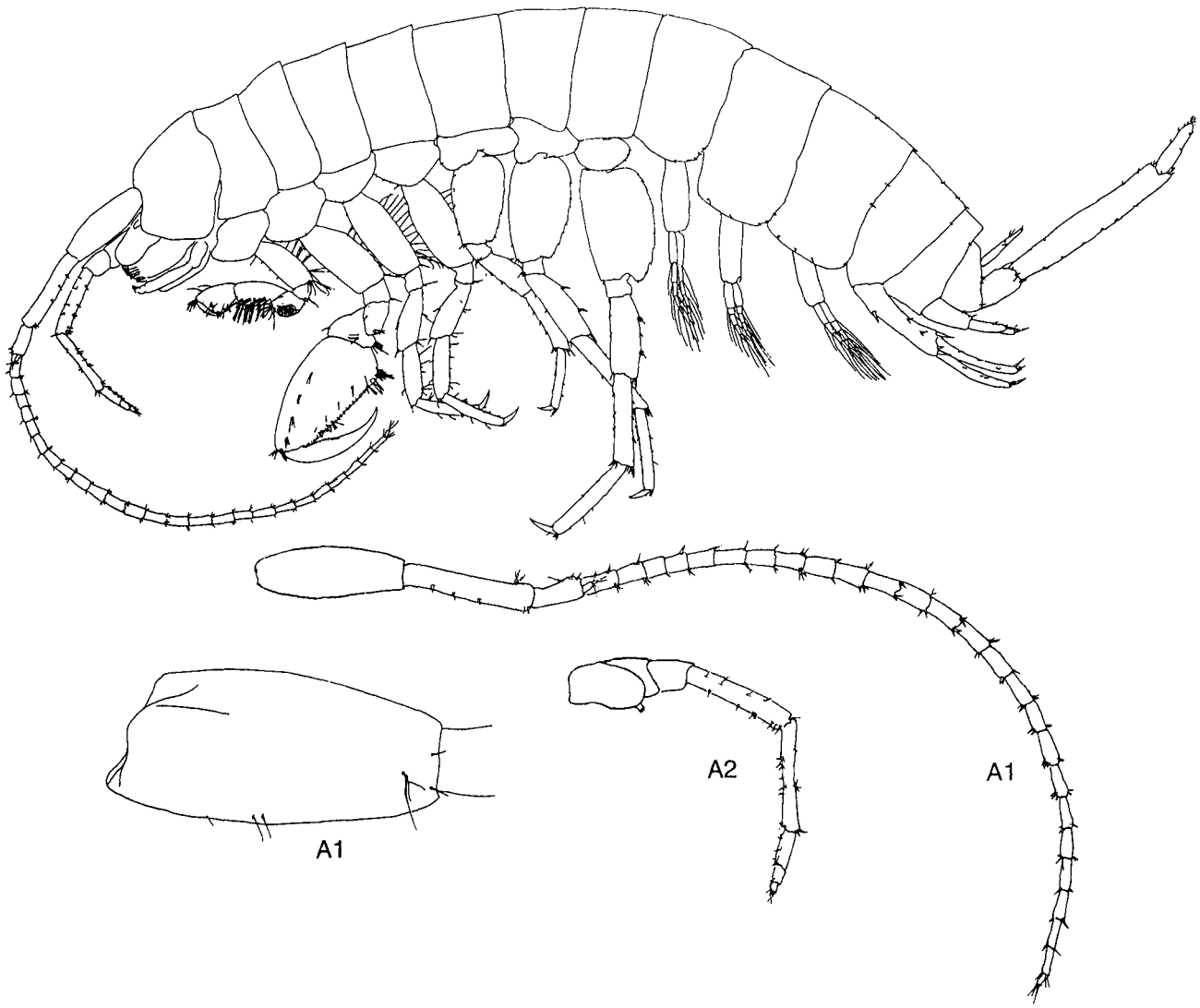

Fig. 1. *Norcapensis mandibulis* n.sp. holotype female "p"; body and antennae.

the rami are equal with no accessory robust setae to the retinacula; the medial margin of the peduncle of the second uropod is without robust setae and the medial ramus bears a single, rather than two robust seta rows; the inner ramus of the third uropod is reduced and the outer ramus long and slender rather than phyllode-like. The telson of *Norcapensis* is cleft 90% rather than 100%, as in *Nedsia*.

The relationship of *Norcapensis* with the other hadzioid genus (*Brachina* Barnard & Williams, 1995) from Australian fresh waters is less close. The genus differs from *Brachina* in: mandibular palp is well developed; lower lip bears inner lobes; inner plate of first maxilliped is ovate, medially setose and pubescent; palp of maxilliped distofacially pubescent and inner plate basofacially pubescent; coxae reduced, all of about the same length; gnathopods and peraeopods 1 and 2 bearing long posterior setae on the second article, dactyls of peraeopods without nail; second article of third uropod elongate; telson slender, with few apical robust setae or setae, cleft 90% rather than 100%.

Norcapensis mandibulis n.sp.

Figs 1–4

Etymology. Named for the presence of well-developed mandibular palps.

Type locality. Underground water, Cape Range, North West Cape, Western Australia.

Material examined. Cape Range, Western Australia. HOLOTYPE (WAM 511-97) female "p" 10 mm, in type series; ALLOTYPE (WAM 512-97) male "t" 12 mm, 7 other female PARATYPES (WAM 513-97), Western Australia Museum: collection CR1989 3236, in gravel in freshwater pool in deep limestone cave, 22°07'S 113°59'E, collected by hand net, R.D. Brooks, 23 June, 1989. Other material: female "q" 10 mm (WAM 514-97), and 4 other females (WAM515-97); station CR1989 3241, in freshwater canal outflow of limestone cave, 22°09'S 114°00'E, collected by hand net, R.D. Brooks, 29 June, 1989; female "r" 9 mm (WAM 516-97) and 2 other females (WAM 517-97), station CR1989 3212, freshwater pool in deep limestone cave, 22°05'S 113°59'E, collected by hand

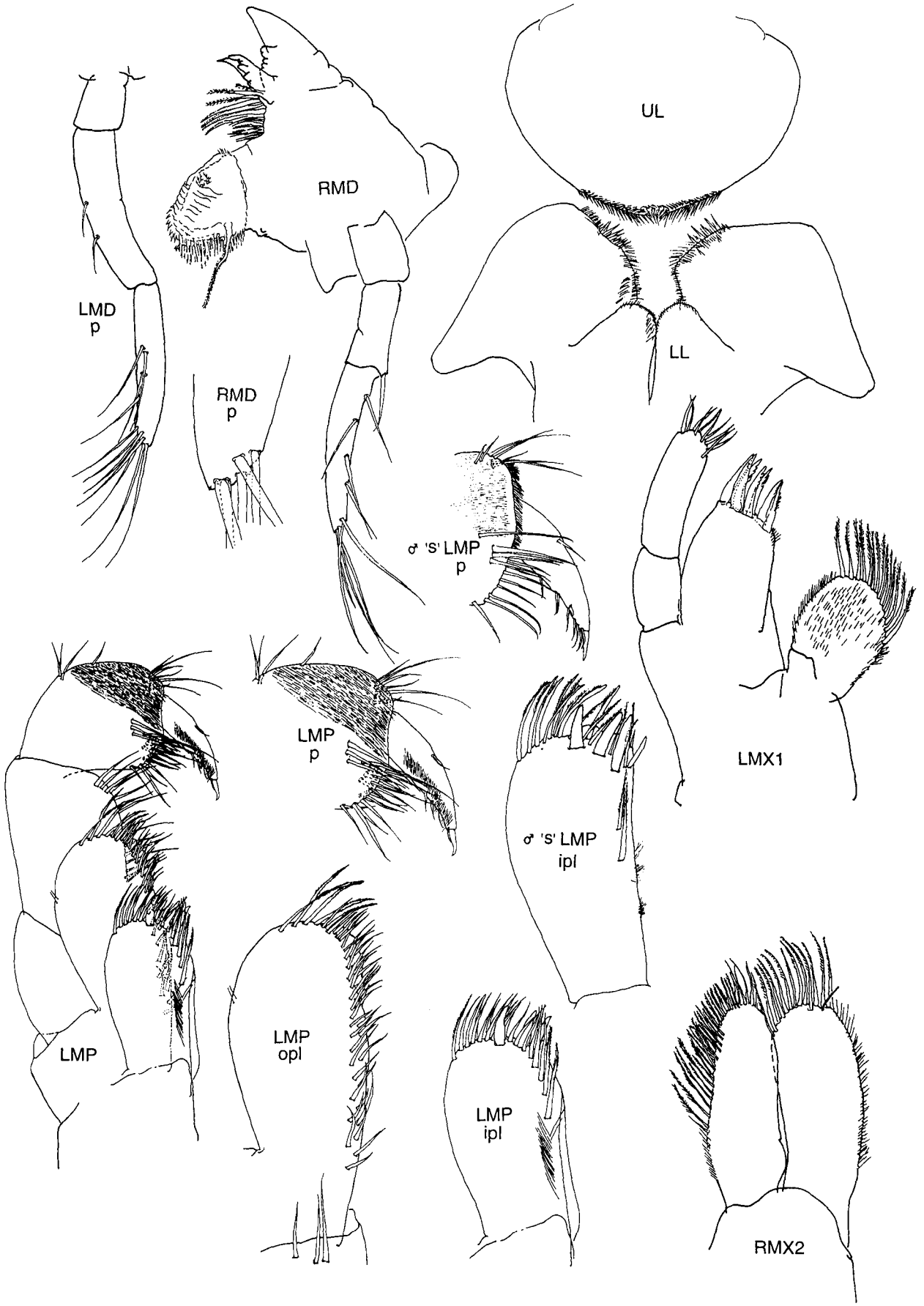

Fig. 2. *Norcapensis mandibulis* n.sp. holotype female "p"; mouthparts (all drawings except those indicated). Male "s" maxilliped inner plate and palp.

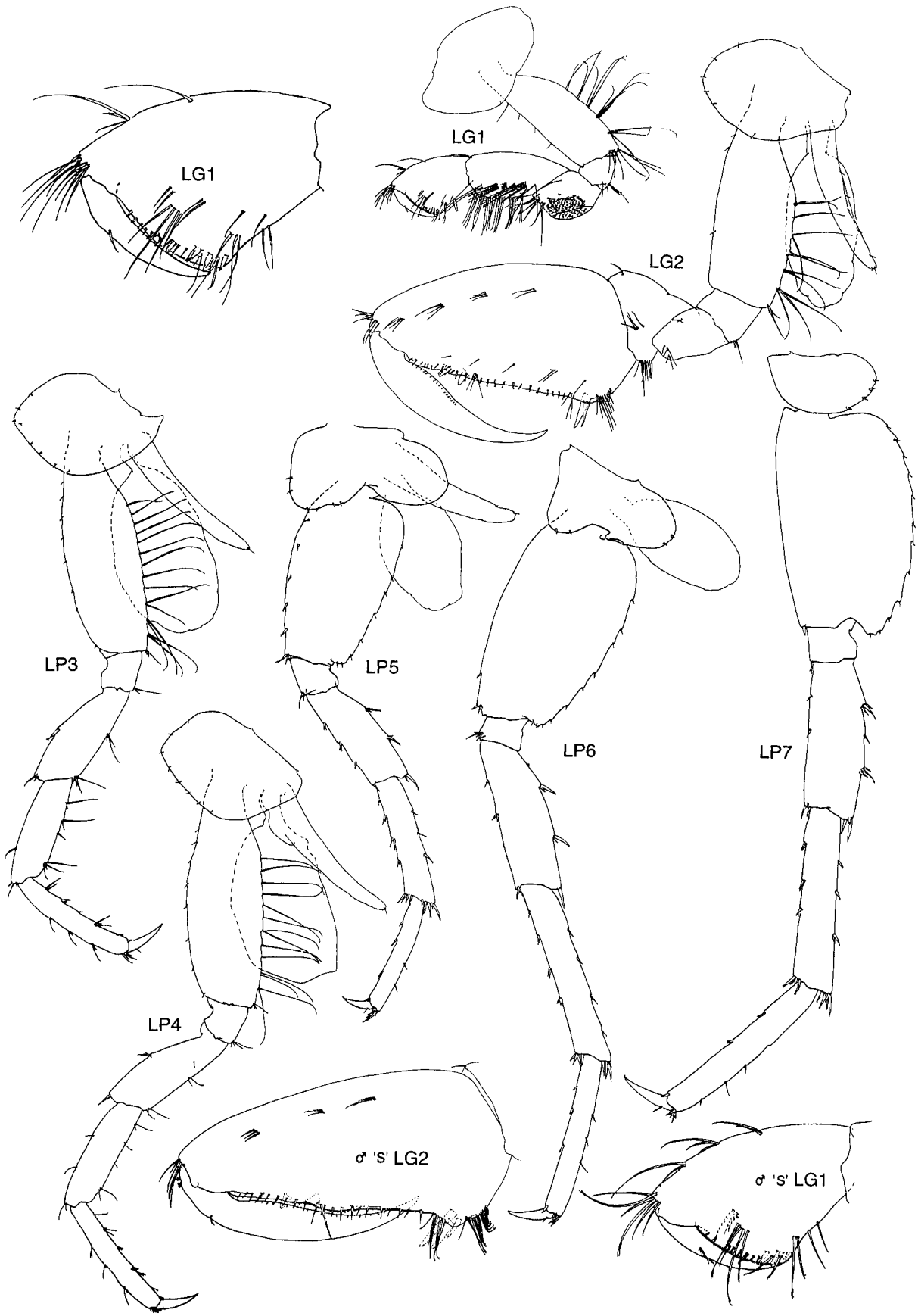

Fig. 3. *Norcapensis mandibulis* n.sp. holotype female "p"; legs (all drawings except those indicated). Male "s" propodus gnathopods 1 and 2.

net, B. Vine, 26 June, 1989; male "s" (WAM 518-97) and 8 females (WAM 519-97), station CR1989 3225, freshwater pool in deep limestone cave, 22°03'S 114°01'E, collected by hand net, B. Vine, 27 June, 1989.

Diagnosis. As in the genus.

Description of holotype (female "p"). *Body* (Fig. 1): urosome poorly armed dorsally, length 10 mm. *Head*: rostrum obsolescent, eyes absent. *First antenna* (Fig. 1): length about 0.7× body, 2.7× second antenna; flagellum longer than peduncle, of 26 articles; peduncle articles 1 and 2 approximately equal, 1 longest, 3 shortest, article 1 with few robust setae or setae, bearing a mediodistal group of three setae but no robust seta, setae sparse on articles 2 and 3; calceoli and aesthetascs absent; accessory flagellum two-articulate, small, second article tiny, extending to M0.5 on first article of primary flagellum. Primary flagellum articles uniform, sparsely setulate. *Second antenna* (Fig. 1): length 0.2× body, peduncle much longer than flagellum, articles 4 and 5 equally long, sparsely setulate, other articles with few setae or robust setae; flagellum short, 5-articulate, few setae, lacking calceoli. *Upper lip* (Fig. 2): symmetrical, ovate, apically pilose. *Lower lip* (Fig. 2): bi-lobed, outer lobes with spinous setae and pilia medially, inner lobes distally pilose. *Left mandible* (Fig. 2): palp three-articulate, ratio of articles 5:7:14, article 1 naked, article 2 linear, subequal to article 1 with two medial setae, article 3 sublinear lacking A or B setae, with 3C1D5E setae; incisor five-teeth, lacinia mobilis six teeth, molar with distal plumose seta and peripheral posterior pubescence. *Right mandible* (Fig. 2): similar, palp ratio of articles 5:13:13, article 2 bearing a single distal seta, setae of article 3 3C1D7E. *First maxilla* (Fig. 2): left and right sides asymmetrical; inner plate ovate to round bearing fourteen plumose apical setae, covered in short pubescence; outer plate bearing seven denticulate terminal robust setae on the left side, ten on the right; palp article 2 terminating in ten long robust setae on the left, eight on the right. *Second maxilla* (Fig. 2): lateral edge of outer plate and basomedial margin of inner plate pubescent; outer plate terminating in 13 long plumose setae (the spinules being restricted to the medial face), and one short naked seta; inner plate bearing five long terminal setae, some naked robust setae mediodistal to distal, and many plumose medial setae extending mediodistally on the face. *Maxilliped* (Fig. 2): peduncle bearing three facial robust setae basal to inner plate; inner plate bearing a medial submarginal row of pubescence; palp article 3 with a row of medial robust setae progressing to submarginal/facial distally, a single distomedial robust seta basal to the dactyl, and two rows of subdistal facial robust setae; adjacent the apex a row of seven robust setae marginal to ventrofacial; distal face covered in non-organised fine setae. *First gnathopod* (Fig. 3): coxal plate with two small setae, one anterodorsal and one ventral; article 4 posteriorly bulbous, but not lobate, covered in short pubescence; article 5 subquadrate, not lobate, bearing clusters of slender robust setae; propodus trapezoidal, expanded apically, longer than wide, few posterior robust setae, cluster of eight robust setae terminally at dactyl base; palmar corner defined by four stout medial robust setae (the first three evenly spaced) and two slender lateral robust setae, palms convex, transverse to slightly oblique, setae along palm small, slender, mostly submarginal, row of fine robust setae proximal to corner; dactyls without medial spination, length short of palmar corner. *Second gnathopod* (Fig. 3): coxal plate broadly rounded, few anterior and one ventral setae; article 4 posteriorly expanded; carpus moderately lobate; propodus enlarged, 3× first gnathopod, ovate, longer than wide, with a row of clusters of facial robust setae dorsally and ventrally; palm strongly oblique, palmar corner rounded, marked by a pair of moderately long, stout robust setae, robust setae along palm mostly small, with triggers, and a pair of distal stout, blunt robust setae; dactyl short of palmar corner, with a submarginal row of small trigger robust setae along the proximal edge. *Peraeopods* (Fig. 3): peraeopods 3–5 equal in length, longer than gnathopods; coxa 3 rounded, subquadrate, slightly broader than long, few marginal setae anteriorly and ventrally; coxa 4 similar, slightly broader, not posteriorly excavate; coxae 5–6 bilobed, small, irregular, coxa 5 without posterior setae, coxa 6 with two small posterior setal robust setae; coxa 7 lacking anterior lobe, with four small posterior robust setae. Peraeopods 3 and 4, article 2 with long, straight, distally curved posterior setae, articles 3 and 4 with few to moderate armaments, articles 5 and 6 with mixed robust setae and setae, the posterior robust seta formulae of articles 6 = 2s,sS,S,3s,S,S and s,3s,2s,2S,s,S with only single locking robust setae on each. Peraeopods 5–7, article 6 armaments few, articles 2–5 moderately spinose with strong apical spination on article 5, dactyls without accessory robust setae except for a single outer penicillate setule. *Gills*: those of coxae 2–6 flask-shaped, that of coxa 6 not reduced. *Oostegites*: present on coxae 2–5 and simple, strap like, poorly setose. *Pleopods* (Fig. 4): each bearing two retinacula with no accessory robust seta, rami equal in length; peduncle of second pleopod with three short median, one apicoposterior and one apical seta, basal articles of rami each with one seta; peduncle of pleopod 3 bearing one mid-median, one apicomedial, one apical and one short apicoposterior seta; rami with one to two setae on basal articles. *Epimera* (Fig. 4): 1 and 2, post-ventrally rounded, bearing five and three small robust setae respectively, epimeron 2 with one moderate anteroventral robust seta and one small mid-ventral robust seta; posterior margin of epimeron 1 slightly concave, epimeron three with small rounded extension posteriorly, one small post- ventral robust seta as well as four small to moderate ventromarginal robust setae, one post-dorsal and one posterior dorsolateral small setae. *Pleon*: pleonite 3 bearing single small posterior dorsal and dorsolateral setae; three small dorsal setae on pleonite 4, pleonites 4 and 5 bearing single dorsolateral setae on the posterior margin, pleonite 6 with small posterior robust setae paired dorsolaterally and single robust setae ventrolaterally. *Uropods* (Fig. 4): length of uropods relative to uropod 1—uropod 2 0.5×, uropod 3 1.8×. Uropod 1, peduncle length 1.2× inner ramus, basofacial robust seta present, and a moderate lateral row of 2-1-1-0-1 robust setae the last being subdistal, two small sublateral distal spurs, one large apicolateral robust seta and one large medial sub apical trigger robust seta; rami of subequal length, the inner being the longer, each with lateral and medial rows of two or three robust setae and a cluster of five terminal robust setae. Second uropod smaller than first, peduncle subequal to lateral ramus, bearing two apicolateral and one apicomedial robust setae; outer ramus 0.75× inner with two sparse rows of single marginal robust setae and four apical robust setae; inner ramus lateral robust setae absent, two medial robust setae, terminal cluster of five robust setae. Third uropod, strongly extended, 0.3× body, peduncle short, 0.25× length of article 1 of the outer ramus, bearing a small ventral robust seta at M0.4, a single ventrodistal robust seta, paired mediodistal and laterodistal short robust setae and a pair of short apicodorsal robust setae; inner ramus small, scale-like, 0.5× peduncle, naked except for a single ventrodistal robust seta and a small distal seta; outer ramus elongate, 2-articulate, proximal article linear, sub rectangular, width to length ratio of 0.2, armed with marginal ranks of short robust setae and setae and a

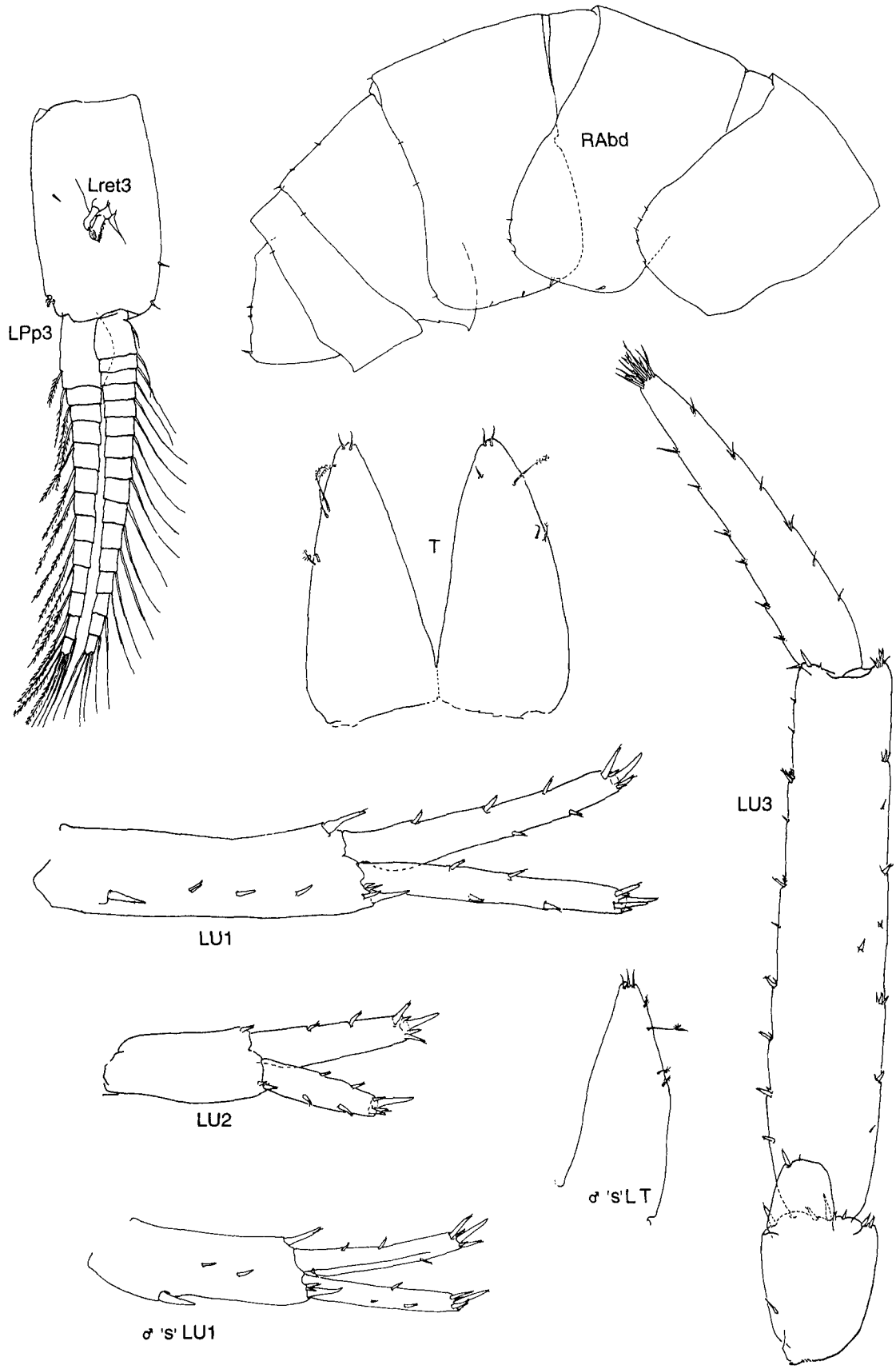

Fig. 4. *Norcapensis mandibulis* n.sp. holotype female "p"; abdomen, pleopod, uropods and telson (all drawings except those indicated). Male "s" left telson.

single facial robust seta at M0.5, a lateral apical cluster of two short robust setae and four setae, the medial apex bearing one robust seta and two setae, distal article 0.6× proximal, slender, similarly armed marginally, tapering from base to apex, terminating in a cluster of 12 slender robust setae. *Telson* (Fig. 4): length twice width, longer than urosomite three (75:60), cleft 90% of length, apices notched, two short marginally sub apical setae on either lobe, with one or two moderately long penicillate dorsal setae at M0.9 and short, paired dorsolateral penicillate setules at M0.7.

Description of allotype (male "t"). *Body*: length 12 mm. *Mandibles*: palps three-articulate, ratio of articles 5:10:12 (cf. 5:7:14 L or 5:13:13 R), setae of article 3 left 4C2D5E, right 1C1D4E. *Maxillae*: inner plate of first maxilla bearing 12 (cf. 14 in the holotype) plumose apical setae; palp article 2 terminating in long robust setae, 8L,7R (cf. 10,8). *Maxilliped*: peduncle bearing two (cf. 3) facial robust setae basal to the inner plate; inner plate with plumose mediodistal seta replaced with medium naked robust seta on L side palp article 3 apex with five rather than seven ventrofacial/marginal robust setae. *First gnathopod*: six anteroapical robust setae of propodus at base of dactyl (cf. 8). *Second gnathopod*: larger than gnathopod 1 3× (cf. 3.3×); defining corner of palm with three strong medial trigger robust setae, and marginally and laterally two long slender trigger robust setae, two similar but distally serrate, and one short slender robust seta distally serrate. *Peraeopods*: article 6 of peraeopods 3 and 4 with posterior robust seta formulae; peraeopod 3: s,2S,s,s2S,s,S and peraeopod 4: 2sS,2s,S,s,s. *Pleopods*: peduncles without setae except a single apicolateral seta on pleopod 2. *First uropod*: peduncle with lateral row of 1-1-0-1 robust setae (cf. 2-1-1-0-1), without small sublateral distal spurs; trigger present on the single apicolateral robust seta, but absent from the medial sub apical robust seta (cf. reverse in the type). *Second uropod*. peduncle bearing a single apicolateral robust seta (cf. 2), outer ramus short 0.7× inner (cf. 0.75). *Third uropod*: peduncle without short apicodorsal robust setae (cf. 2); inner ramus 0.6× peduncle (cf. 0.5) bearing a pair of small distal setae (cf. 1); outer ramus proximal article bearing a lateral apical cluster of three robust setae and three setae (cf. 2&4) the medial apex two robust setae and two setae (cf. 1&2). The distal article terminating in 11 slender robust setae (cf. 12). *Telson*: apices with a single notch, three short, subapical setae on either lobe; plumose dorsal setae at M0.5, 0.6, 0.8; single dorsolateral penicillate setules at M0.7.

Description of other material. Specimen "q", female. *Body*: length 10 mm. *First antenna*: flagellum of 30 articles. *Mandibles*: ratio of lengths of articles of left palp 5:12:11 (cf. 5:7:14), second article not reduced, longer than article 1; setae of article 3 3C2D5E; lacinia mobilis with four teeth, ratio of lengths of articles of right palp 5:10:9.5, setae of article 3 4C1D5E. *Maxillae*: inner plate of first maxilla bearing 13 apical plumose setae, right outer plate bearing 11 denticulate terminal robust setae; outer plate of second maxilla terminating in 12 long plumose setae; inner plate of second maxilla bearing one long terminal seta and many short, curved setae. *Maxilliped*: palp inner plate without facial pubescent row, several distomedial robust setae basal to dactyl and five robust setae adjacent the apex. *First gnathopod*: coxal plate bearing eight small setules; three anterodorsal, one apical, and four ventral. *Second gnathopod*: corner of palm marked by one lateral and two medial robust setae; palmar robust setae include three rather than two stout, blunt distal robust setae. *Peraeopods*: coxa of peraeopod 5 bearing four small submarginal and ventral posterior setae; posterior robust seta formulae of articles 6 of peraeopods 3 and 4 2sS,S,s2S,s,S and s2S,S,s2S,s,S respectively. *Uropods*: lengths of uropods relative to uropod 1; uropod 2 0.6×, uropod 3 2.1×; length of peduncle of uropod 1 1.1× inner ramus; with lateral row of 1-1-1-1 robust setae; outer ramus of second uropod bearing five apical robust setae; lateral robust setae present on inner ramus, and one medial robust seta. Peduncle of uropod 3 with two small ventral robust setae at M0.4, three mediodistal and laterodistal short robust setae, and three apicodorsal robust setae; medial apex of outer ramus bearing two robust setae and three setae. *Telson*: apices bearing a single notch, a single terminal robust seta within the notch, displaced laterally, submarginal robust setae at M0.5 and M0.7, long penicillate setules at M0.9 and short single penicillate setule at M0.7.

Specimen "r", female. *Body*: length 9 mm. *Mandibles*: ratio of articles of palp; 5:12:12, setae of article 3 of left palp 2C3D5E of right palp 3C1D6E; left lacinia mobilis with four teeth (cf. 6). *Maxillae*: inner plate of first maxilla bearing 12 plumose setae, palp article 2 terminating in eight robust setae (cf. 10). *Maxilliped*: peduncle bearing two facial robust setae basal to inner plate; palp with row of five robust setae adjacent the apex. *First gnathopod*: coxa bearing a distal marginal row of six setae, two ventral to the apex, four dorsal; corner of palm defined by two stout medial bifid robust setae (cf. 4) and two slender lateral robust setae. *Second gnathopod*: palm with a single stout, blunt distal robust seta (cf. 2). *Uropods*: uropod 1 peduncle with 0-0-1-1-2 robust setae in lateral row, rami with lateral and medial rows of 1–2 robust seta (cf. 2–3). second uropod; two apicolateral robust setae of peduncle displaced medially, outer ramus with a sparse row of marginal robust setae, inner ramus with one medial robust seta; uropod 3 peduncle without small ventral robust seta at M0.4; inner ramus small, 0.65× length of peduncle, bearing two rather than a single distal seta; proximal article without facial robust seta at M0.5; lateral apical group of two robust setae and three setae; distal article 0.5× proximal (cf. 0.6). *Telson*: apices notched unevenly, one notch displaced laterally, retaining two short marginally sub apical setae on both sides, but with single short penicillates at M0.9

Specimen "s", male. *Body*: length 10 mm. *First antenna*: flagellum of 28 articles (cf. 26). *Mandibles*: palp ratio of articles 5:10:12 (cf. 5:7:14), article 2 naked, incisor of left mandible with six teeth (cf. five), setae of right palp; 2C2D4E. *First maxilla*: inner plate bearing 11 plumose apical setae (cf. 14); left outer plate bearing five terminal robust setae (cf. 7). *Maxilliped* (Fig. 2): peduncle bearing two (cf. 3) facial robust setae basal to the inner plate; inner plate plumose mediodistal seta replaced with medium naked robust seta on left side; palp article 3 apex with five rather than seven ventrofacial/marginal robust setae. *First gnathopod* (Fig. 2): coxal plate with several small submarginal anterior setae rather than one anterodorsal and one ventral seta; propodus with nine rather than eight robust setae in a terminal cluster at the base of the dactyl. *Peraeopods*: coxal plate five bearing a single small posterior seta; coxa 7 with three small posterior robust setae (cf. 4); peraeopods 3 and 4, articles 5 and 6 with posterior robust seta formulae 2sS,S,s2S,s,S and S,sS,s2S,s,S. *Epimera*: posterior margin of epimera 1 bearing three mid-lateral to dorsal small setae; epimeron three with small post-ventral notch, three rather than four ventral marginal robust setae. *First uropod*: peduncle with 1-1-1-0-1 lateral row of robust setae, no sub marginal lateral distal spurs *Second uropod*: peduncle bearing one apicolateral robust seta and a single medial robust seta on the inner ramus. *Third uropod*: peduncle with single (cf. paired) mediodistal

and laterodistal short robust setae and a single short apicodorsal robust seta (cf. 2); outer ramus without facial robust seta at M0.5, but with five rather than three robust setae at the medial apex: distal article short (perhaps regenerate) 0.28× proximal, with few marginal armaments, terminating in a cluster of eight (cf. 12) slender robust setae. *Telson* (Fig. 4): apices with single rather than paired notches bearing single setae; single dorsolateral setae at M0.6, M0.7 and M0.9. *Penis*: paired penial processes laterally on sternum adjacent coxal plates of P7.

Distribution. Cape Range, North West Cape, Western Australia.

Neoniphargidae Bousfield, 1977

The family Neoniphargidae was established by Bousfield (1977). It was subsequently redefined by Bousfield (1982) and by Williams & Barnard (1988) who reduced it to one of entirely Australian content. In their redefinition, Williams & Barnard (1988) eliminated several earlier characters, but introduced two new and significant ones: dendritic sternal gills, and rugosities on gnathopods and maxillipedal palps. Gnathopodal and maxillipedal rugosities were recognised as characters common to all known neoniphargids. Bousfield (1977, 1982) had earlier recognised dendritic gills as a frequent, but not obligatory, character. However, Williams & Barnard (1988) foreshadowed further familial emendment stating (p. 115f) "... we recognise the case for a more formal re diagnosis of the Neoniphargidae—but—given the likelihood of discovery of further neoniphargid species in Australia (and thus familial emendation), we do not consider it appropriate to do this at present."

We describe herein two new genera (*Neocrypta*, *Wombeyanus*) and seven new species. All of these we consider to be neoniphargids. However, they do not exactly fit the family diagnosis as outlined by Williams & Barnard (1988) in so far as they do not bear dendritic sternal gills. Furthermore, in addition to these new genera and species we possess numbers of both epigean and hypogean species from Tasmania, Victoria, and New South Wales, yet to be described, which also have simple gills but which are otherwise undoubted neoniphargids. In a separate study (Bradbury, *et al.*, in press), we confirm the taxonomic significance of gnathopodal and maxillipedal rugosities as definitive diagnostic markers for the family. These rugosities are found on the new species as well as all known neoniphargids.

We believe that a definitive family diagnosis is not possible at this stage of knowledge of Australian neoniphargids. However, it is clear that for practical purposes some further emendation is appropriate even now. Accordingly, the family Neoniphargidae is redefined, taking into account the earlier works of Bousfield (1977, 1982) and Williams & Barnard (1988), the characters of known species, and those displayed by new genera and species described in this report: antennal sinus of head weak or absent; molar of mandible well developed, triturative; outer plate of maxilla 2 with one kind of seta apicolaterally; outer plate of maxilliped of ordinary size; rugosities present on maxillipedal palp and gnathopods; gnathopods small or of medium size, almost mittenform, first not dominant, carpi short and post-ventrally lobate or bearing keel, propodi attached to carpi normally, robust setae on palms not of bifid crangonyctoid form; posterior lobes of coxae 5–7 dominant; oostegites narrow to broad; sternal gills 2–6 present; urosomites separate; inner ramus of uropod 3 present as well as short article 2 of the outer ramus; telson cleft, with few robust apical setae, lobes truncate, apically notched.

No previously described neoniphargids are confirmed troglobites. Differences observed among the new species we report here, including morphological modifications such as loss of eyes and attenuation of bodies, are characteristic of troglobites (Holsinger, 1994a). Exclusion from the family definition of characters such as body form and possession of eyes (Williams & Barnard, 1988), previously included by Bousfield (1977, 1982), is therefore supported. Bousfield (1982) defined the third uropod as short; we find the third uropod long in several species, considering it an adaptation to troglobitic habit (Holsinger, 1994a). However, it is noted an inner ramus is always present, and that the outer ramus always bears a second, albeit small, article. These conditions of the character are noted. Simplification of sternal gills has not been attributed to troglobitic adaptation, yet reduction of dendritic to "incipiently dendritic" gills has been observed in the troglophilic *Wesniphargus nichollsi* (Straškraba); the troglobitic *W. yanchepi* n.sp. and *Jasptorus solepti* n.sp., both bearing lumpy or "incipiently dendritic" sternal gills, are reported here. Furthermore, the sternal gills of even *Neoniphargus* are not wholly dendritic; anterior gills are simple, and fully dendritic sternal gills occur only on the more posterior sternites. Bousfield (1982) considered dendritic gills frequent rather than obligatory among neoniphargids, thus we remove the dendritic condition as an essential familiar character. The telson of some new species described here is cleft less (14–20%) than among previously known neoniphargids (50–75%), which Bousfield (1982) considered significant. However, the telson of these new species is otherwise similar, with truncate, notched lobes, few apical robust setae, and a pair of dorsal setae in most cases; certain characters of the telson are taken into account.

Neocrypta **n.gen.**

Etymology. Named for the family, and for the cryptic habit of the genus.

Type species. *Neocrypta primaris* n.sp.

Diagnosis. Pleonites with weak dorsal arms; rostrum small; lateral cephalic lobes weakly to moderately projecting; antennal sinus weak to moderate; eyes absent. First antenna: elongate, longer than second antenna, ratio of lengths of peduncular articles 10:9:5 to 10:13:8, accessory flagellum two-articulate, calceoli absent. Second antenna: peduncle and flagellum without calceoli. Mandibular palp; ratio of articles 8:11:12 to 8:18:17, article 2 naked, article 3 weakly falcate to linear, setae DE, rarely CDE. Labium without inner lobes. Maxillae inner plates not setose medially; first maxilla inner plate

ovatotriangular with two, rarely three apical plumose setae, the outer plate with seven robust setae, the palps asymmetric—left side with thin apical robust setae, the right side broad, with thick apical robust setae, not fused to the article; second maxilla inner plate with no oblique row of facial setae, but upper member of 1–2 main medial setae slightly submarginal, or not. Maxillipedal palp article 3 with a rugose apical lobe. Coxae 1–4 elongate, sparsely to moderately setose ventrally; coxae 1–3 lacking a posterior row of robust setae; coxa 1 weakly tapering below or not; coxa 4 with shallow emargination; coxa 5 much shorter than coxa 4. Gnathopods small, sexual dimorphism minor, carpi short and lobate, articles 2–4 both with or without a posterior rugose lobe, palms slightly oblique and convex, bearing rugosities, three robust setae at the palmar corner, occasionally four, robust setae along palm sparse to moderate, without triggers, dactyls with stiff spinules at inner nail articulation, with additional spinules along inner dactyl margin. Peraeopods 5–7 moderately elongate, subequal, article 2 broadly expanded, ovate, and weakly to moderately post-ventrally lobate. Peraeopods 3–7 with one marginal and one facial dactylar setules. Coxae 2–6 with sac like gills; sternites 2–6 bearing simple gills without dendricities or lumps. Pleopods reduced; rarely the outer ramus of moderate length and article number, most with one, rarely two articles on the inner ramus, with no or one marginal setae, and two terminal setae, and reduced numbers of articles on the outer ramus; peduncles each with two retinaculae, no accessory retinaculae. Epimera postventral tooth short or absent, some with facial robust setae near the vent margin, posterior margins weakly setulate. Peduncles of uropods 1 and 2 with one subapical robust seta on the apicomedial corner, of moderate length, not long with a complex tip. Basofacial arms absent from the first uropod, rami of both uropods extending unequally, their margins variably spinose, the inner rami usually with one robust seta row, the outer rami one or two rows, never with dense spination. Third uropod strongly extended, parviramous, the peduncle short, outer ramus 2-articulate, the second article very short, the first article without setae, the inner ramus reaching to M0.13 or less of article 1 of the outer ramus. Telson moderately long, cleft 11–20%, the lobes basolaterally weakly tumid with apical and in some mid lateral spination, no major setation or basofacial armaments, paired lateral penicillate setules at M0.6 on either lobe.

Additional description. Upper lip uniform, rounded but weakly asymmetrical below. Mandibular accessory blades (rakers) usually with interraker plumose setae. Very few additional penicillate setae beyond rakers riding onto the base of the molar, rather two to four basal molarial ragged setae. Lower lip uniform, inner lobes indistinct or absent, second maxilla—both plates with long apical setae. Maxillae inner plates and the lateral margins of the second maxilla moderately pubescent. Maxilliped inner plate with few distal plumose setae, two or three blunt naked robust setae, few or no medial plumose setae. The outer plate with a distal row of few plumose setae continuous with a distal row of blunt naked tooth like robust setae. Palp articles 2 and 3 poorly setose laterally, well to moderately setose medially, article 3 with a few non comb robust setae near the base of the dactyl. Dactyls of gnathopods with or without recumbent inner tooth like robust seta with stiff spinules or setules at the inner nail articulation, sometimes with additional spinules along the inner dactylar margin. Pleopods similar, peduncles not strongly setose, rami diverse, inner ramus strongly reduced. Urosomite 1 without an articulated ventrodistal robust seta at the base of the first uropod.

Relationship. The new genus *Neocrypta* is most closely related to *Neoniphargus* (Stebbing), but differs in the following: eyes are absent; the first article of the mandibular palp is relatively long, the second is naked, the third without A or B setae; coxae 1–4 are not as long, and coxa 4 less deeply emarginate; gnathopodal palmar robust setae are simple; thoracic segments 2–6 bear simple rather than dendritic sternal gills; the inner ramus of the pleopods is reduced to one or two articles; the third uropod extends beyond uropods 1 and 2 in the intact specimen and is up to 1.5× the length of the first uropod; the telson is cleft to 20% rather than to 50–75%. As well as in the above characteristics, *Neocrypta* differs from *Wesniphargus* (Williams & Barnard) in that rugosities are borne on propodi of both gnathopods, from *Tasniphargus* Williams & Barnard as antennae bear only short, sparse setae, and the basal articles of the primary flagellum of antenna 1 are short, and from *Yulia* Williams & Barnard in that the pleopod peduncles are not strongly setose, and the outer ramus of male uropod 1 does not bear a long apical spur.

Neocrypta primaris n.sp

Figs 5–9

Etymology. From Latin, *primordius*, the first or most primitive, referring to the type species of the genus and apparently the most plesiomorphic.

Material examined. HOLOTYPE (Australian Museum P51361) female "a" 6.5 mm, ALLOTYPE (Australian Museum P51362) male "c" 6.5 mm. Others in the type series: female "b" 7 mm, and five other specimens. Collected 8 March, 1995 by S. Eberhard from among tree roots in a pool, Limekiln Cave (cave WE14) Wellington, New South Wales, 32°33'S 148°57'E.

Diagnosis. Lateral cephalic lobes moderately projecting, antennal sinus moderate, ratio of lengths of peduncular articles of first antenna 10:12:8; ratio of lengths of mandibular palp articles 8:11:12 to 8:13:14, article 3 linear, setae (C)DE, the inner plate of the first maxilla with two plumose apical setae, inner pate of the second maxilla with two mediodistal submarginal plumose setae. Coxa 1 tapering apically, second article of the first gnathopod and second and third articles of the second gnathopod without posterior rugose hump, robust setae at palmar corner 4-3 respectively, palmar robust setae sparse to moderate, peraeopod 6 longer than seven, articles 2 of legs 5–7 moderately postventrally lobate. outer rami of pleopods moderately long, inner rami strongly reduced, of one article, with few marginal setae. Epimera without postventral teeth, with facial robust setae on the first and second. Uropods 1 and 2 with no more than one robust seta row on rami, inner ramus of third uropod reaching m0.1 of the outer ramus. Telson cleft 16%, with mid lateral spination.

Description of holotype (female "a"). *Body* (Fig. 5): pleon with few dorsal armaments, pleonite 5 with two mid dorsolateral robust setae, six with one posterodorsal robust seta basal to the telson; length 6.5 mm. *Head*: rostrum small, eyes absent. *First antenna* (Fig. 5): length 0.58× body, 2.2× second antenna, peduncle shorter than flagellum, ratio of article lengths 10:12:8, setae sparse, flagellum of 26 articles, aesthetascs present on articles 3–25, flagellar segments uniform,

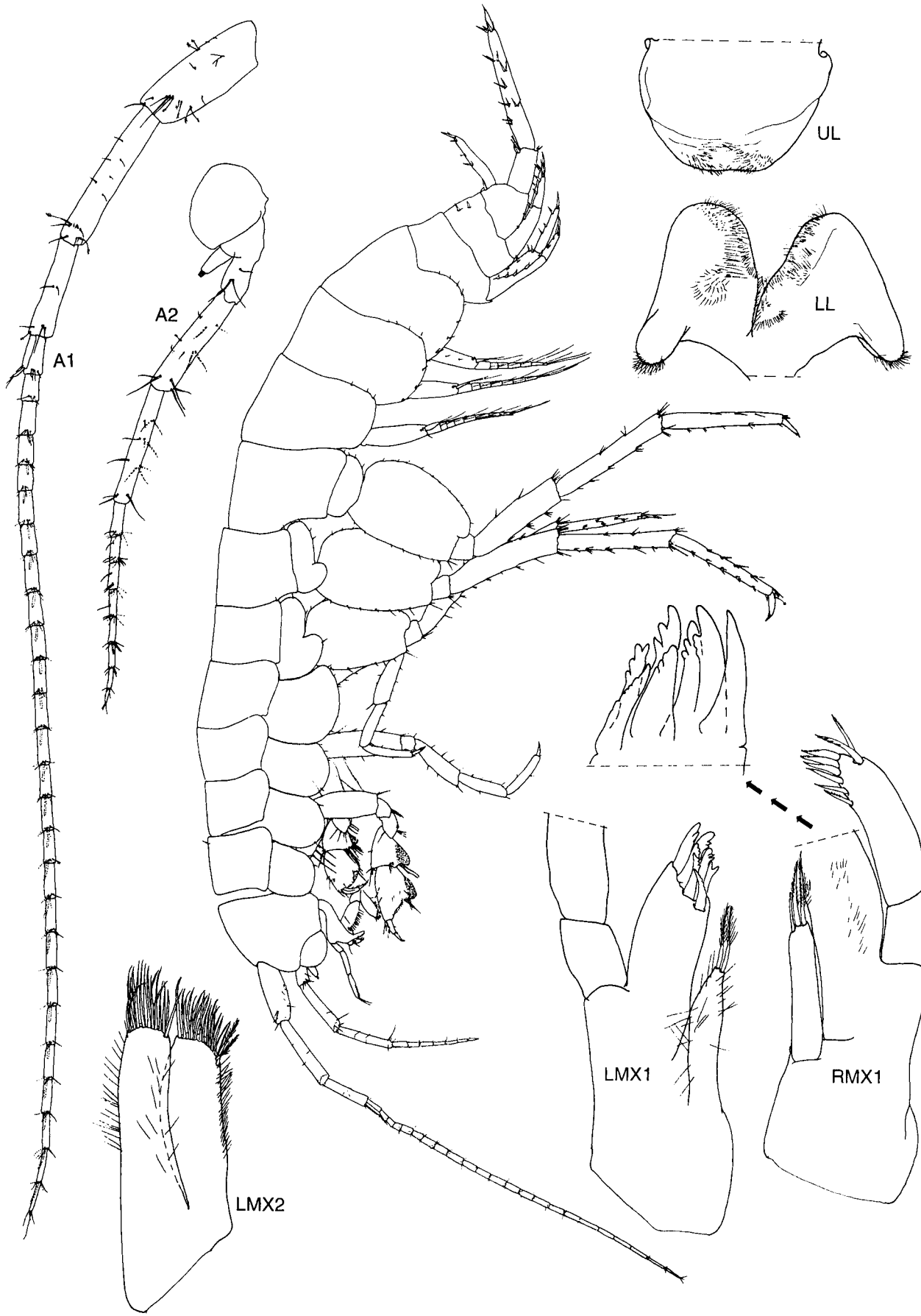

Fig. 5. *Neocrypta primaris* n.sp. holotype female "a"; body, antennae, mouthparts.

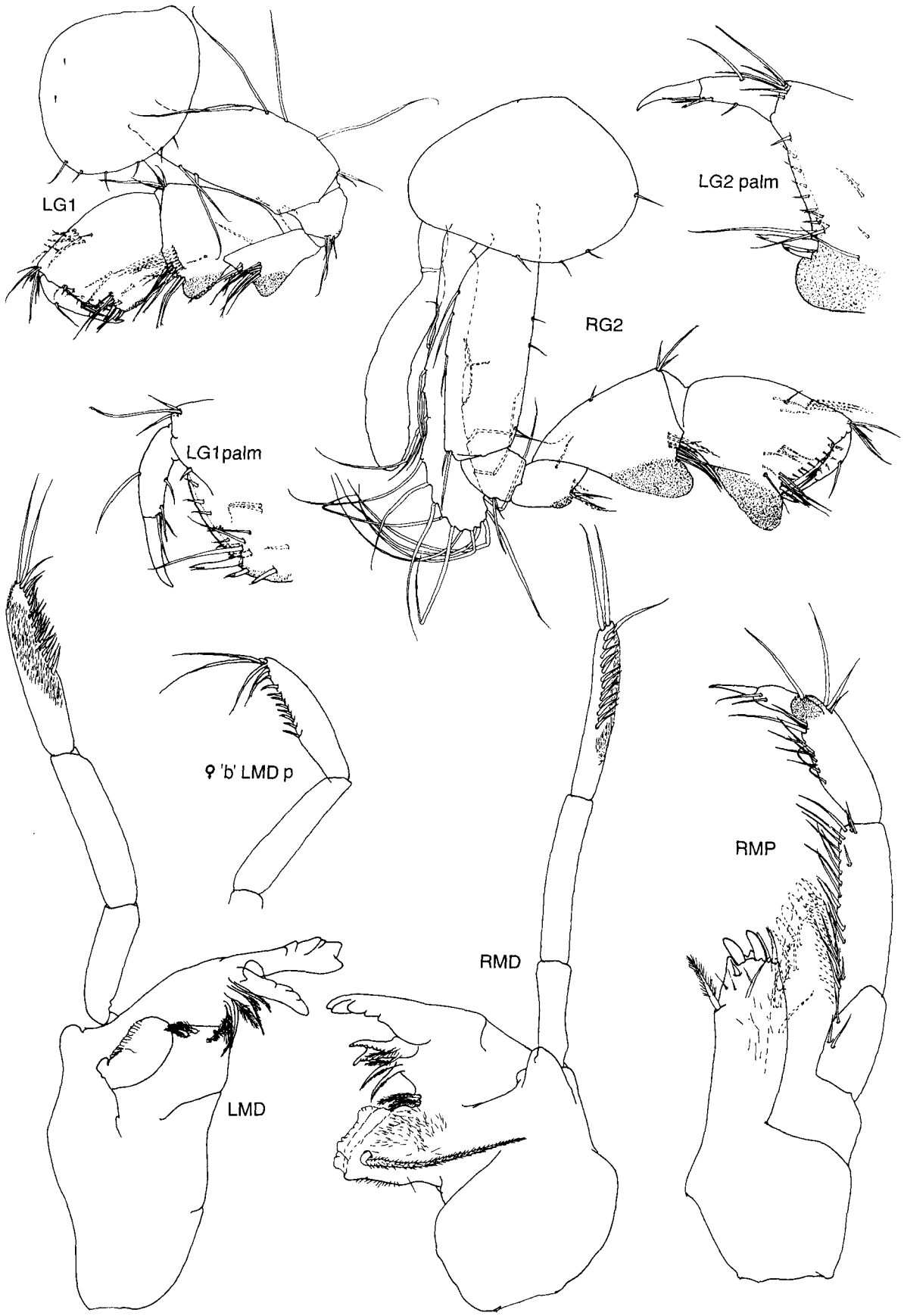

Fig. 6. *Neocrypta primaris* n.sp. holotype female "a"; mandibles, maxilliped, gnathopods (all drawings except those indicated). Female "b" left mandibular palp.

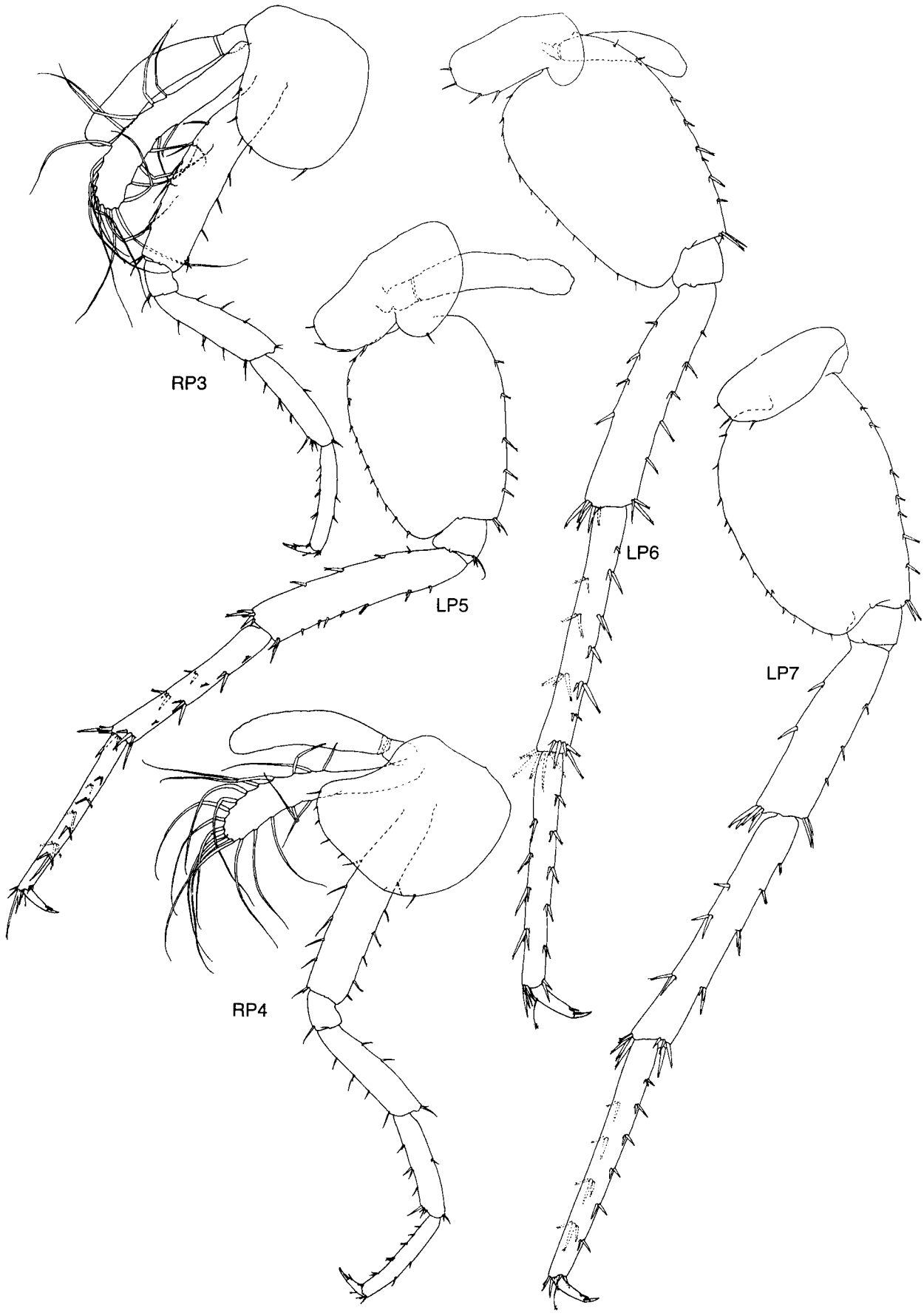

Fig. 7. *Neocrypta primaris* n.sp. holotype female "a"; peraeopods.

sparsely setulate; accessory flagellum 2-articulate, reaching to M0.5 of the second primary flagellum article. *Second antenna* (Fig. 5): length 0.3× body; peduncle 1.9× flagellum, articles 4 and 5 subequal (20:25), articles 3–5 with moderate ventral setation; flagellum of eight articles, weakly setose ventrally, aesthetascs absent. *Left mandible* (Fig. 6): palp article 3 longer than 2, ratio of lengths of articles 8:11:12, article 3 linear, facially and apically rugose, setae 5C14D3E, articles 1 and 2 naked; incisor with six teeth; lacinia mobilis four teeth; accessory blades of three chisel robust setae and three plumose robust setae, four brushy setae onto the base of the molar; molar triturative without a posterior seta. *Right mandible* (Fig. 6): palp article 3 with setae 13D3E, laterofacially rugose; incisor with five teeth; lacinia bifid, denticulate; accessory blades of two chisel robust setae and two plumose setae, two plumose robust setae onto the molar base; molar triturative with a long posterior pappose seta. *Maxillae* (Fig. 5). Left first maxilla: palp article 2 with a row of two naked and one armed mediodistal slender robust setae and three armed transverse apical robust setae; outer plate with seven apically denticulate robust setae; inner plate with two apical plumose setae. Right first maxilla: palp article 2 with a mediodistal row of six strong robust setae, naked and armed, and two laterodistal submarginal armed robust setae; the outer plate with seven mostly denticulate robust setae; inner plate with two apical plumose setae and a moderate, simple sub apical seta. Second maxilla: outer plate with one mediodistal naked seta, inner plate apicomedial corner with two weakly submarginal plumose setae. *Maxilliped* (Fig. 6): palp article 3 without inner ventral setae, moderately setate distomedially, three distolateral setae, two setae basofacial to the dactyl and two accessory spinules on the dactyl, apex moderately produced and rugose; inner plate apex with two thick tooth like robust setae, one distolateral armed and one simple seta, a short stout sub marginal, sub distal seta and one medial plumose seta. *Gnathopods* (Fig. 6): coxal plate of first gnathopod broad, apically tapering, with sparse moderate apical setae; article 2 without posterior rugose extension; article 3 with a small posterior rugose hump; articles 4 and 5 with strong posterior rugose lobes; carpus short, lobe rounded, without apical setae; propodus trapezoidal, as wide as long, the posterior angle sub quadrate with a barely expanded posterior rugose area, palmar corner robust setae one medial, three lateral, palmar robust setae moderate, simple; dactyl with accessory spinules on the inner margin, reaching beyond palmar corner robust setae. Second gnathopopod: larger than the first; articles 2 and 3 without posterior rugose enlargement; article 4 with a small rugose lobe; carpus and propodus with strong posterior rugose lobes larger than on gnathopod 1; palmar corner marked by one medial and two lateral robust setae, palmar robust setae moderately crowded, simple; dactyl with inner marginal accessory setules and small facial setules, reaching the palmar corner robust setae; coxa weakly setose apically, bearing a long sac like gill and long slender setose oostegite. *Peraeopods* (Fig. 7): coxa 3 with three small apical, and two moderate posterior setae, bearing a long sac like gill and long narrow setose oostegite; coxa 4 moderately emarginate with few apical setae; peraeopods 3 and 4 subequal in length, longer than the second gnathopod, articles 4 and 5 moderately setose posteriorly, articles 6 with robust seta formulae 1-1-3-2 and 1-1-2-3-2 respectively; peraeopods 5–7 similar, 6 and 7 subequal, longer than five, coxae with 4-3-4 weak robust setae on the ventral margin of the posterior lobe, coxae 5 and 6 with moderate sac like gills, articles 2 expanded posteriorly (5<6<7) and moderately lobate postventrally, with weak posteromarginal setae; propodi posterior margins lacking long setae except for a long basodactylar seta on leg five. *Gills* (Fig. 8): coxae 2–5 bearing sac like gills; sternites 2–6 each with paired simple gills. *Epimera* (Fig. 8): without postventral teeth, posterior margins slightly to moderately convex with weak setation, ventral margins of epimera 2 and four with three and seven facial robust setae respectively. *Pleon* (Fig. 8): pleonites 1–4 with no arms; pleonite 5 with a strong pair of dorsolateral robust setae; pleonite 6 with a single dorsal robust seta basal to the telson. *Pleopods* (Fig. 8): peduncles each with two retinacula; peduncle 1 with a small distal seta basal to the rami; peduncle three with two laterodistal setae; outer rami of pleopods moderately long with 11, 10, 9 articles, inner rami reduced to single articles, only the first ramus with a marginal seta. *Uropods* (Fig. 8): third uropod long, extending well beyond first and second uropods in the intact specimen; uropod lengths relative to uropod 1; uropod 2 0.8–0.9×, uropod 3 1.9×. First uropod peduncle length 1.3× inner ramus, 2.3× outer ramus; the outer margin with one slightly subapical distal robust seta and a dorsal row of five robust setae, the inner margin with three short dorsal robust setae and one sub apical robust seta; inner ramus length 1.9× outer ramus, with two medial and four apical robust setae, outer ramus with four apical robust setae only. Second uropod: left peduncle with a row of two short dorsolateral robust setae and one sub apical robust seta, the inner margin with one sub apical robust seta; right peduncle with an outer marginal row of four short robust setae and one sub apical distal robust seta, the inner margin with only a sub apical distal robust seta; inner ramus length 1.2× outer, with two medial and four apical robust setae; outer ramus with one lateral robust seta and four apical robust setae. Third uropod: peduncle length 0.3× outer ramus, greater than the length of urosomite three, without facial robust setae, with one distolateral robust seta and one distomedial robust seta basal to the inner ramus; proximal article of outer ramus with five lateral transverse rows of 1-2-2-2-2 robust setae and six medial transverse rows of 1-1-2-2-1-2 robust setae and three medial and three lateral distal robust setae; distal article with two small apical setules only; inner ramus with a single apical robust seta, length 0.09× outer ramus. *Telson* (Fig. 8): moderately long, 1.7× urosomite three, cleft 16%, apices of lobes bearing three right and four left setae, two robust setae laterodorsally at M0.4, paired lateral penicillate setules at M0.6, and small setules on the dorsal face.

Description of allotype (male "c"). *Body*: length 6.5 mm. *First antenna* (Fig. 9): peduncle article 2 longest, ratio of lengths of articles 10:12:8; primary flagellum of 25 articles, all bearing aesthetascs, articles 2, 5, 7, 9, 11 each with two distal aesthetascs, article 4 with three. *Second antenna*: flagellum of seven articles, without aesthetascs. *Mandibles* (Fig. 9): left and right palps similar; naked except for apical setae and rugosities, ratio of lengths of articles 8:14:13, setae of third article 8D4E. Left incisor, lacinia mobilis, accessory blades similar to holotype, molar with one anterior plumose seta, two brushy setae leading to the molar and a moderate posterior pappose seta. Right mandible incisor with five teeth, accessory blades of three chisel robust setae and two plumose setae, with three plumose setae leading to the base of the molar. *First maxilla* (Fig. 9): left palp with four slender armed transverse apical robust setae and two distomedial simple slender robust setae; right palp with four slender distomedial robust setae, and apical slightly stouter distally armed robust seta, and two slender laterodistal armed robust setae; inner plate of both first maxillae with two apical plumose setae. *Second maxilla* (Fig. 9): outer plate with two subdistal lateral

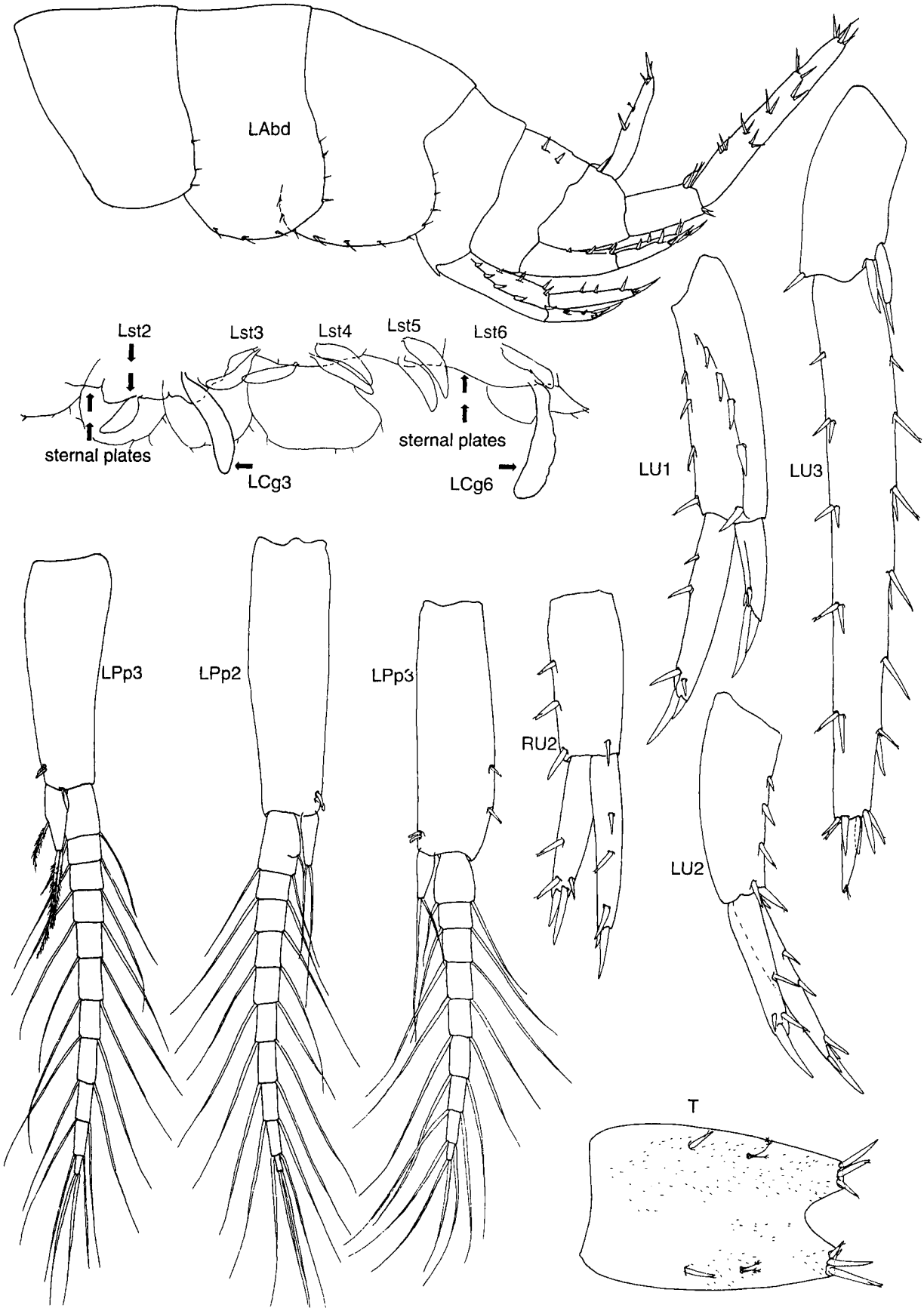

Fig. 8. *Neocrypta primaris* n.sp. holotype female "a"; abdomen, gills, pleopods, uropods, telson.

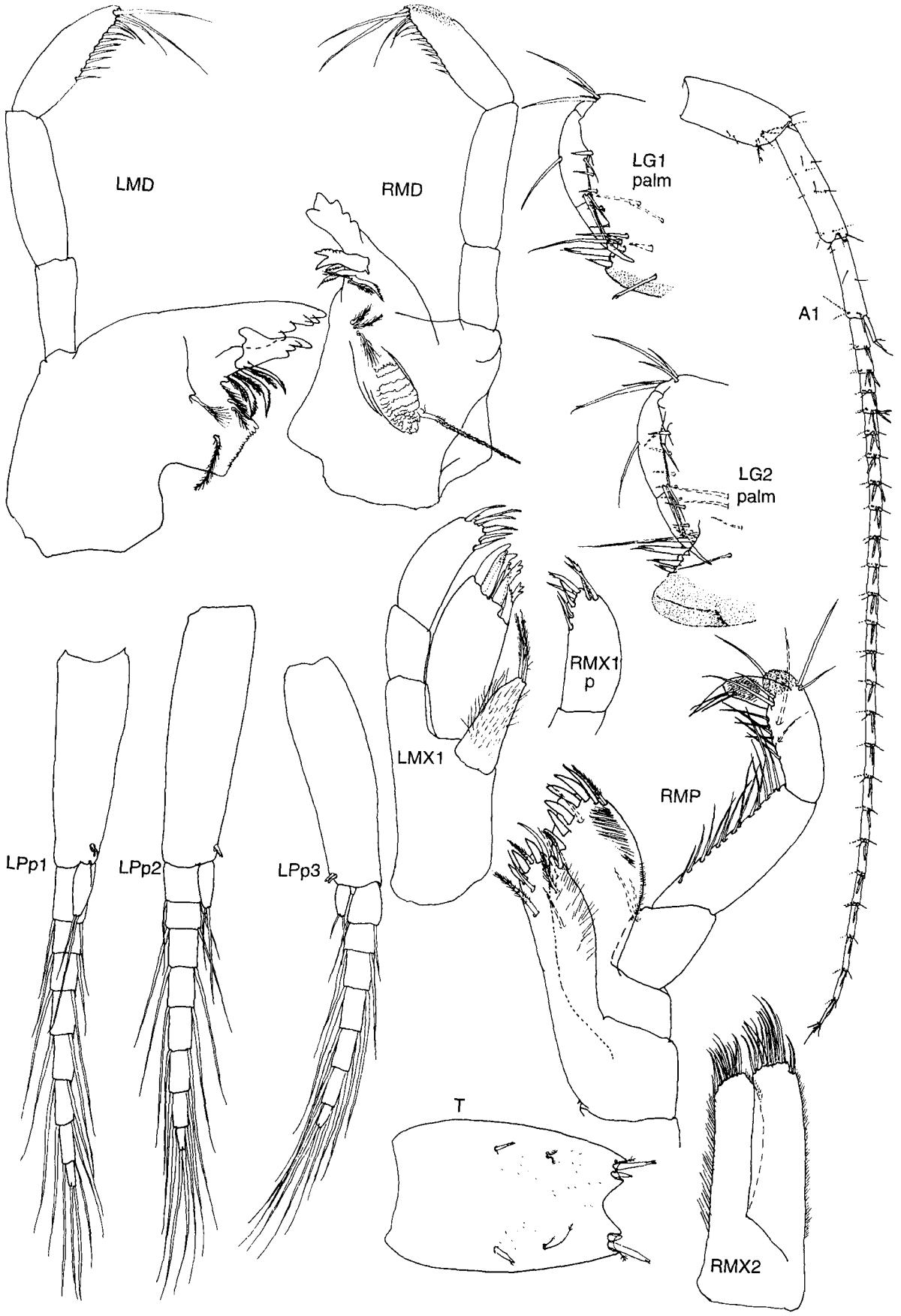

Fig. 9. *Neocrypta primaris* n.sp. allotype male "c"; first antenna, mouthparts, pleopods, telson.

short robust setae, inner plate without two weak submarginal apicomedial plumose setae. *Maxilliped* (Fig. 9): outer plate medial submargin with a row of simple and plumose setae; mid medial to apical face a row of five long naked tooth like robust setae; distolateral margin with slender robust seta and plumose seta. *Pleopods* (Fig. 9): peduncles without arms except a small simple seta basal to the inner ramus on the first pleopod; inner rami each of one article; outer rami of 8, 8, 7 articles. *Telson* (Fig. 9): length 1.5× width; cleft 9%; apices each with one short medial and one longer lateral robust seta and a single lateral penicillate setule; dorsolateral robust setae at M0.4; paired penicillate setules on each side at M0.7; the distodorsal surface with scattered very small setules.

Description of female "b". *Body*: length 7 mm. *First antenna*: with 25 flagellar articles. *Second antenna*: flagellum of seven articles. *Left mandible*: palp third article with small rugosities, setae 9D3E. *Right mandible*: palp article 3 rugose, setae 8D5E. *Pleon*: pleonite 5 with two dorsolateral robust setae, pleonite 6 with one dorsal robust seta basal to telson. *First uropod*: peduncle lateral margin with four dorsal and one apical short robust setae; medial margin with two dorsal and one slightly sub apical robust seta; inner ramus with two medial and four apical robust setae; outer ramus with two lateral, one distomedial and four apical robust setae. *Second uropod*: peduncle lateral margin with two dorsal plus one apical robust seta, medial margin with one small mid dorsal and one apical robust seta; inner ramus with one medial and four apical robust setae, outer ramus with one lateral and four apical robust setae. *Third uropod*: peduncle with only distal robust setae, inner ramus with one apical robust seta, outer ramus proximal article with three lateral ranks of 2-2-2 and three distal robust setae, and four medial ranks of 4-3-3-4 and two distal robust setae; distal article with one small apical spinule. *Telson*: bearing dorsolateral robust setae at M0.5 on either side, paired dorsolateral penicillate setules at M0.7, and with two left and three right apical robust setae.

Distribution. Limekiln Cave, Wellington, New South Wales, 32°33'S 148°57'E.

Neocrypta robinae n.sp.

Figs 10–12

Etymology. Named for the wife of the first author in recognition of her indirect support of amphipod studies.

Type locality. Diprotodon Cave, Cave number CN-10, Canomodine, New South Wales, 33°30'S 148°52'E.

Material examined. HOLOTYPE (Australian Museum P51363) male 6 mm; collected by S. Eberhard; 2 April, 1995.

Diagnosis. Lateral cephalic lobes moderately projecting, antennal sinus moderate, first antenna peduncle ratio of articles 26:24:13, mandibular palp ratio of articles 8:16:16 to 8:18:17, article 3 weakly falcate, setae DE, first maxillae inner plates with two plumose apical setae, inner plate of second maxilla with two distomedial submarginal plumose setae, coxa 1 very weakly tapering apically, gnathopod 1 articles 2 and 3 without posterior rugose hump, gnathopod 2 articles 3 and 4 without rugose hump, palmar corner robust setae 3-3, robust setae along the palm moderately dense, peraeopod 6 longer than seven, articles 2 of legs 5–7 weakly lobate postventrally. Rami of pleopods reduced; inner rami of pleopod 1 with two articles on the right, others with only one article, each with a single marginal seta. Epimera with a small postventral tooth like on the second epimeron only, each with ventrofacial robust setae. Rami of the first and second uropods without dorsal robust setae, the inner ramus of uropod 3 0.1× the length of the outer ramus. Telson cleft 12%, without mid lateral spination.

Description of holotype (male). *Body* (Fig. 10): pleon not armed dorsally except for a single dorsal robust seta adjacent the base of the telson; length 6 mm. *Head*: rostrum small, eyes absent. *First antenna* (Fig. 10): length 0.4× body, 1.2× second antenna, peduncle subequal to the length of the flagellum—63:65—ratio of lengths of the articles 10:9:5, flagellum of 11 articles, uniform and sparsely setulate, articles 1–8 with aesthetascs in pairs, nine to 11 with single aesthetascs, accessory flagellum of two articles, reaching to the end of the first article of the primary flagellum. *Second antenna* (Fig. 10): 0.28× length of body, peduncle much longer than flagellum—79:26—articles 4 and 5 subequal—27:28—articles 3–5 with moderate ventral setation; flagellum of four articles, weakly setose ventrally, without aesthetascs. *Left mandible* (Fig. 10): palp; ratio of lengths of articles 8:16:16, article 3 weakly falcate, setae 17D5E, apex rugose, articles 1 and 2 naked; slender seta at the base of the palp; incisor with five teeth; lacinia mobilis four teeth and fine posterior basal setules; accessory blades of three chisel robust setae and three interraker plumose robust setae, with four brushy setae to the base of the molar; molar triturative, with a short posterior pappose seta. *Right mandible* (Fig. 10): palp article 3 with setae 17D5E, apex rugose; incisor with five teeth; lacinia bifid and denticulate, with an area of setules at the base; accessory blades of two chisel robust setae and one plumose seta, with a short plumose and two brushy setae onto the base of the molar; molar triturative with a long posterior pappose seta. *Maxillae* (Fig. 10). Left first maxilla palp article 2 with one apical and one subapical armed and one naked robust seta, one distolateral plumose seta and two disto medial naked setae; outer plate with seven denticulate robust setae, the inner plate with two apical plumose setae. Right first maxilla palp article 2 with a row of four submarginal mediodistal to apical stout robust setae, the apical two terminally armed, a similar distolateral robust seta and a single distofacial seta; outer plate bearing seven denticulate robust setae; inner plate with two plumose apical setae. Second maxilla: outer plate with a small spinule and moderate seta distolaterally, the inner plate with two submarginal distomedial plumose setae. *Maxilliped* (Fig. 10): Palp article 3 without basomedial and with few distomedial setae, two long setae facio basal to the apex, and a ventral row of three setae basal to the dactyl; apex moderately produced and rugose, dactyl facially pubescent with two accessory spinules basal to the nail; article 2 moderately to well setose medially; apex of inner plate with two thick tooth like robust setae, a stout plumose seta and a naked seta, two ventrofacial setae and one mediofacial seta; outer plate with an apical transverse row of three slender and one stout pappose robust setae, a barely facial medial row of four basally pappose moderate robust setae, a distofacial slender seta and five basomedial setae arranged 1-2-2. *Gnathopods* (Fig. 11): coxal plate of gnathopod 1 with one postventral, one anteroventral and two mid facial setae as well as several small facial setules; articles 2 and 3 without posterior rugose extension, article 4 with a small posterior rugose lobe; carpus short, strongly lobate and rugose posteriorly, the lobe rounded, without apical setae; propodus trapezoidal, longer than wide, the post-lateral edge subquadrate, faintly rugose, with one medial and two lateral

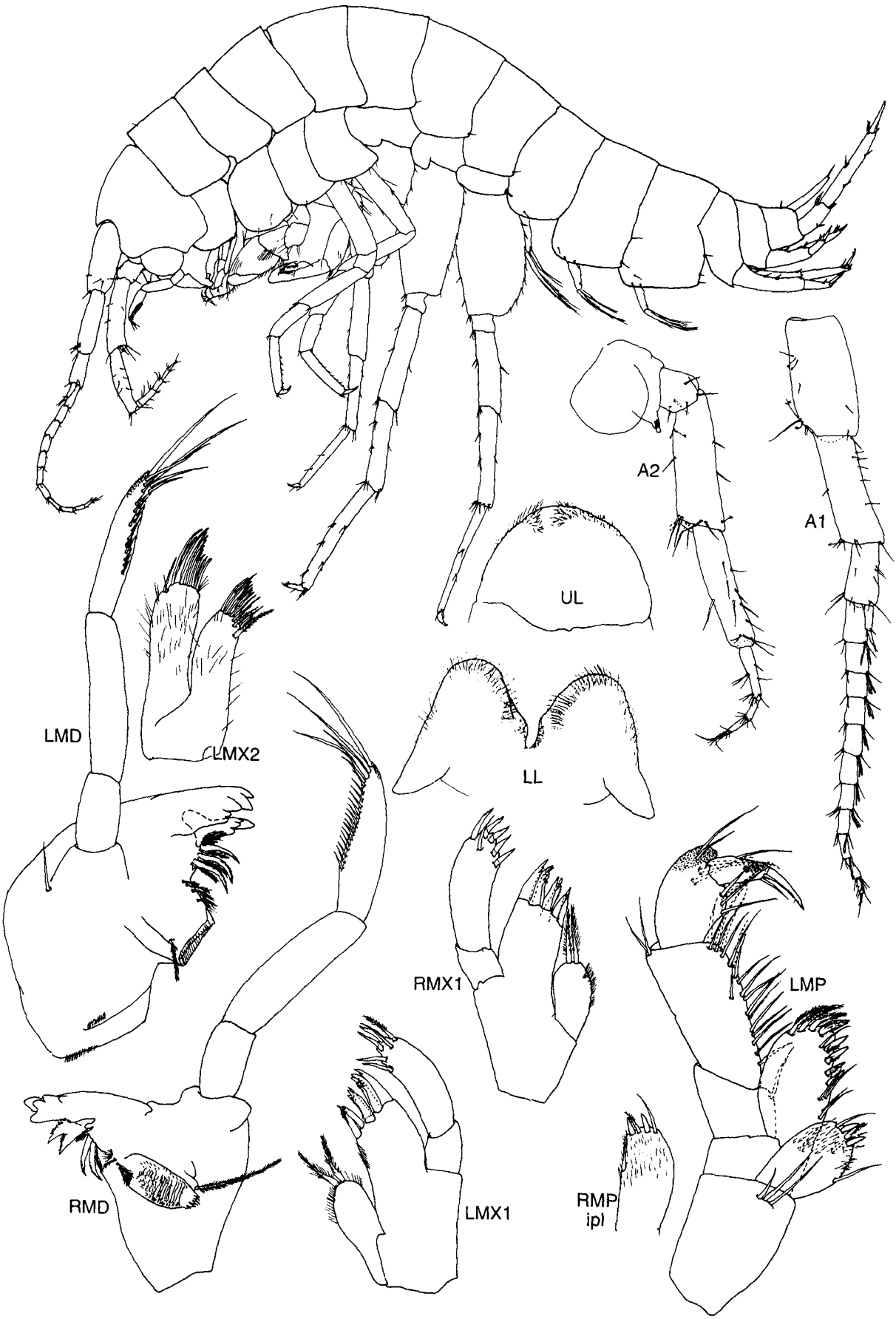

Fig. 10. *Neocrypta robinae* n.sp. holotype male 6 mm; body, antennae, mouthparts.

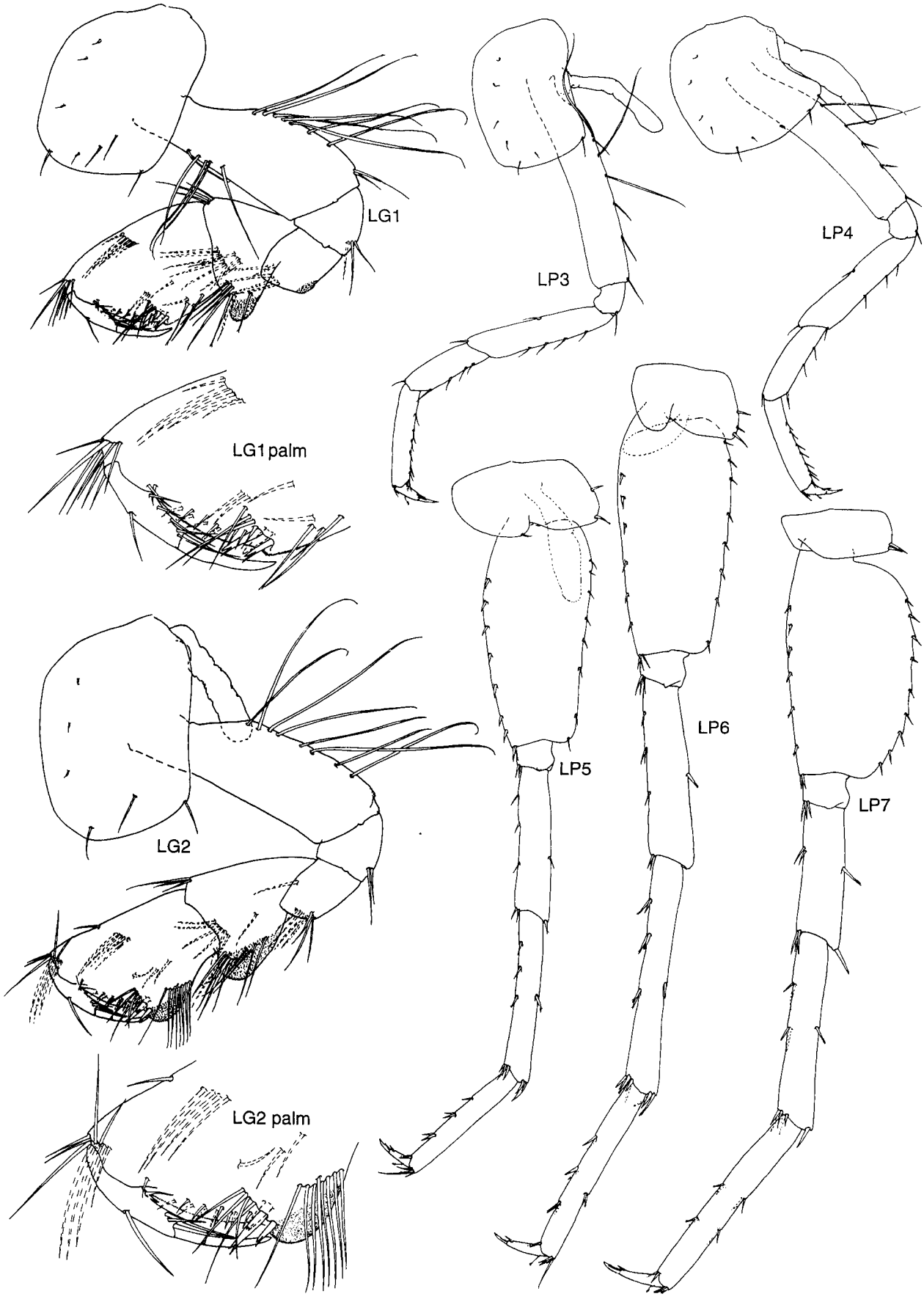

Fig. 11. *Neocrypta robinae* n.sp. holotype male 6 mm; legs.

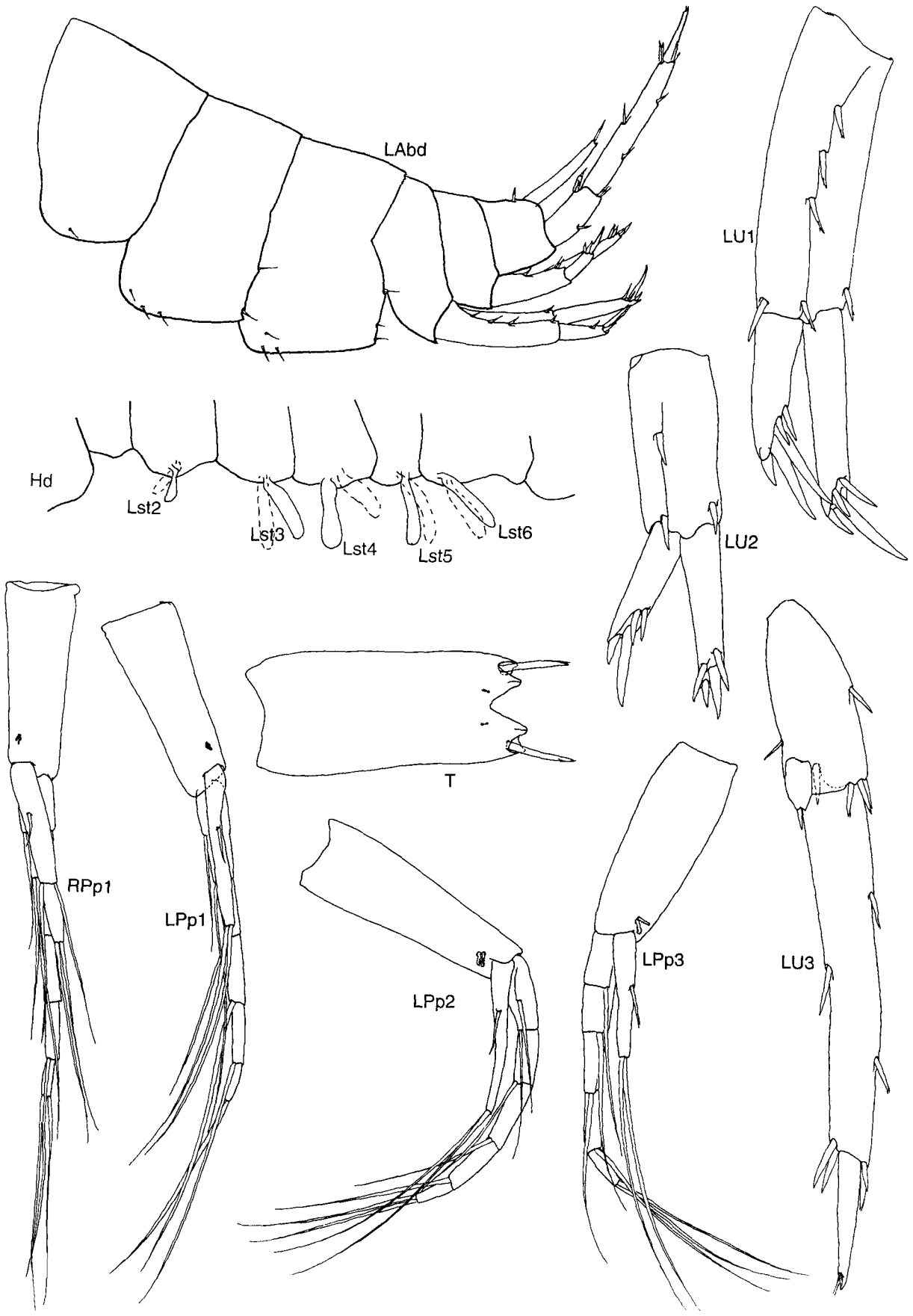

Fig. 12. *Neocrypta robinae* n.sp. holotype male 6 mm; abdomen, gills, pleopods, uropods, telson.

palmar corner robust setae; robust setae along the palm moderately crowded; dactyl with accessory spinules and a small recumbent robust seta on the inner margin, reaching beyond the palmar corner. Second gnathopod: slightly larger than gnathopod 1; article 2 with a small posterior rugose hump, articles 3 and 4 without; carpal lobe broader than gnathopod 1; propodus with distinct posterior rugose lobe, palmar corner with one medial, two lateral robust setae, the palm moderately crowded with robust setae; dactyl with a small proximal recumbent robust seta and accessory setules on the inner margin, reaching to palmar corner robust setae; coxa sparsely setulose apically, bearing a small sac like gill. *Peraeopods* (Fig. 11): coxae 3 and 4 with sparse, weak apical setae; coxa 4 weakly emarginate; peraeopods 3 and 4 subequal, longer than gnathopod 2, articles 3 and 4 weakly spinose posteriorly, propodi with evenly spaced single posterior robust setae; peraeopods 5–7 similar, leg six longest, five and seven subequal, coxae with 2-3-2 robust setae on the posterior margins, second articles expanded moderately, sub quadrate to ovate, weakly postventrally lobate, with weak marginal setation; propodi lacking strong setae on the posterior margins except for long subdactylar setae on legs 5 and 6. *Gills* (Fig. 12): coxae 2–6 with sac like gills; sternites 2–6 with paired simple medial gills. *Epimera* (Fig. 12): second epimeron only with a small postventral tooth; posterior margins of E1–2 almost straight, of E3 convex, the posterior margins weakly setulate; first epimeron with a single mid facial robust seta, the second and third with one anterofacial and two mid ventral robust setae. *Pleon* (Fig. 12): pleonites 1 to six without posteromarginal setae or robust setae, six with a single posterodorsal robust seta adjacent the telson. *Pleopods* (Fig. 12): two retinacula each, peduncles all naked; pleopods reduced, right pleopod 1 with two articles on the inner ramus, all other pleopods with one moderately elongate inner article, each with a single medial marginal seta; outer rami with 6-5-5 articles. *Uropods* (Fig. 12): third uropod extending well beyond uropods 1 and 2 in the intact specimen; uropod lengths relative to uropod 1, uropod 2 0.68×, uropod 3 1.4×; first uropod peduncle 1.4× medial ramus, 2× lateral ramus, the outer margin with one slightly sub apical distal robust seta and one ventrodistal robust seta, dorsal margin with three robust setae, medial margin with one sub apical robust seta, rami of unequal length—medial 1.4× lateral—without marginal robust setae, both with four apical robust setae; second uropod peduncle slightly longer than rami—1.5× lateral, 1.2× medial—with one short dorsolateral robust seta plus a slightly sub apical robust seta, and one subdistal medial robust seta; rami without marginal robust setae, both with four apical robust setae; third uropod peduncle as long as urosomite three, 0.4× outer ramus, with one medial and one laterofacial robust seta, three distolateral and one distoventral robust seta; proximal article of outer ramus with one mid-medial and two mediodistal robust setae, two lateral and two distolateral robust setae; distal article length 0.27× proximal, with two small apical setules; inner ramus small, 0.1× length outer ramus, with one small apical robust seta. *Telson* (Fig. 12): moderately long, 1.6× urosomite three, longer than broad, length 2.1× width, cleft 12%, apices with a single robust seta set in a notch, single penicillate setules either side at M0.88

Relationship. *Neocrypta robinae* differs from *N. primaris* in: the short length of its antennae, which also have fewer flagellar articles; lacking C but with greater numbers of D and E setae on the mandibular palp; less rugosity of the first gnathopod, and with greater numbers of palmar robust setae on both gnathopods; second article of peraeopods 5–7 less posteriorly expanded; outer rami of pleopods with fewer articles; telson cleft less and narrower. *Neocrypta robinae* differs from *N. simoni* in: first antenna shorter but with a greater number of flagellar articles; second antenna without aesthetascs; mandibular palp bearing many more D and E setae; left first maxilla palp not narrowed; first gnathopod less rugose, both gnathopods with more spinous palms; outer rami of pleopods with more articles; telson less cleft and narrow. *Neocrypta robinae* differs from *N. georginae* in: second antenna flagellum of less articles, and without aesthetascs; mandibular palp with more D and E setae; first gnathopod less rugose and without facial rugosities; outer rami of the pleopods with more articles; uropods are less spinous; telson not tumid, and longer.

Distribution. Diprotodon Cave, Canomodine, New South Wales, 33°30'S 148°52'E.

Neocrypta moniae n.sp.

Figs 13–16

Etymology. Named for the first daughter of the first author in recognition of her indirect support of amphipod research and contributions in field collections.

Type locality. Bowan Park, New South Wales, Cave BP 13, 31°54'S 148°05'E.

Material examined. HOLOTYPE (Australian Museum P51364) female 6.5 mm; collected by S. Eberhard; 13 March, 1995.

Diagnosis. Lateral cephalic lobes weakly projecting, antennal sinus weak, eyes absent, ratio of lengths of peduncular articles of first antenna 10:11:8, ratio of lengths of mandibular palp articles 8:11:13, article 3 almost linear, with DE setae. The inner plate of the first maxilla with two apical plumose setae, inner plate of the second maxilla with one member of the distomedial slightly sub marginal, coxa 1 tapering apically, articles 2–4 of both gnathopods bearing posterior rugose lobes, three robust setae at the palmar corners, robust setae along the palms sparse on first, moderate on the second gnathopod. Peraeopod 6 longer than 7, legs 5–7 moderately lobate post-ventrally on the second article. Outer ramus of pleopods of moderate length, of 9,8,8 articles, inner rami reduced to one article each, without marginal setae. Epimera without postventral teeth, with facial robust setae on some, margins of rami of uropods 1 and 2 with one row of dorsal robust setae only, the lateral ramus of uropod 1 without dorsal robust setae, inner ramus of third uropod reaching to M0.09 of outer. Telson cleft 16%, bearing mid lateral dorsal spination.

Description of holotype (female). *Body* (Fig. 13): pleon with few dorsal arms, pleonites 1–4 with few setae, pleonite 5 with three lateral robust setae, pleonite 6 with one distolateral robust seta, length 5.5 mm. *Head*: rostrum small, eyes absent. *First antenna* (Fig. 13): long, length 0.7× body, 2.4× second antenna, the peduncle shorter than the flagellum, ratio of lengths of articles 23:26:19, setae sparse, flagellum of 22 articles, aesthetascs present on articles 6–22, flagellar segments uniform, sparsely setulate; accessory flagellum 2-articulate, reaching to M0.5 of the second article of the primary flagellum. *Second antenna* (Fig. 13): length 0.3× body,

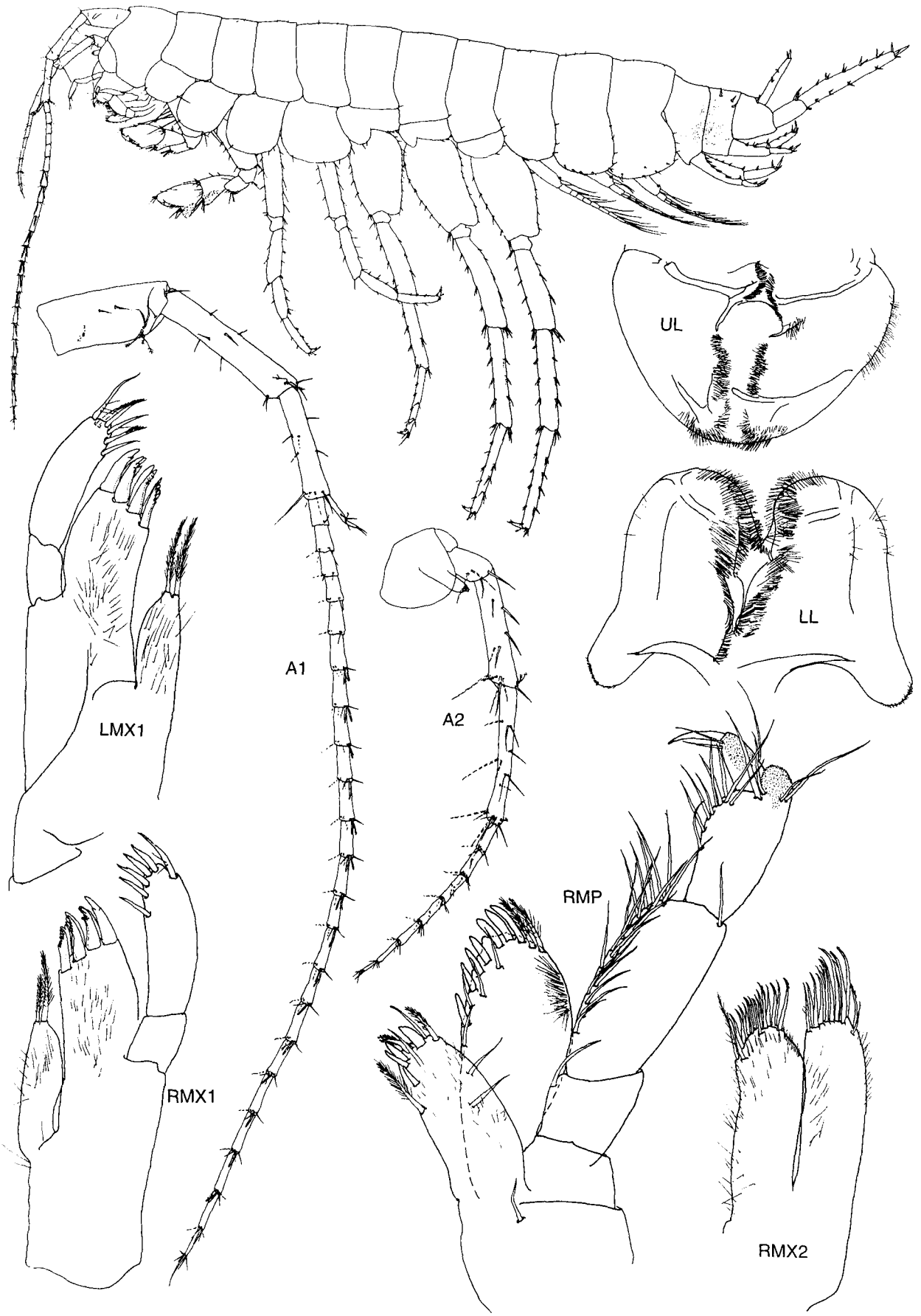

Fig. 13. *Neocrypta moniae* n.sp. holotype female 6.5 mm; whole, antennae, mouthparts.

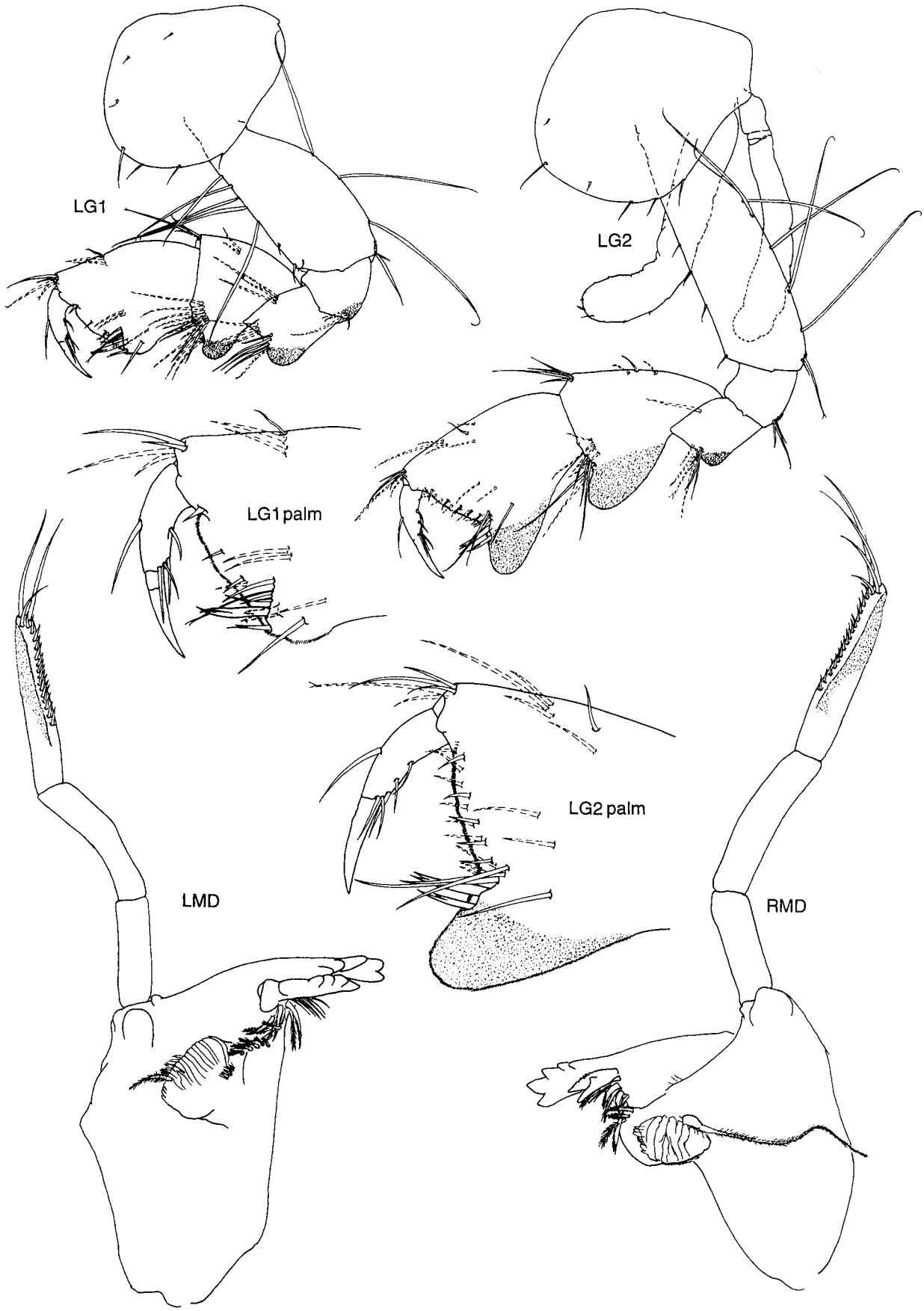

Fig. 14. *Neocrypta moniae* n.sp. holotype female 6.5 mm; mandibles, gnathopods.

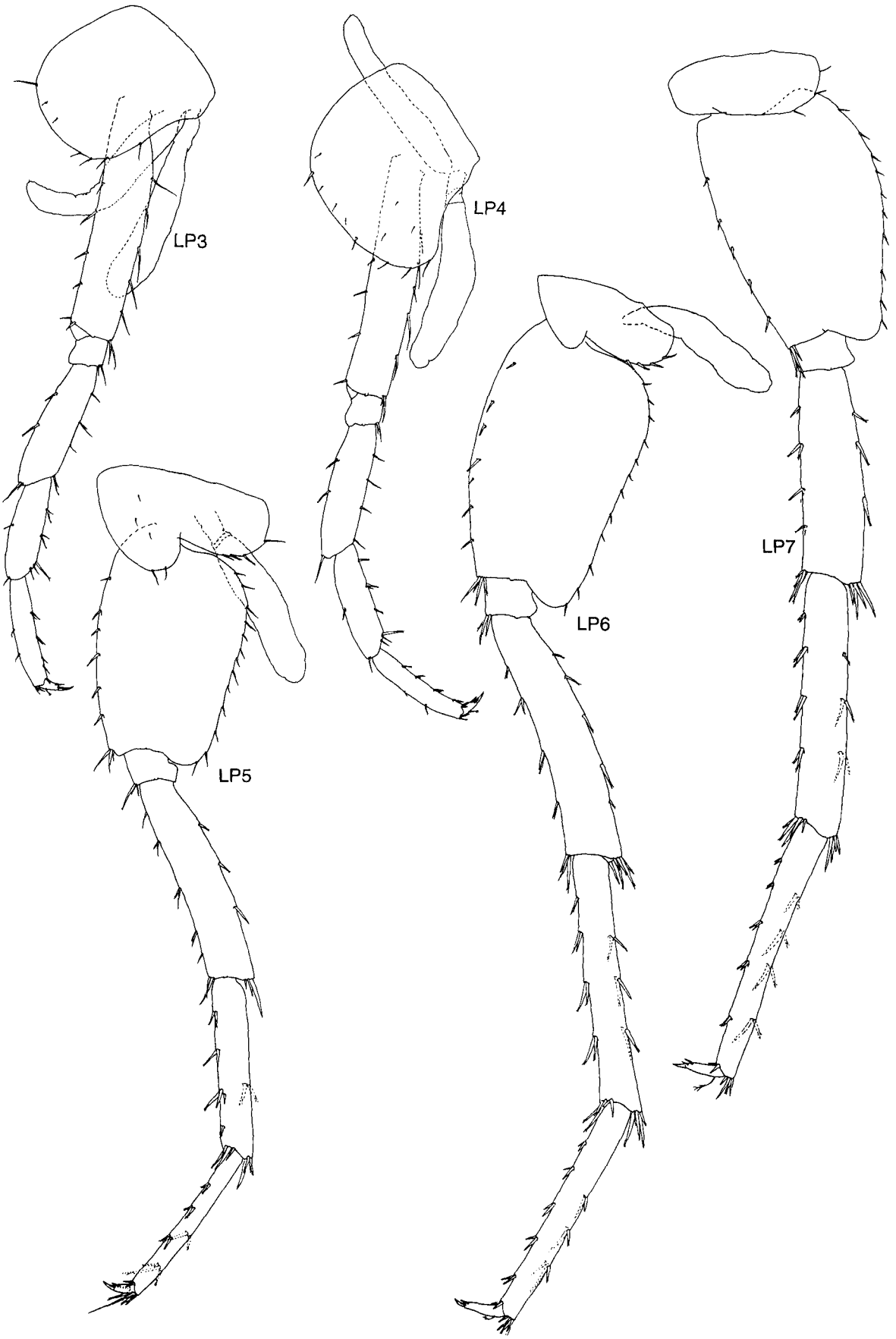

Fig. 15. *Neocrypta moniae* n.sp. holotype female 6.5 mm; peraeopods.

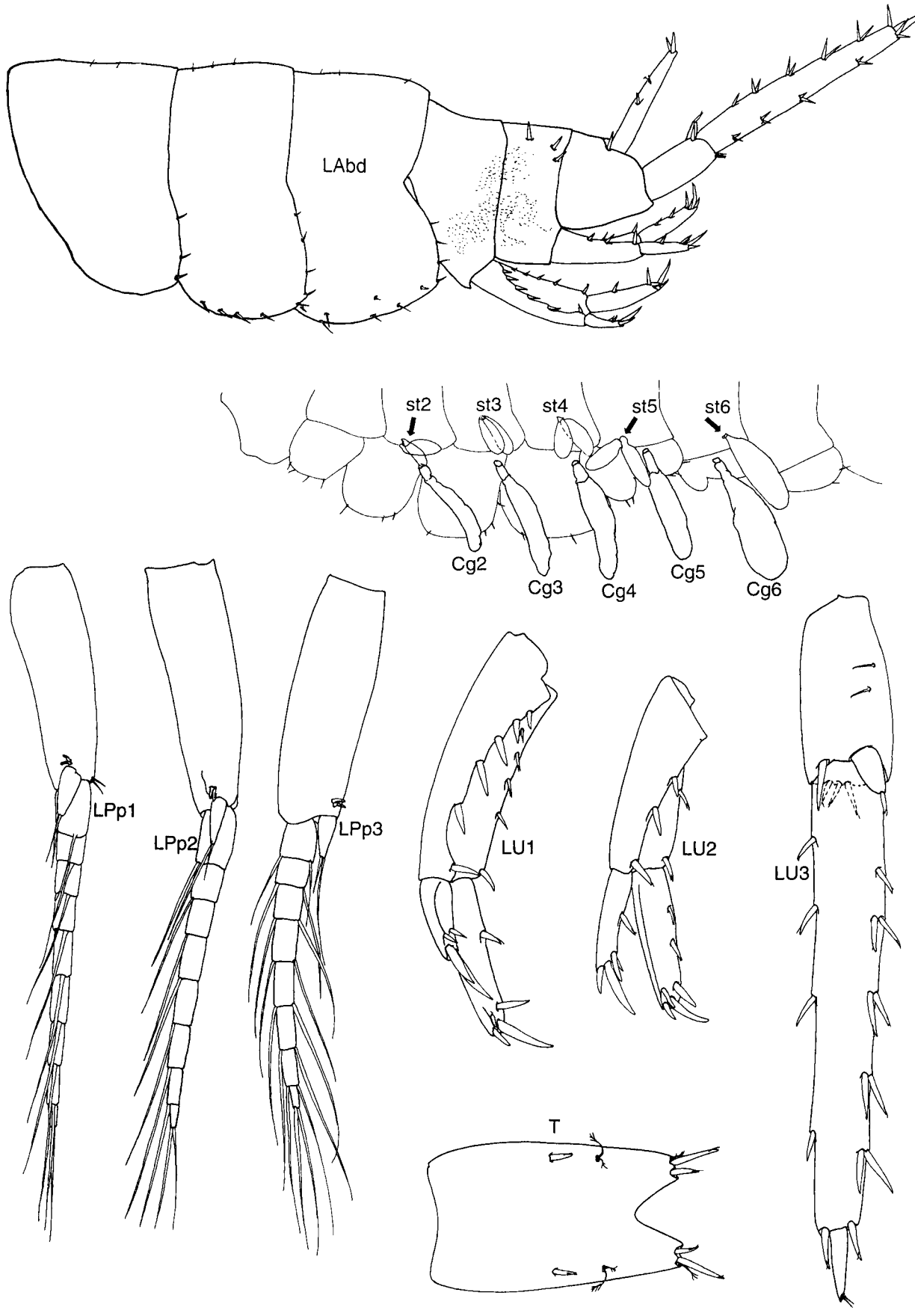

Fig. 16. *Neocrypta moniae* n.sp. holotype female 6.5 mm; abdomen, gills, pleopods, uropods, telson.

peduncle longer than flagellum—1.9×—article 4 slightly shorter than five—21:24—articles 3–5 with moderate ventral setation; flagellum of seven articles, weakly setose ventrally. *Left mandible* (Fig. 14): palp article 3 longer than 2—25:20—linear and distofacially rugose, setae 14D3E; incisor with five teeth, lacinia mobilis four; six slender naked setae basal to the incisor; accessory blades of three rakers and four interraker plumose setae, five brushy setae onto the base of the molar; molar triturative with a short posterior pappose seta. *Right mandible* (Fig. 14): palp article 3 with 15D4E setae, the third article facially rugose; incisor with five teeth; lacinia mobilis bifid, denticulate anteriorly, posteriorly bearing long incisive edge, two slender naked setae and a plumose robust seta basal to the mandible; accessory blades of three rakers, five interraker plumose setae, and a short hooked seta; molar triturative with a long posterior pappose seta. *Maxillae* (Fig. 13). Left first maxilla with two apical and three apicomedial robust setae and one ventrofacial sub apical robust seta; two robust setae naked, the others armed basally or apically with long or short setules; outer plate with seven apically dentate strong robust setae; inner plate two plumose apical setae. Right first maxilla palp article 2 with a row of four stout, mediodistal to distal, apically armed robust setae, one similar apicolateral robust seta and one mediodistal naked robust seta; outer plate with seven denticulate apical robust setae; inner plate with two apical plumose setae. Second maxilla outer plate with two setae on the apicolateral margin; inner plate apicomedial corner with one submarginal thick seta and one plumose seta. *Maxilliped* (Fig. 13): palp article 3 without setae on the inner ventral face, the outer apex with two medial and two lateral setae basal to a strongly produced rugose apical lobe; dactyl with two accessory robust setae basal to the nail, medially rugose; inner plate apex with two thick naked tooth like robust setae, one distal and one apicolateral plumose seta, a slender distal seta, two medial submarginal, and one mid facial setae, with a single naked basal seta; outer plate with a row of six slender naked setae extending from the basomedial face to the mid distal face, a row of seven blunt naked tooth like robust setae from the mid medial margin across the apical face almost to the lateral apex, continuous with a pair of distolateral plumose setae, the distomedial and apical margin broadly scalloped. *Gnathopods* (Fig. 14): coxal plate of the first gnathopod with four short to moderate length apical setae; articles 2–4 with progressively enlarged posterior rugose hump, the fourth forming a strong lobe; carpus short, posteriorly lobate, the lobe rounded, without apical setae and rugose; propodus trapezoidal, slightly longer than wide, the posterior angle rounded, with a small rugose hump, robust setae of the palmar corner one medial and two lateral, the dactylus reaching the corner robust setae, with several accessory spinules along the inner margin, but without a recumbent robust seta. Second gnathopod moderately larger than the first; posterior lobe of the fourth article smaller; carpal lobe larger; propodus with a strong rugose posterior lobe, palmar corner with one medial and two lateral robust setae, dactylus with inner marginal spinules, without recumbent robust seta, reaching robust setae of the palmar corner; coxa bearing slender oostegite and sac like gill, with few short apical setae. *Peraeopods* (Fig. 15): coxa 3 with a sparse apical row of short to moderate setae and single posterior seta; coxa 4 weakly emarginate, with one anteroventral and four postventral setae, several small facial setules and a long oostegite and sac like gill; peraeopods 3 and 4 longer than second gnathopod, subequal, articles 4 and 5 spinous posteriorly, articles 6 with 2-2-1-1 and 2 locking, and 1-2-2-1 and 2 locking robust setae, respectively; peraeopods 5–7 similar; coxae with 4-4-3 robust setae on the ventral margins of the posterior lobes; second articles expanded posteriorly—5>6=7—and moderately lobate, with short posterior setae; propodi of legs 5 and 6 with long setae basal to the dactyls. *Gills* (Fig. 16): coxae 2–6 with sac like gills; sternites 2–6 with simple gills attached to the mid lateral edge. *Epimera* (Fig. 16): without postventral teeth, posterior margins moderately convex with 3-4-4 setae, and 0-5-6 ventrofacial robust setae. *Pleon* (Fig. 16): pleonites 1–4 with few posterior setae; pleonite 5 with three dorsolateral robust setae, six with a single dorsolateral robust seta basal to the telson, pleonites 4 and 5 bearing areas of tiny facial setules. *Urosomite one* (Fig. 16) at the base of uropod 1 bearing a robust seta like extension. *Pleopods* (Fig. 16): two retinacula each; peduncle of pleopod 1 only with two distal setae at the base of the outer ramus; inner rami reduced to a single article each; outer rami with 9,8,8 articles. *Uropods* (Fig. 16): third uropod extending well beyond first and second uropods in the intact specimen; lengths relative to uropod 1—uropod 2 = 0.8×, uropod 3 = 1.6×; first uropod peduncle length 1.7× medial ramus, 3.1× lateral ramus, the outer margin five short robust setae plus a sub apical distal robust seta, medial margin with four robust setae plus an apical robust seta; rami strongly unequal, the medial 1.8× lateral, with reduced spination, only the medial ramus with a single mid medial, short robust seta; both rami with four apical robust setae: second uropod peduncle length 1.4× medial ramus, 2× lateral ramus, with two plus one sub apical lateral robust setae, and one plus one apicomedial robust setae; rami with two medial robust setae on the medial ramus and one lateral robust seta on the lateral ramus, both rami with four apical robust setae; third uropod peduncle length less than the third urosomite—33:38—and 0.36× the length of the outer ramus, with two small basofacial setae, one ventrodistal and a row of three distolateral robust setae; the proximal article of the outer ramus with four approximately evenly distributed lateral robust setae, five transverse medial sets of 1-2-2-2-2 robust setae and single distal lateral and medial robust setae; the second article with a small pair of apical setules; the inner ramus length 0.09× outer ramus, with a single apical robust seta. *Telson* (Fig. 16): moderately long, 1.3× urosomite three, length 1.7× width; cleft 16% with a lateral penicillate setule and two robust setae in small notches dorsal on each lobe, a medio facial robust seta on each side at M0.5, and paired dorsolateral penicillate setules at M0.65 on each side.

Relationship. *Neocrypta moniae* differs from *N. primaris* in: denser medial setae on the maxillipedal palp; denser palmar robust setae; less posterior expansion of the second article of peraeopods 5–7; pleopods with fewer articles of the outer ramus; telson less tumid and shorter. *Neocrypta moniae* differs from *N. robinae* in: longer antennae with more articles; less D and E setae on the mandibular palp; left first maxilla palp broad; maxillipedal palp second article with dense medial setae; greater posterior expansion of the second article of peraeopods 5–7; outer rami of pleopods with more articles; uropods 1 and 2 more spinous; telson more cleft and broader. *Neocrypta moniae* differs from *N. simoni* in: antennal flagellum longer and with more articles; aesthetascs never paired; mandibular palp with many more D setae; left first maxilla palp not narrowed; maxillipedal palp second article with denser medial setation; article 2 of peraeopods 5–7 more expanded posteriorly; outer rami of pleopods with greater numbers of articles; uropods more spinous; telson less cleft, less tumid and more

slender. *Neocrypta moniae* differs from *N. georginae* in: flagellum of first antenna longer, both antennae with more flagellar articles; mandibular palp with more D setae, less E setae; setae of medial margin of maxillipedal palp denser; first gnathopod less rugose; article 2 of peraeopods 5–7 more expanded; pleopod outer rami with more articles; first and second uropods more spinous; telson more cleft, less tumid, more slender.

Distribution. Cave BP13, Bowan Park, New South Wales, 31°54'S 148°05'E.

Neocrypta georginae n.sp.

Figs 17–20

Etymology. Named for the second daughter of the first author in recognition of her indirect support of amphipod studies and assistance in field work.

Type locality. From a pool in the dark zone, Apple Tree Cave, Copperhania, Abercrombie, New South Wales; Cave A 79, 33°55'S 149°22'E.

Material examined. HOLOTYPE (Australian Museum P51365) female "b" 5.5 mm, ALLOTYPE (Australian Museum P51366) male "a" 5 mm, five other small specimens in the type series; collected by S. Eberhard; 16 June, 1995.

Diagnosis. Lateral cephalic lobes moderately projecting, antennal sinus weak, ratio of lengths of peduncles of first antenna 10:10:7, ratio of lengths of mandibular palp articles 8:13:14 to 8:14:15, article 3 weakly falcate, setae DE. Inner plate of first maxillae with two and three apical plumose setae, inner plate of second maxilla without sub marginal medial seta. Coxa 1 apically tapered, articles 2–6 of both gnathopods with posterior rugose projections, three robust setae at corners of palms, length of peraeopod 6 equal to seven, articles 2 of peraeopods 5–7 moderately to weakly lobate. Rami of pleopods reduced, inner rami each of one article without marginal setae. Epimera without postventral teeth and ventrofacial robust setae, spination of the rami of the first and second uropods reduced to a single robust seta for each pair, inner ramus of the third uropod 0.11× length of outer ramus. Telson cleft 11% with only a single mid lateral robust seta on one side.

Description of holotype (female). *Body* (Fig. 17): pereion with few armaments, pleonites 1–4 with sparse short dorsal setae, pleonite 5 with a distal transverse row of three dorsal to dorsolateral robust setae, six with a single mid dorsal robust seta; length 5.5 mm. *Head*: rostrum small, eyes absent. *First antenna* (Fig. 17): moderately long, 0.42× body, 1.7× second, peduncle shorter than flagellum—71: 116,—relative lengths of articles 10:11:7, flagellum of 12 articles, segments uniform, sparsely setulate, aesthetascs present on articles 2–11; accessory flagellum 2-articulate, reaching to M0.3 of the second article of the primary flagellum. *Second antenna* (Fig. 17): length 0.23× body, peduncle longer than flagellum—73:40—article 4 shorter than five—22:26—articles 3–5 with moderate ventral setation; flagellum of six articles, weakly setose ventrally, article 6 with a small apical aesthetasc. *Left mandible* (Fig. 18): palp article 3 subequal to two, ratio of lengths 8:14:15, weakly falcate medially and distally rugose, setae 8D4E, first and second articles naked; incisor with five teeth; lacinia mobilis five teeth and four long basal setules; accessory blades of three chisel robust setae and two plumose robust setae, several fine setules basal to the molar; molar triturative with a short pappose posterior seta. *Right mandible* (Fig. 18): palp article 3 slightly longer than three, ratio of lengths 8:13:14, medially rugose, setae 8D4E, first and second articles naked; incisor with five teeth; lacinia mobilis bifid, denticulate, basally setose; accessory blades two chisel robust setae and two plumose robust setae, two brushy setae basal to molar; molar triturative with a long posterior pappose seta. *Maxillae* (Fig. 17): palp of left first maxilla with five thin apical robust setae and one medial sub apical robust seta; outer plate with seven denticulate strong robust setae; inner plate with two plumose apical setae; right first maxilla with three apical and one medial sub apical thick robust setae, one facial and one ventral simple seta, a long distofacial strong naked seta and distolateral slender robust seta; outer plate with seven denticulate strong robust setae; inner plate with three apical plumose setae; second maxilla with long curved terminal setae, inner distal margin without a submarginal seta. *Maxilliped* (Fig. 17): palp article 3 without ranks of fine setae on the inner basal face, with moderate distomedial setation, a pair of ventrofacial setae basal to the dactyl, without lateral setation, the apex strongly produced and rugose, the dactyl facially rugose with a pair of accessory spinules basal to the nail; article 2 naked laterally with a medial row of long naked setae, outer plate with a row of basomedial simple setae, a distomedial to apical row of six submarginal to facial tooth like robust setae and two distolateral plumose setae, apex of the inner plate with two moderate naked tooth like robust setae and a brushy seta, distolaterally a slender simple seta, two medio facial slender robust setae and a submarginal disto medial short robust seta. *First gnathopod* (Fig. 18): coxal plate with three moderate distal setae, article 2 with three posterior rugose keel like extensions, article 3 with a small posterior rugose hump, article 4 with a distinct posterior rugose lobe; carpus short with a distinct rugose lobe, rounded and without apical setation; propodus with a small posterior rugose keel and a mid dorsofacial area of rugosity, trapezoidal, longer than wide with two lateral and one facial palmar corner robust setae, palm with moderately crowded simple robust setae, dactyl with accessory inner edge spinules, reaching to the palmar corner. *Second gnathopod* (Fig. 18): slightly larger than first, articles 2–4 with small posterior rugose humps; carpus and propodus with strong rugose lobes; carpus short, lobe larger than on gnathopod 1; propodus with a small mid dorsal area of rugosity, palmar corner marked with two lateral and one medial robust seta, palmar robust setae moderately sparse and simple, dactyl with accessory inner margin setules, reaching beyond palmar corner robust setae; coxa sparsely setose apically, bearing a short slender sac like gill and long narrow oostegite. *Peraeopods* (Fig. 19): coxae 3 and 4 weakly setate apically, coxa 4 very weakly emarginate, both bearing slender sac like gills and long slender oostegites; peraeopods 3 and 4 subequal, longer than gnathopod 2, articles 4 and 5 sparsely spinose posteriorly, articles 6 with 1-1-1-1 and 1-1-1-1-1 posterior setae respectively; peraeopods 5–7 similar, 5 shorter than 6 and 7, coxae with 1-1-0 weak posterior robust setae, articles 2 posteriorly expanded, weakly postventrally lobate, with sparse moderate to weak marginal setae; propodi with few posterior setae, but peraeopods 5 and 6 with long basodactylar seta. *Gills* (Fig. 20): coxae 2–6 bearing slender to moderate sac like gills; sternites 2–6 each with a pair of simple gills attached to the mid medial area of each segment. *Epimera* (Fig. 20): without postventral teeth, posterior margins convex, with few moderate setae, the ventral faces with 1-3-4 facial robust setae. *Pleon* (Fig. 20): pleonites 1–4 with sparse dorsal setae; pleonite 5 with a transverse dorsal row

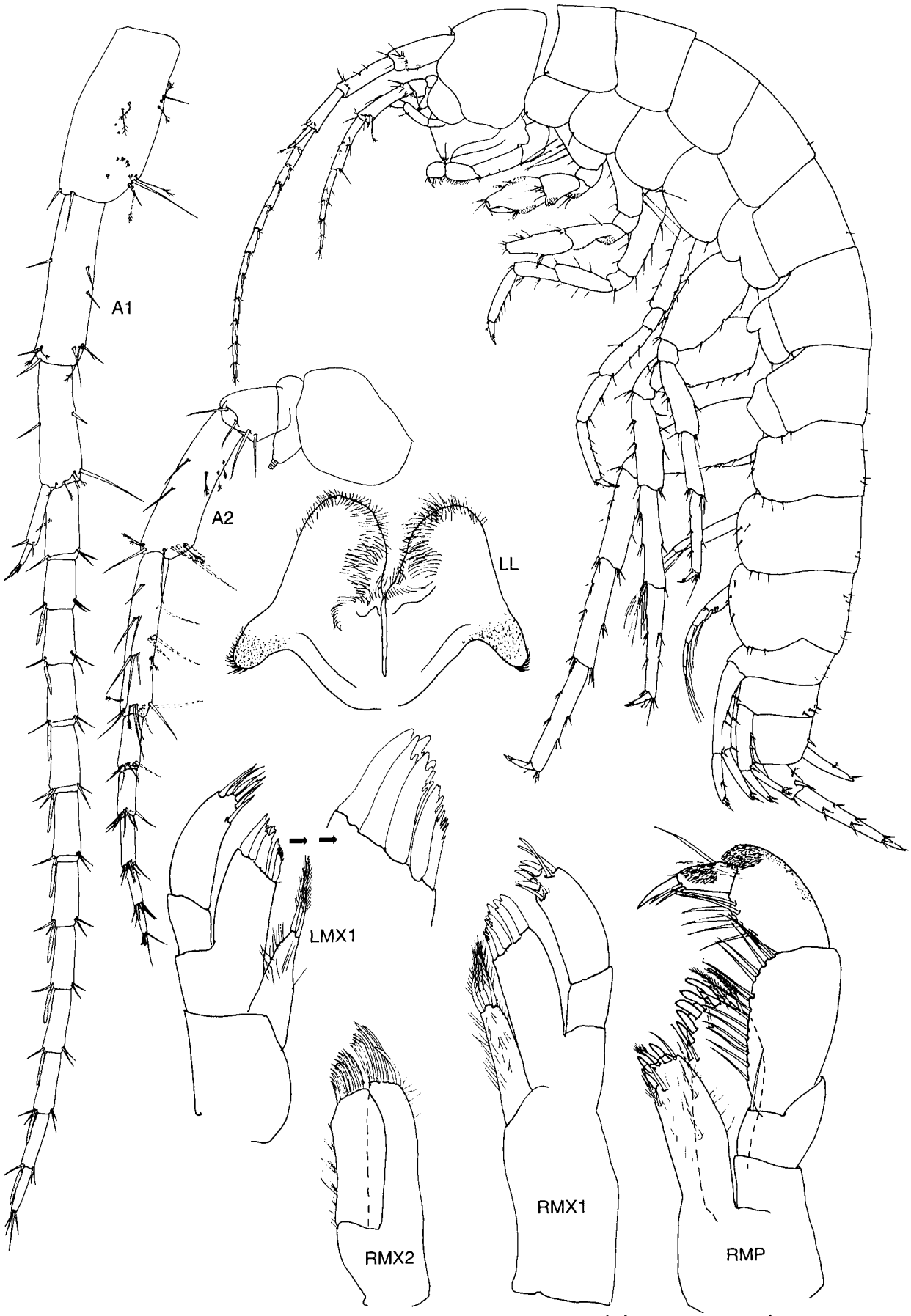

Fig. 17. *Neocrypta georginae* n.sp. holotype female "b" 5.5 mm; whole, antennae, mouthparts.

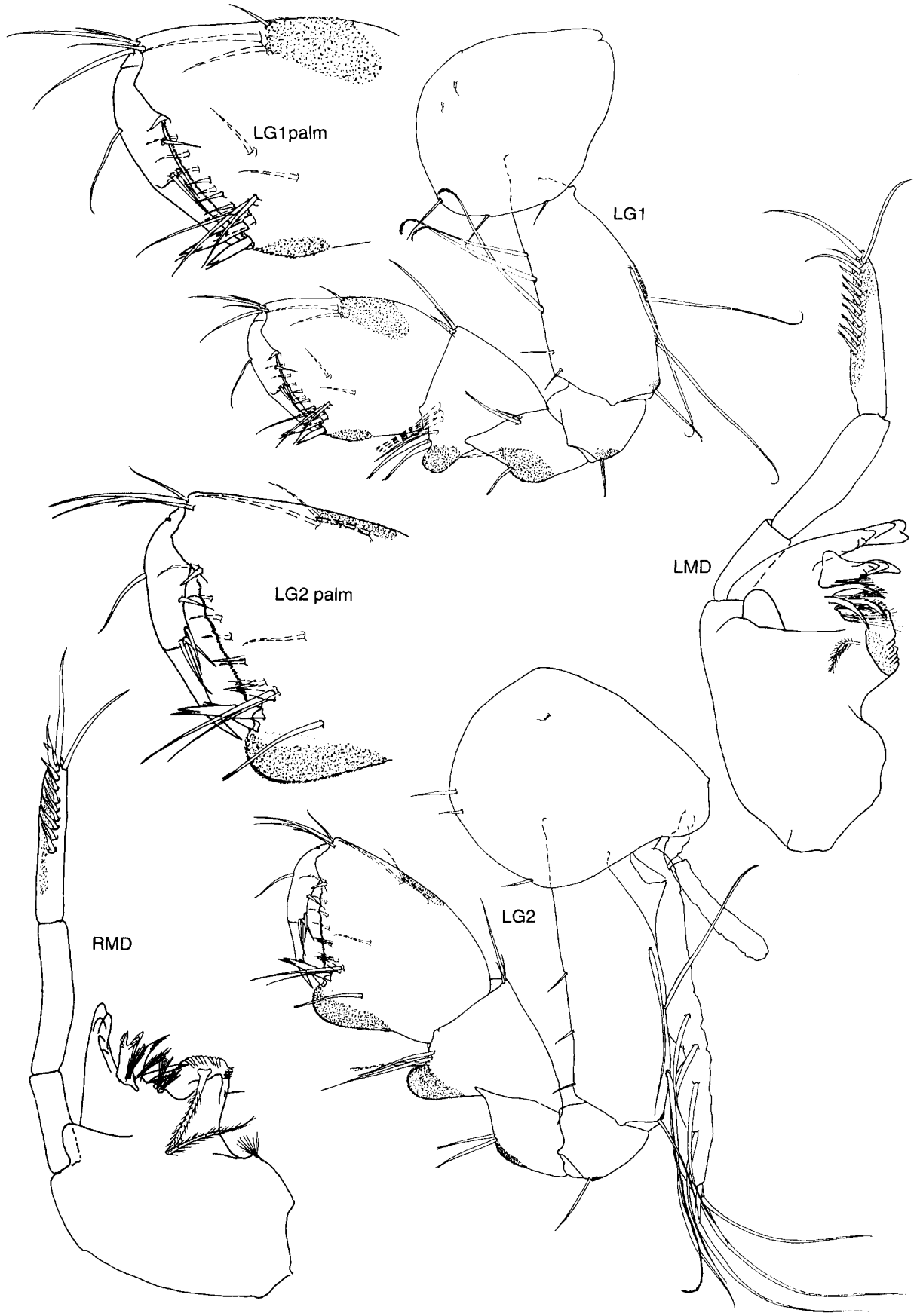

Fig. 18. *Neocrypta georginae* n.sp. holotype female "b" 5.5 mm; mandibles, gnathopods.

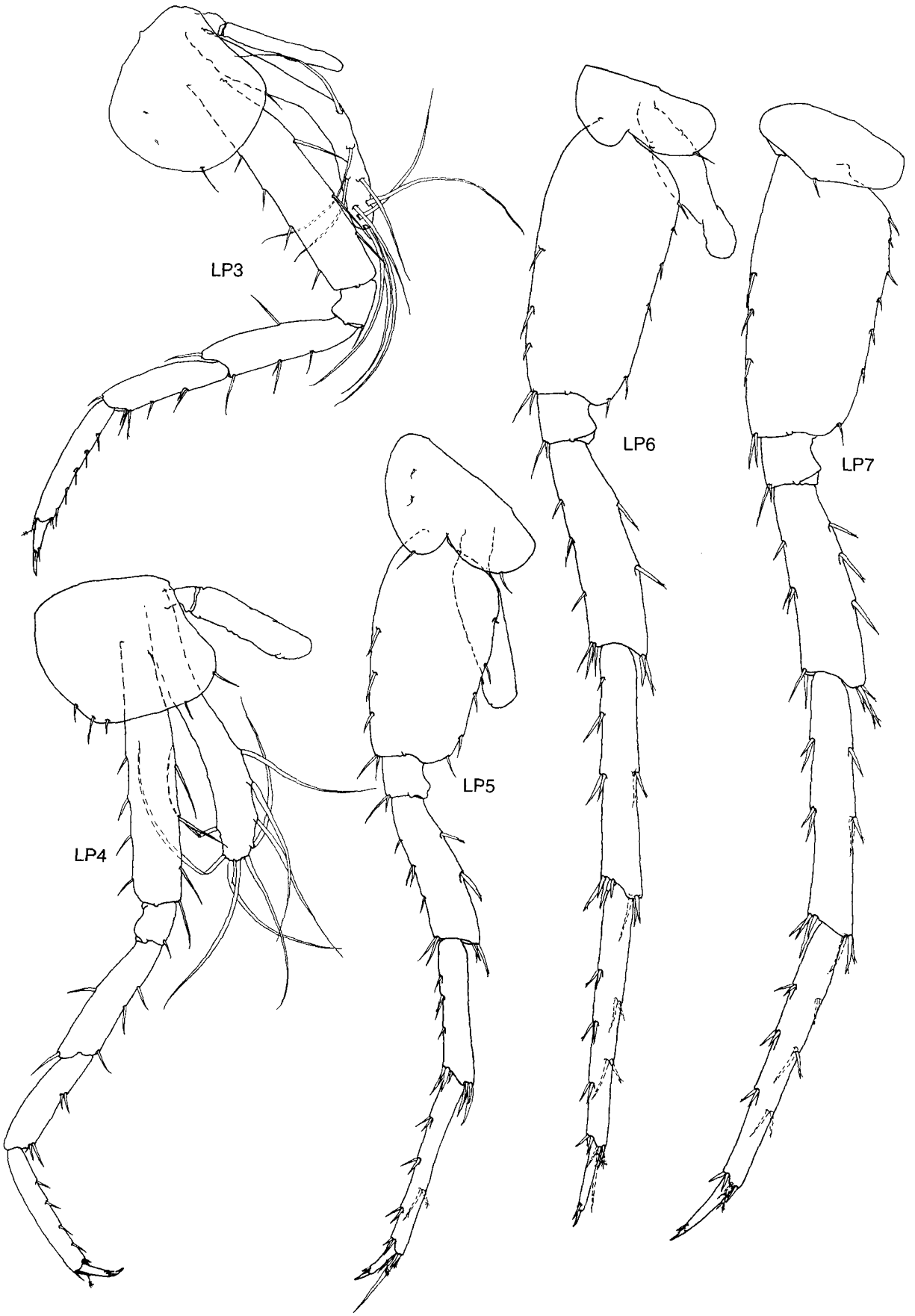

Fig. 19. *Neocrypta georginae* n.sp. holotype female "b" 5.5 mm; peraeopods.

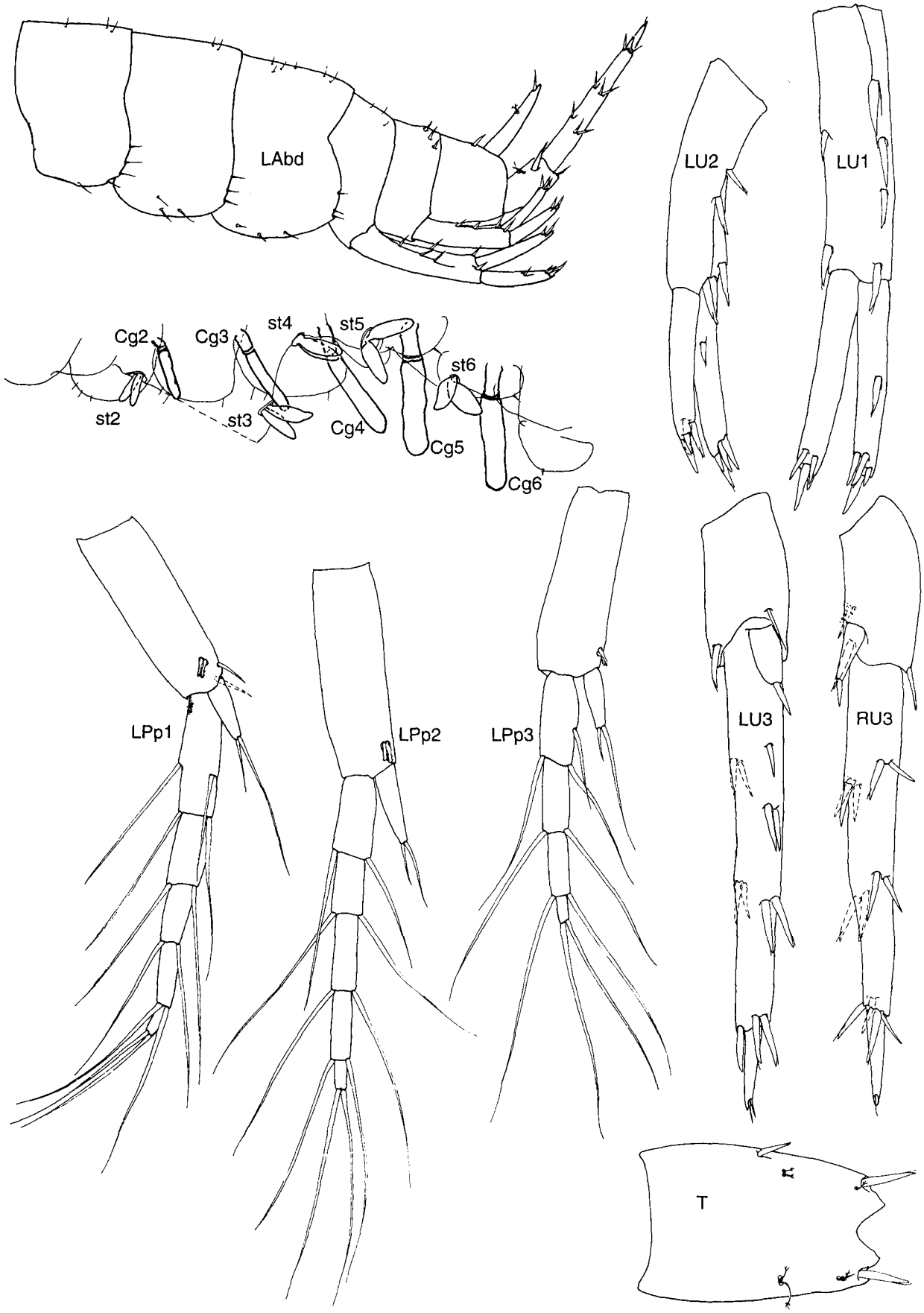

Fig. 20. *Neocrypta georginae* n.sp. holotype female "b" 5.5 mm; abdomen, gills, pleopods, uropods, telson.

of three moderate robust setae; six with a single dorsal robust seta basal to the telson. *Pleopods* (Fig. 20): each with two retinacula; peduncle one with two apicomedial setae, rami strongly reduced, outer rami of 5-5-4 articles, inner rami each of one article, without marginal setae. *Uropods* (Fig. 20): uropod 3 extending beyond 1 and 2 in the intact specimen; lengths relative to uropod 1, uropod 2 0.8×, uropod 3 1.3×; uropod 1 peduncle length 1.3× medial ramus, 1.4× lateral ramus, outer margin with three dorsal robust setae and one subdistal robust seta, inner margin with one dorsal robust seta and one subdistal robust seta; rami of subequal length, inner ramus without marginal robust setae and four apical robust setae, outer ramus with one lateral marginal robust seta and four apical robust setae; second uropod peduncle length 1.2× medial ramus, 1.5× lateral ramus; outer margin with two dorsal robust setae and one subdistal robust seta, inner margin with only a sub apical robust seta; inner ramus with one lateral robust seta and four apical robust setae, outer ramus without marginal robust setae and with four terminal robust setae; uropod 3 peduncle length almost as long as urosomite three, 0.29× outer ramus, the left uropod without facial robust setae on the peduncle, with a moderate dorsal robust seta and a simple seta basal to the inner ramus; outer ramus with transverse rows of 2-2 lateral and 1-2-2 medial robust setae, and one distolateral and two distomedial robust setae basal to the distal article; distal article with two small apical setules; inner ramus 0.11× length of outer ramus, with a single apical robust seta; right third uropod with three small ventrofacial setae, a moderate robust seta adjacent the base of the inner ramus, and one distodorsal robust seta; outer ramus with transverse rows of 2-2 lateral and 3-2 medial robust setae and paired distolateral and distomedial robust setae basal to the distal article; distal article with one small apical seta; inner ramus with a single apical robust seta. *Telson* (Fig. 20): moderately long, as long as urosomite three, length 1.5× width; cleft 11%; apices with one robust seta, the right side with a single penicillate setule, the left with two; a single laterodorsal robust seta on the right side only, at M0.5; paired lateral penicillate setules at M0.6 on either side.

Description of allotype (male "a"). *Body*: length 5 mm. *First antenna*: peduncle sparsely setulate, relative lengths of articles 10:9:7; accessory flagellum of two articles reaching to M0.3 of the second article of the primary flagellum; primary flagellum of 12 articles, all but articles 1 and 12 bearing single aesthetases. *Second antenna*: peduncle longer than flagellum, relative lengths of articles 4 and 5 27:24; flagellum of four articles, the first relatively long, the last bearing a small apical aesthetasc. *Left mandible*: palp relative lengths of articles 8:13:14, third article rugose, setae 10D3E; incisor with five teeth, lacinia mobilis with four teeth and four fine basal robust setae; accessory blades of two robust setae and two plumose setae, with one large bent brushy seta onto the base of the mandible; mandible triturative, with a short posterior pappose seta. *Right mandible*: palp ratio of lengths of articles 8:14:15, article 2 with one mediodistal seta, setae of third article 8D4E; incisor with five teeth, lacinia mobilis bifid with fine basal and facial setae, accessory blades of two robust setae and two plumose setae; two brushy setae onto the base of the molar; molar triturative with a long posterior pappose seta. *Left first maxilla*: inner plate with two plumose apical setae; outer plate with seven denticulate robust setae; palp with three slender apical robust setae, two distofacial slender setae and two mediodistal slender robust setae. *Right first maxilla*: inner plate with two plumose apical setae; outer plate with seven denticulate robust setae; palp article 2 with a mediodistal to apicolateral row of five moderately broad robust setae, the most lateral armed with setules, and a single distofacial broad naked seta. *Second maxilla*: similar to female except for the presence of two mediodistal plumose setae. *Maxilliped*: inner plate with two broad naked and one moderate plumose apical robust seta, one apicolateral long curved robust seta, one distomedial plumose seta and two distofacial stout robust setae. *Pleopods*: peduncle of each with two retinacula and one mediodistal seta; inner rami of each one article only; outer rami of 6, 5, 4 articles respectively. *Uropod one*: without a basal robust seta on urosomite one; peduncle with three dorsolateral, one apicolateral, one dorsomedial and one apicomedial robust seta; rami with one lateral robust seta each and four apical robust setae. *Uropod 2*: peduncle with two dorsolateral and one apicolateral and apicomedial robust seta; rami without marginal robust setae, each with four apical robust setae. *Uropod 3*: relative lengths of articles; peduncle 28, inner ramus 8, outer ramus proximal article 62, distal article 15; peduncle bearing single lateral and medial distal robust setae and three small dorsofacial setae; inner ramus with one apical robust seta; outer ramus proximal article with transverse rows of 2-2 plus one distal lateral robust setae and 2-2 plus two distal medial robust setae; distal article with two small apical setules. *Telson*: moderately long, length approximately equal to urosomite three; cleft about 11%; lobes slightly tumid basally; one apical robust seta on either lobe; a pair of lateral penicillate setules at M0.6 on either side.

Relationship. *Neocrypta georginae* differs from *N. primaris* in: antennae short, with less flagellar articles; second antenna with an apical aesthetasc; mandibular palp bears less D setae, but more E setae; first gnathopod bearing facial rugosities; posterior expansion of second article of peraeopods 5–7 slight; pleopod outer rami with fewer articles; telson cleft 11%.

Distribution. Apple Tree Cave, cave A79, Copperhania, Abercrombie, New South Wales, 33°55'S 149°22'E.

Neocrypta annae n.sp.

Figs 21–24

Etymology. Named for the wife of the second author in recognition of her years of indirect support of amphipod studies.

Type locality. Cave BP-6, Bowan Park, New South Wales, 31°54'S 148°05'E.

Material examined. HOLOTYPE (Australian Museum P51367) male 4.5 mm; collected by S. Eberhard; 13 March, 1995.

Diagnosis. Lateral cephalic lobes weak, antennal sinus weak, ratio of lengths of peduncular articles of first antenna 10:11:7, ratio of lengths of mandibular palp articles 8:11:13 to 8:14:17, the third palp article weakly falcate, bearing DE setae, the inner plate of the first maxilla with two apical plumose setae, inner plate of the second maxilla with submarginal medial setae. Coxa 1 weakly tapering, second article of gnathopod 1 and second and third articles of gnathopod 2 without posterior rugose lobe, three robust setae at the palmar corners, robust setae along the palms sparse, peraeopod 6 longer than seven, the second articles of legs 5–7 moderately lobate post-ventrally. Rami of pleopods reduced, inner rami of one article only, without marginal setae, epimera without postventral teeth, second and third epimera with ventrofacial robust setae,

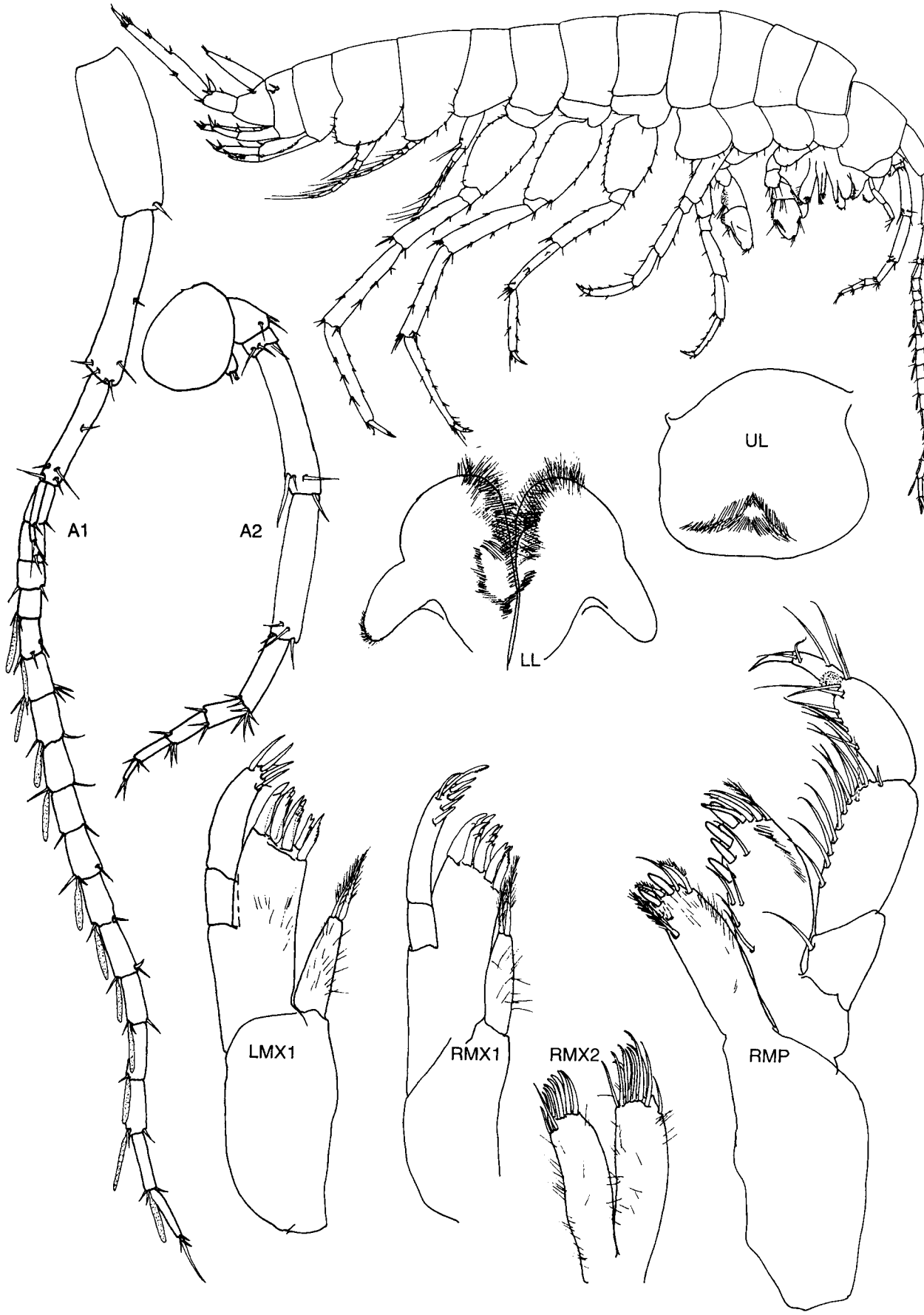

Fig. 21. *Neocrypta annae* n.sp. holotype male 4.5 mm; whole, antennae, mouthparts.

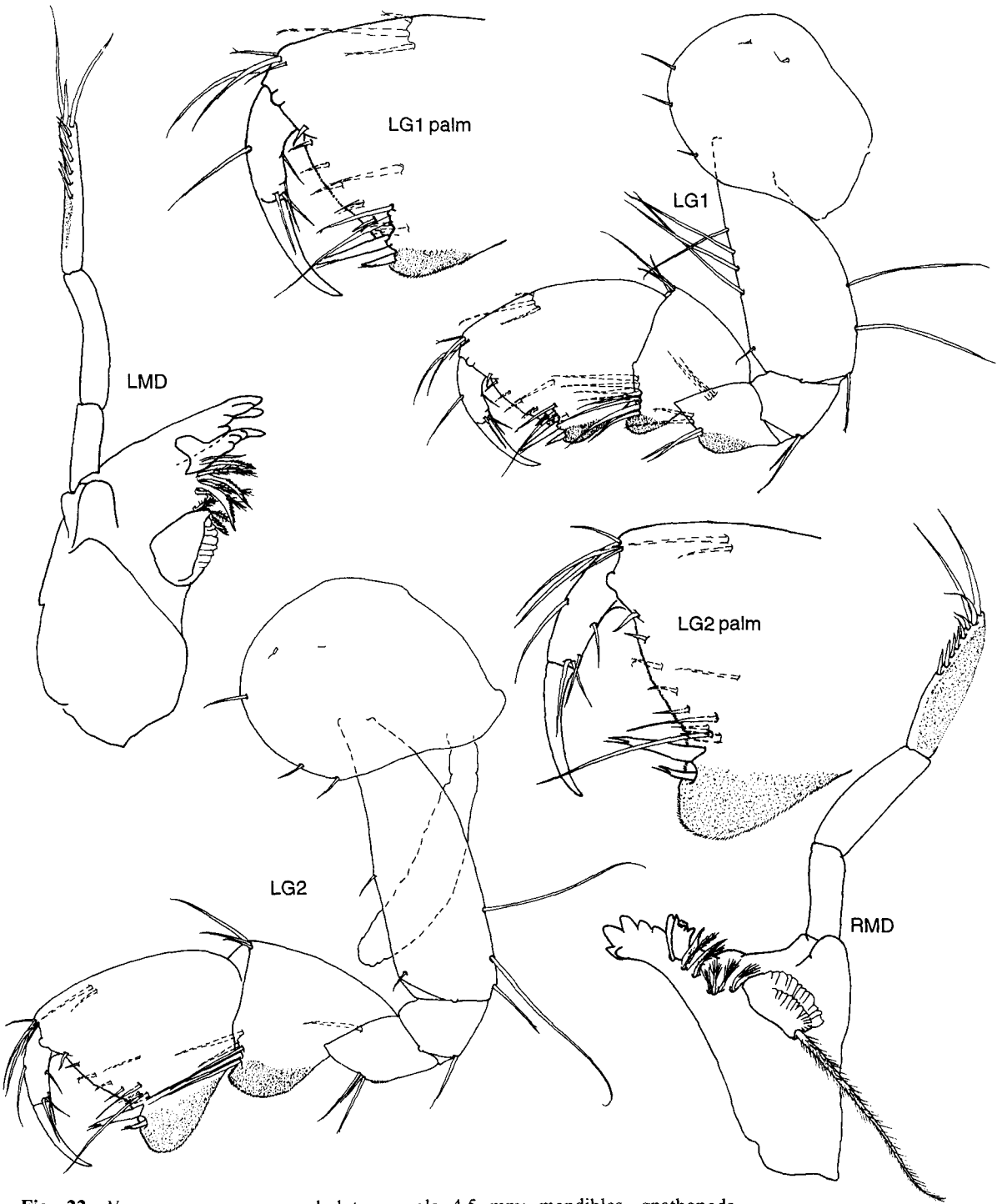

Fig. 22. *Neocrypta annae* n.sp. holotype male 4.5 mm; mandibles, gnathopods.

rami of uropods 1 and 2 with one or no dorsal robust seta rows, the inner ramus of uropod 3 0.09× length of outer ramus. Telson cleft 20%, with mid lateral spination

Description of holotype (male). *Body* (Fig. 21): pleon with few dorsal arms, pleonites 1–4 with few setae, pleonite 5 with two distolateral robust setae, pleonite 6 with one mid dorsolateral robust seta basal to the telson, length 4.5 mm. *Head*: rostrum small, eyes absent. *First antenna* (Fig. 21): length 0.56× body, 2.1× second antenna, peduncle shorter than flagellum; ratio of lengths of peduncular articles 25:27:18, with sparse setae; flagellum of seventeen articles, uniform and sparsely setulate, aesthetascs present on articles 4–17; accessory flagellum 2-articulate, extending to M0.5 of the second primary flagellum article. *Second antenna* (Fig. 21): length: 0.27× body; the peduncle much longer than flagellum—68:35—articles 4 and 5 subequal in length, articles 3–5 with moderate ventral setation; flagellum of five articles, weakly setose ventrally, aesthetascs absent. *Left mandible* (Fig. 22): palp article 3 1.2× article 2, weakly falcate, with setae 6D3E, articles 1 and 2 naked; incisor with five teeth; lacinia mobilis with four; three chisel robust seta accessory blades with three

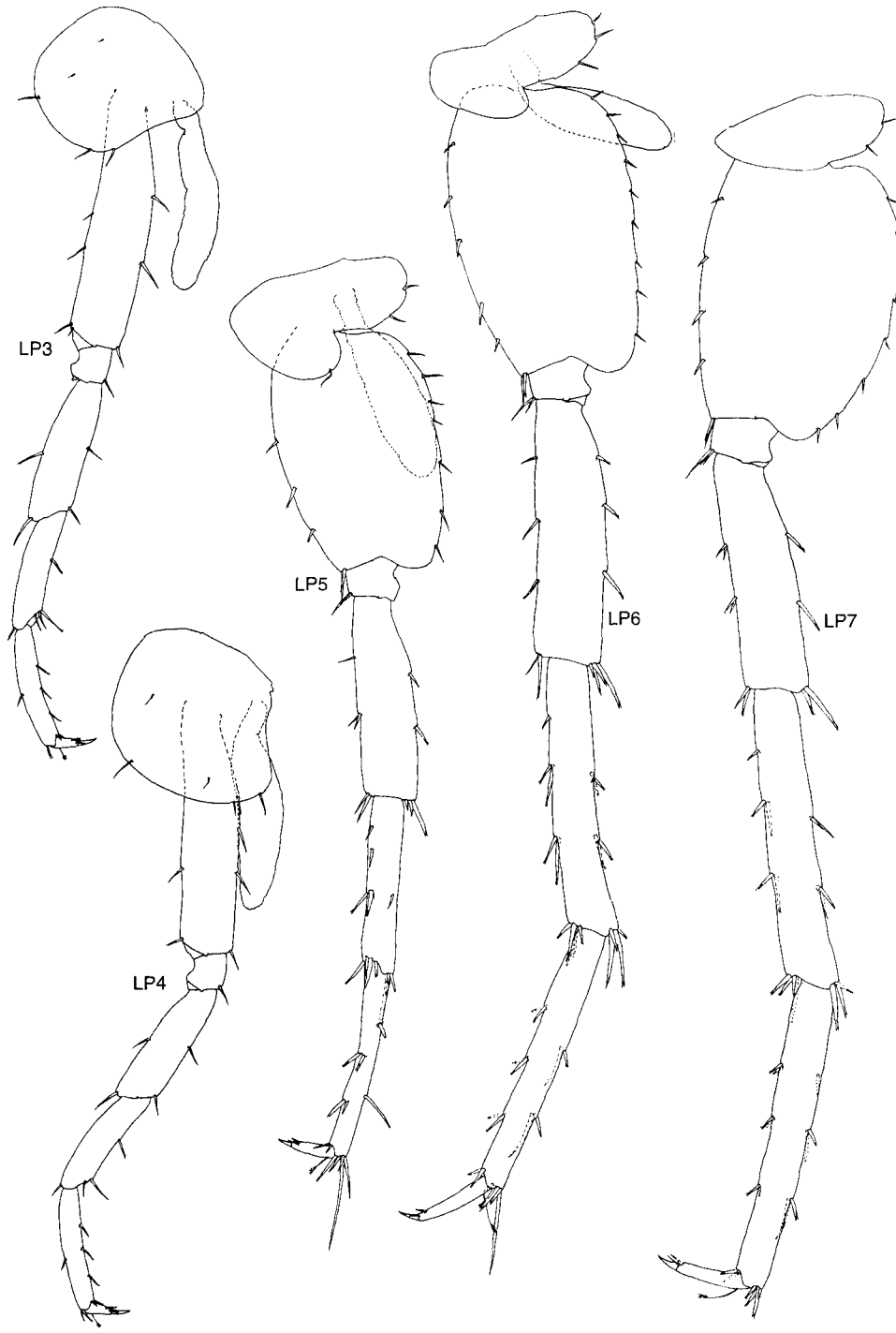

Fig. 23. *Neocrypta annae* n.sp. holotype male 4.5 mm; peraeopods.

interraker plumose setae and one naked robust seta at the base of the incisor, two brushy setae leading to the molar; molar triturative with a short anterior raker blade, no pappose seta. *Right mandible* (Fig. 22): palp with setae 6D3E; incisor with six teeth; lacinia mobilis bifid, denticulate; accessory blades of two chisel robust setae and two plumose setae, four brushy setae basal to the molar; molar triturative with a long posterior pappose seta. *Maxillae* (Fig. 21). Left first maxilla: palp with three thin medio distal to apical robust setae and one similar laterodistal robust seta; outer plate with seven denticulate strong apical robust setae; inner plate with two apical plumose setae. Right first maxilla: palp with a mediodistal row of four robust setae and two distolateral long robust seta setae, the distal with apical armaments; outer plate with seven denticulate robust setae, the inner plate with two plumose apical setae. Second maxilla: both plates with long curved apical setae; outer plate distolateral margin with a single small seta; inner plate with two medio distal submarginal slender setae. *Maxilliped* (Fig. 21): palp article 2 moderately setose medially, article 3 with two slender setae basal to the

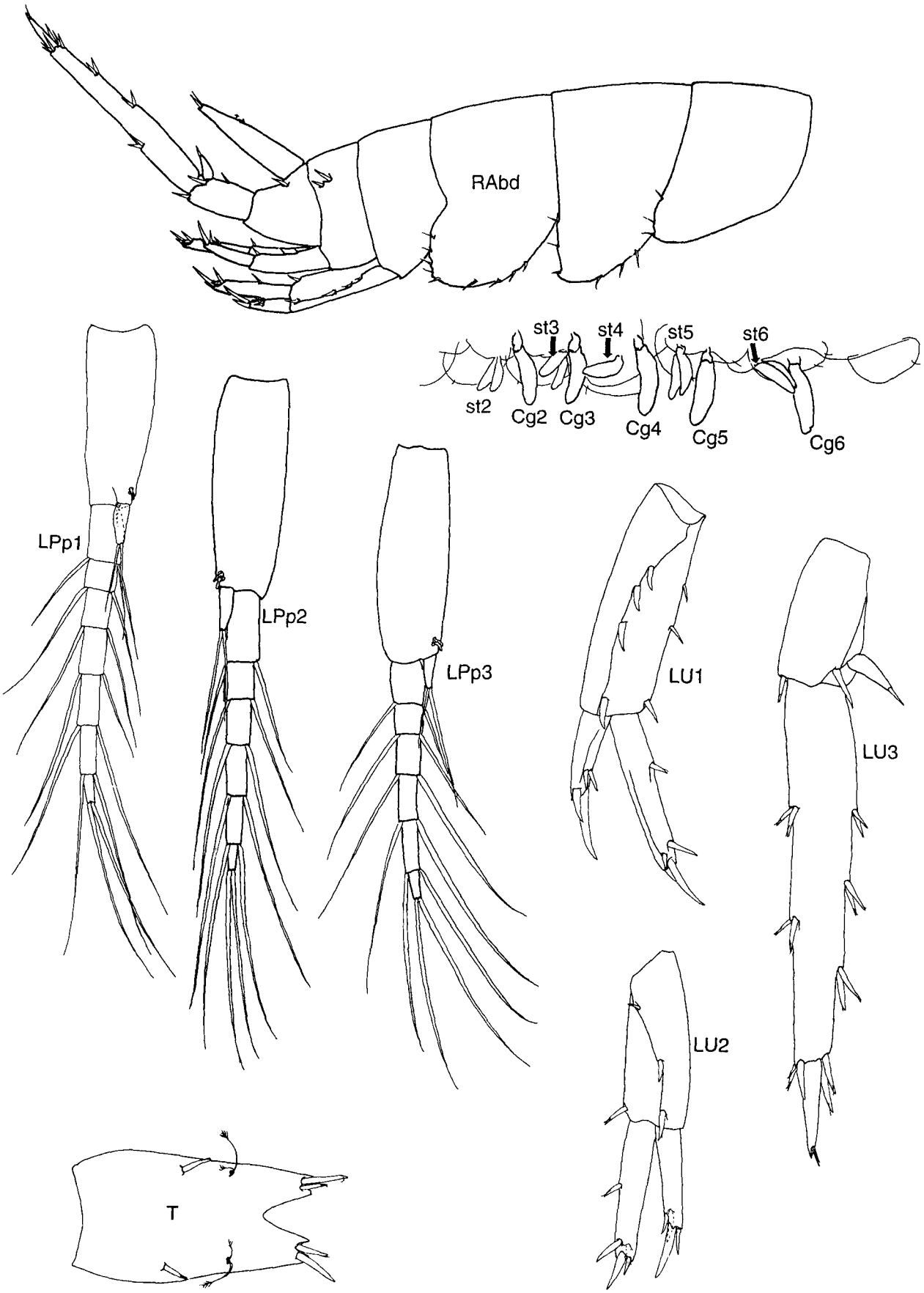

Fig. 24. *Neocrypta annae* n.sp. holotype male 4.5 mm; abdomen, gills, pleopods, uropods, telson.

dactyl, a row of five mediodistal setae, two accessory spinules adjacent the nail, the apex moderately lobate and rugose; inner plate apex with two thick naked robust setae, two plumose and one long naked setae a disto medial plumose seta and two ventrofacial naked setae; outer plate bearing a distolateral plumose robust seta, three slender setae, one naked tooth like robust seta continuous with a row of stout naked sub marginal medial robust setae and a basal row of four slender robust setae. *First gnathopod* (Fig. 22): coxal plate with a row of three moderate length apical setae, article 2 without posterior rugose extension, article 3 with a small postdistal rugose lobe, articles 4–6 with substantial posterior rugose lobes; carpus short, without apical setae on the posterior lobe; propodus trapezoidal, wider than long, posterior rugose lobe keel-like, few, simple palmar robust setae, palmar corner marked by one medial and two lateral robust setae, dactylus with two inner accessory setae and stiff spinules at the inner nail articulation; dactylus reaching slightly beyond the palmar corner robust setae. *Second gnathopod* (Fig. 22): slightly larger than the first; coxa sparsely setose apically, bearing a slender sac like gill; articles 2 and 3 without posterior rugosities; article 4 with only a small mid marginal posterior rugose extension; carpus and propodus strongly lobate; palmar corner with one medial and two lateral stout robust setae, robust setae of palm sparse; dactyl with inner accessory setae, reaching to palmar corner robust setae. *Peraeopods* (Fig. 23): coxae 3 and 4 with three weak apical setae only; coxa 4 weakly emarginate, with a few small facial setules; peraeopods 3 and 4 subequal, slightly longer than the second gnathopod, articles 4 and 5 spinose posteriorly, articles 6 with posterior robust setae 1-1-1 and 1-1-1; peraeopods 5–7 similar, coxae with 2-3-2 weak to moderate posterior robust setae, articles 2 expanded, ovate—P5<6<7—post-ventrally moderately lobate, with small marginal setae, posterior margins of propodi lacking long setae except for long subdactylar setae on legs 5 and 6, dactyls without additional accessory spinules. *Gills* (Fig. 24): coxae 2–6 with sac like gills; sternites 2–6 with paired medial simple gills. *Epimera* (Fig. 24): without postventral teeth; posterior margins of E1 convex, E2 straight, E3 broadly convex, with 3-3-4 posterior setae; ventrofacial robust setae = 0-3-5. *Pleon*: pleonites 1–4 naked, five with two distolateral robust setae, pleonite 6 with one mid lateral robust seta basal to the telson. *Pleopods* (Fig. 24): each with two retinacula, peduncles otherwise naked except for a single small seta basal to the inner ramus of the first pleopod; rami diverse, both reduced, inner rami reduced to a single article only, without marginal setation, outer rami each of six articles. *Uropods* (Fig. 24): third uropod strongly elongate, extending well beyond first and second uropods in the intact specimen; uropod lengths relative to the first uropod 2 0.8×, uropod 3 1.7×. First uropod: peduncle length 1.3× medial, 2.3× lateral rami; apicodistal robust seta of outer margin slightly subapical, with a row of three short dorsal robust setae; medial margin with two robust setae plus the apical robust seta; rami unequal, medial 1.8× lateral, only the medial ramus with a single medial short robust seta, both rami with four terminal robust setae. Second uropod: peduncle longer than rami, 1.2× medial, 1.7× lateral ramus, with two short dorsolateral robust setae plus a distal subapical robust seta; rami unequal, medial ramus 1.4× lateral, only the medial ramus with a single medial robust seta, both rami with four apical robust setae. Third uropod: long, peduncle length 0.9× length of urosomite one, 0.3× length of outer ramus, bearing single distolateral and disto medial robust setae; outer ramus proximal article without setae, with two trans-lateral rows of 2-2 robust setae, three trans-medial rows of 2-2-2 robust setae, three distolateral and two distomedial robust setae, second article short, 0.2× length of the first, with two small apical setules; inner ramus short, 0.09× length of the outer ramus, with a single apical robust seta. *Telson* (Fig. 24): moderately long, 2× urosomite three, 1.8× longer than broad, cleft 20%, apices with one long and one short robust seta, single dorsolateral robust setae at M0.4 on either side and a pair of lateral penicillate setules at M0.6 on either side.

Relationship. *Neocrypta annae* differs from *N. primaris* in: first and second antennae shorter with fewer articles; mandibular palp without C setae, less D and E setae; palp of right first maxilla narrow; first gnathopod more rugose; second article of peraeopods 5–7 less expanded posteriorly; outer rami of pleopods with fewer articles; uropods 1 and 2 with fewer robust setae; telson more deeply cleft, less tumid and narrower. *Neocrypta annae* differs from *N. moniae* in: first and second antennae with less flagellar articles, shorter; mandibular palp with few D setae; palp of right first maxilla narrow; medial margin of article 2 of maxillipedal palp less setose; first gnathopod with little rugosity; outer rami of pleopods with fewer articles; uropods 1 and 2 with fewer robust setae; telson more deeply cleft. *Neocrypta annae* differs from *N. robinae* in: first antenna longer, with more flagellar articles; second antenna longer, but with the same number of articles; mandibular palp bearing fewer D and E setae; palp of right first maxilla narrow; first gnathopod bearing moderate rugosities; second article of peraeopods 5–7 more expanded; telson cleft much more deeply, and broader. *Neocrypta annae* differs from *N. simoni* in: flagellum of first antenna longer and with more articles; second antenna without aesthetascs; mandibular palp with more D setae; right rather than left first maxilla palp narrow; first gnathopod more rugose; outer rami of pleopods of more articles; telson less tumid. *Neocrypta annae* differs from *N. georginae* in: first antenna longer and with a greater number of articles; second antenna with less articles and without apical aesthetasc; mandibular palp with less D setae; palp of right maxilla narrow; first gnathopod without facial rugosities; second article of peraeopods 5–7 more expanded posteriorly; first and second uropods less spinous; telson more deeply cleft, less tumid and more slender.

Distribution. Cave BP6, Bowan Park, New South Wales, 31°54'S 148°05'E.

Neocrypta simoni n.sp.

Figs 25–28

Etymology. Named for the first son of the second author in acknowledgment of his indirect contributions to the study of amphipods.

Type locality. Paradox Cave (Cave J-48), Jenolan, New South Wales, 33°49'S 150°02'E.

Material examined. HOLOTYPE (Australian Museum P51368) female "a" 4 mm, ALLOTYPE (Australian Museum P51369) male "b" 3 mm; collected 9 March, 1993 by S. Eberhard.

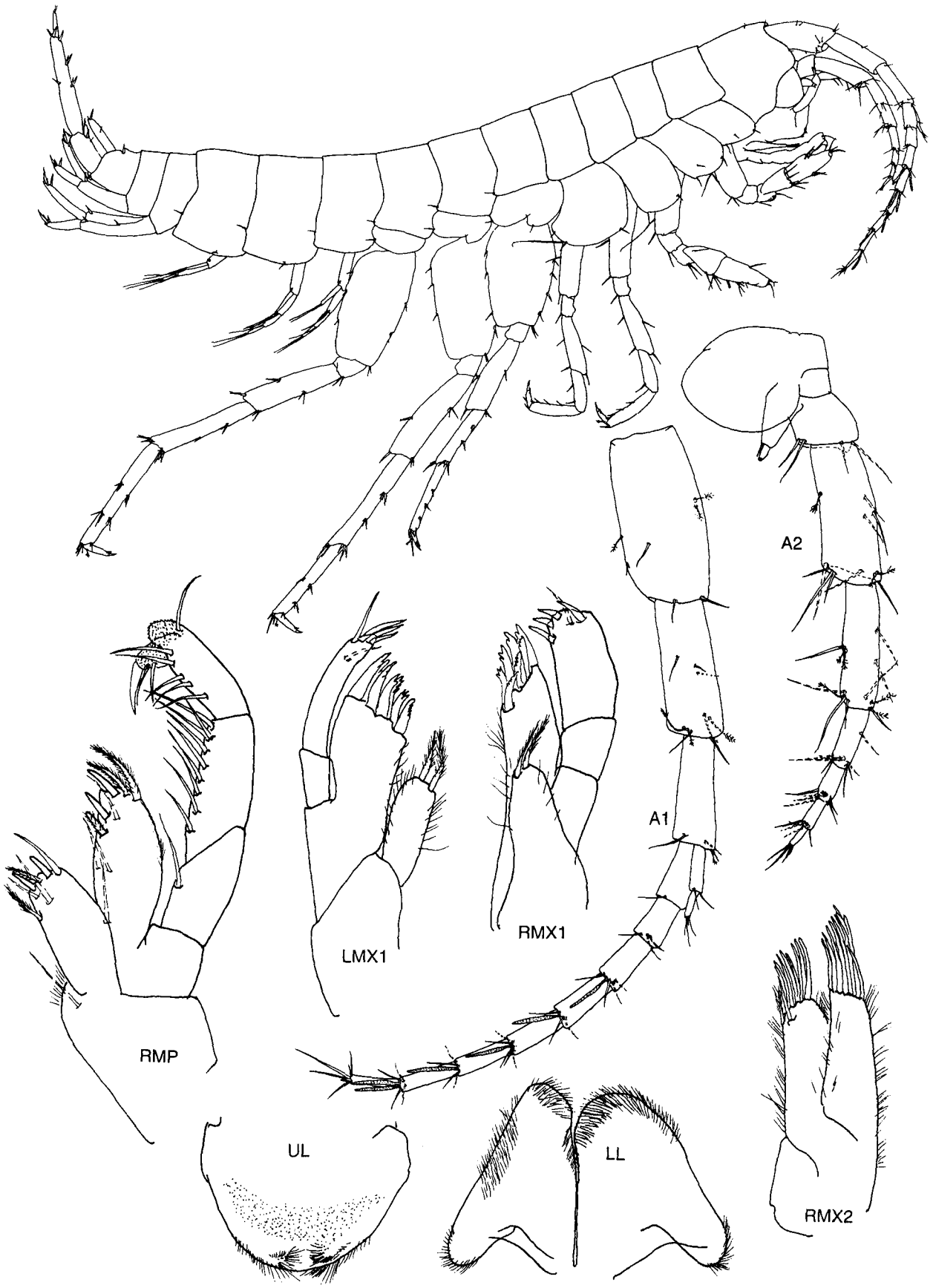

Fig. 25. *Neocrypta simoni* n.sp. holotype female "a" 4.0 mm; whole, antennae, mouthparts.

Diagnosis. Lateral cephalic lobes moderately projecting, antennal sinus moderate, ratio of lengths of peduncular articles of first antenna 10:8:5, ratio of lengths of mandibular palp articles 8:12:10 to 8:13:12, third article linear, setae DE. Inner plate of first maxilla with two plumose apical setae, inner plate of second maxilla with one mediodistal seta submarginal. Coxa 1 tapering apically, articles 2–4 of both gnathopods with posterior rugose lobe, robust setae of the palmar corner 3-2, palmar robust setae short and sparse, peraeopod 6 subequal to seven,, second article of peraeopods 5–7 weakly postventrally lobate. Rami of both pleopods strongly reduced, inner rami of one article only, without marginal setation. Epimera without postventral teeth, rami of pleopods 1 and 2 without dorsal robust seta rows, inner ramus of third uropod 0.13× length of outer ramus. Telson cleft 20%, without mid lateral spination.

Description of holotype (female "a"). *Body* (Fig. 25): pereon and pleon without dorsal armaments except for a single small dorsolateral robust seta on pleonite 6 basal to the telson; length 4 mm. *Head*: rostrum small, eyes absent. *First antenna* (Fig. 25): moderate length, 0.56× body, 1.5× second antenna, peduncle shorter than flagellum, ratio of lengths of articles 10:8:5, setae sparse; flagellum of eight articles, segments uniform, sparsely setulate, bearing single aesthetascs on articles 3–6 and a pair on article 7; accessory flagellum of two articles reaching to M0.2 of article 2 of the primary flagellum. *Second antenna* (Fig. 25): length 0.4× body, peduncle much longer than flagellum—80:30—articles 4 and 5 subequal in length—27:24—articles 3–5 with moderate ventral setation; flagellum 4-articulate, weakly setose bearing a single small apical aesthetasc on article 4. *Left mandible* (Fig. 26): palp article 3 shorter than 2—23:26—linear, with 3D4E setae, distolaterally rugose, articles 1 and 2 naked; incisor with six teeth; lacinia mobilis four teeth; accessory blades of three chisel robust setae and two plumose robust setae; molar triturative with a short posterior pappose seta. *Right mandible* (Fig. 26): palp article 3 setae 3D4E, distolaterally rugose; incisor with five teeth; lacinia mobilis bifid, denticulate; no accessory robust setae, but three very short setae onto the base of the molar; molar bearing a hooked brushy basal seta and long posterior pappose seta. *Maxillae* (Fig. 25): palp of left first maxilla slender, bearing four thin apical robust setae and a ventrofacial seta, outer plate with seven denticulate robust setae, inner plate with two apical plumose setae; right first maxilla palp broad, with four thick mediodistal to apical robust setae and one ventrofacial seta; outer plate with seven strong denticulate robust setae, inner plate with two plumose apical setae; second maxillae: both plates with long curved apical setae; inner plate bearing one subdistal medial plumose seta and one simple disto facial submarginal seta. *Maxilliped* (Fig. 25): palp article 3 without thin basomedial setae, with two facial setae basal to the dactyl, and a single distolateral seta at the base of the strongly produced rugose apex; dactyl facially rugose, with two accessory setules on the inner distal margin; inner plate apex with two thick tooth like robust setae, one pappose robust seta and a long lateral seta, inner margin with one plumose seta, ventrodistal face with two simple setae; outer plate with three naked basofacial setae, medial submarginal pappose and naked robust setae, a ventrofacial long seta, one naked and two long pappose robust setae apically. *First gnathopod* (Fig. 26): coxal plate with two marginal and one ventrofacial setae; articles 2 and 3 with small posterior rugose lobes; articles 4 and 5 with strong posterior rugose lobes; article 6 with a small area of posterior rugosity; carpus short, rugose lobe rounded, without apical setae; propodus trapezoidal, longer than wide, the posterior angle subquadrate, palmar corner robust setae two lateral and one medial, palm with moderate numbers of simple setae, dactyl with recumbent inner tooth like robust seta, and reaching to the palmar corner. *Second gnathopod* (Fig. 26): slightly larger than the first; articles 2–4 all with posterior rugosities; article 4 posteriorly lobate, but less so than on the first gnathopod; carpal lobe larger than on the first; posterior proposal margin strongly lobate and rugose; palmar corner marked with one medial and one lateral robust seta; dactyl with an inner accessory setule, and reaching beyond the robust setae of the palmar corner; coxa sparsely setose apically with a sac like gill and slender oostegite. *Peraeopods* (Fig. 27): coxae 3 and 4 with sparse apical setation, coxa 4 moderately emarginate, both bearing slender sac like gill and oostegite; peraeopods 3 and 4 subequal, longer than gnathopod 2, articles 3 and 4 weakly setose and spinose, both propodi with the posterior robust seta formula 1-1-1-1; peraeopods 5–7 similar, coxae each with only a single weak posterior robust seta, article 2 expanded posteriorly, weakly lobate, with few moderate marginal setae, propodi with few posterior setae. *Gills* (Fig. 28): sac like simple gills present on coxae 2–6; sternites 2–6 bearing paired simple non-dendritic gills on each segment. *Epimera* (Fig. 28): without post-ventral teeth, posterior margins almost straight, each with a single seta only, and single mid ventrofacial robust setae on epimera two and three. *Pleon* (Fig. 28): pleonites 1–5 naked; six with a single dorsolateral robust seta basal to the telson. *Pleopods* (Fig. 28): each with two retinaculae; peduncles without setae or robust setae; rami reduced, outer rami each with three articles, the third outer ramus with a single additional distal seta on the first article; inner rami of one article each, without marginal setae. *Uropods* (Fig. 28): uropod 3 strongly extended, well beyond uropods 1 and 2 in the intact specimen; uropod lengths relative to uropod 1: uropod 2 0.78×, uropod 3 1.3×. First uropod: peduncle length 1.3× medial, and 1.5× lateral ramus, outer margin with a row of two short dorsal robust setae plus a sub apical distal robust seta, medial margin with a sub apical robust seta only; both rami without marginal robust setae, each with four apical robust setae. Second uropod: peduncle 1.3× medial, 1.5× lateral ramus, outer and inner margins with one sub apical distal robust seta; rami without marginal robust setae, each with four apical robust setae. Third uropod: peduncle length 0.35× outer ramus, as long as urosomite three with one small facial seta, a mediodistal robust seta adjacent the base of the inner ramus, and distolateral robust seta; outer ramus proximal article with two transverse medial rows of two robust setae each, two transverse lateral rows of one and two robust setae, and two medial and one lateral distal robust setae basal to the distal article; distal article length 0.26× proximal, with two fine apical setules; inner ramus small, 0.13× outer ramus with a single apical robust seta. *Telson* (Fig. 28): moderately long, longer than urosomite three, length 1.3× width; cleft 20%; apices each with a single robust seta set in a small notch, and a single lateral penicillate setule; without other dorsal spination or setation except for a pair of penicillate setules on either side at M0.49.

Description of allotype (male "b"). *Body*: length 3.5 mm. *First antenna*: primary flagellum of eight articles, aesthetascs present on articles 3–8, those on articles 3 and 4 paired; accessory flagellum of two articles, reaching to M0.4 of the second article of the primary flagellum. *Second antenna*: flagellum of four articles, the fourth with a small apical aesthetasc. *Mandibles*: similar to female. *Gnathopods*: similar to female. *Peraeopods*: leg three second article lacking one long posterior seta, similarly article 5 with one less posterior

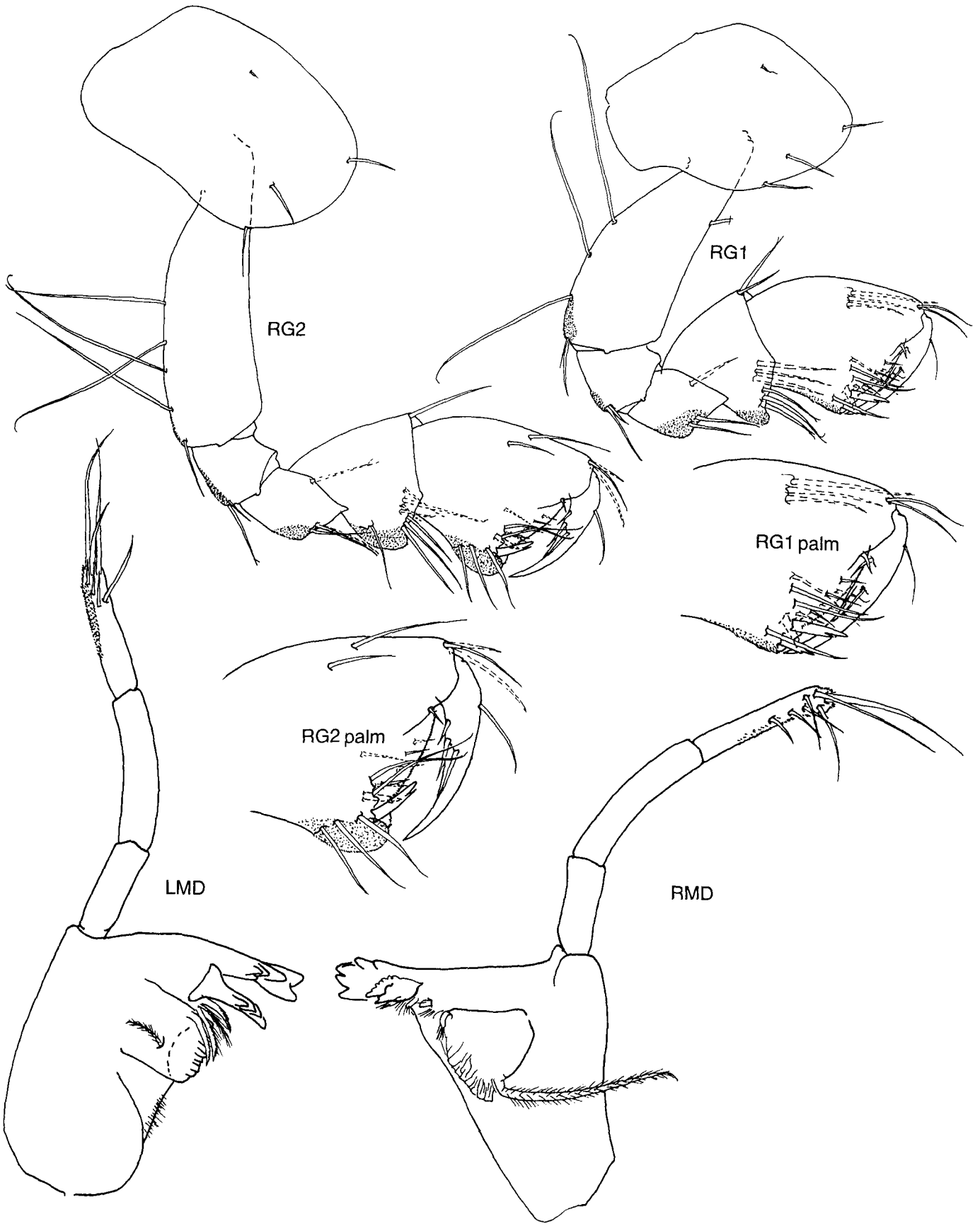

Fig. 26. *Neocrypta simoni* n.sp. holotype female "a" 4.0 mm; mandibles, gnathopods.

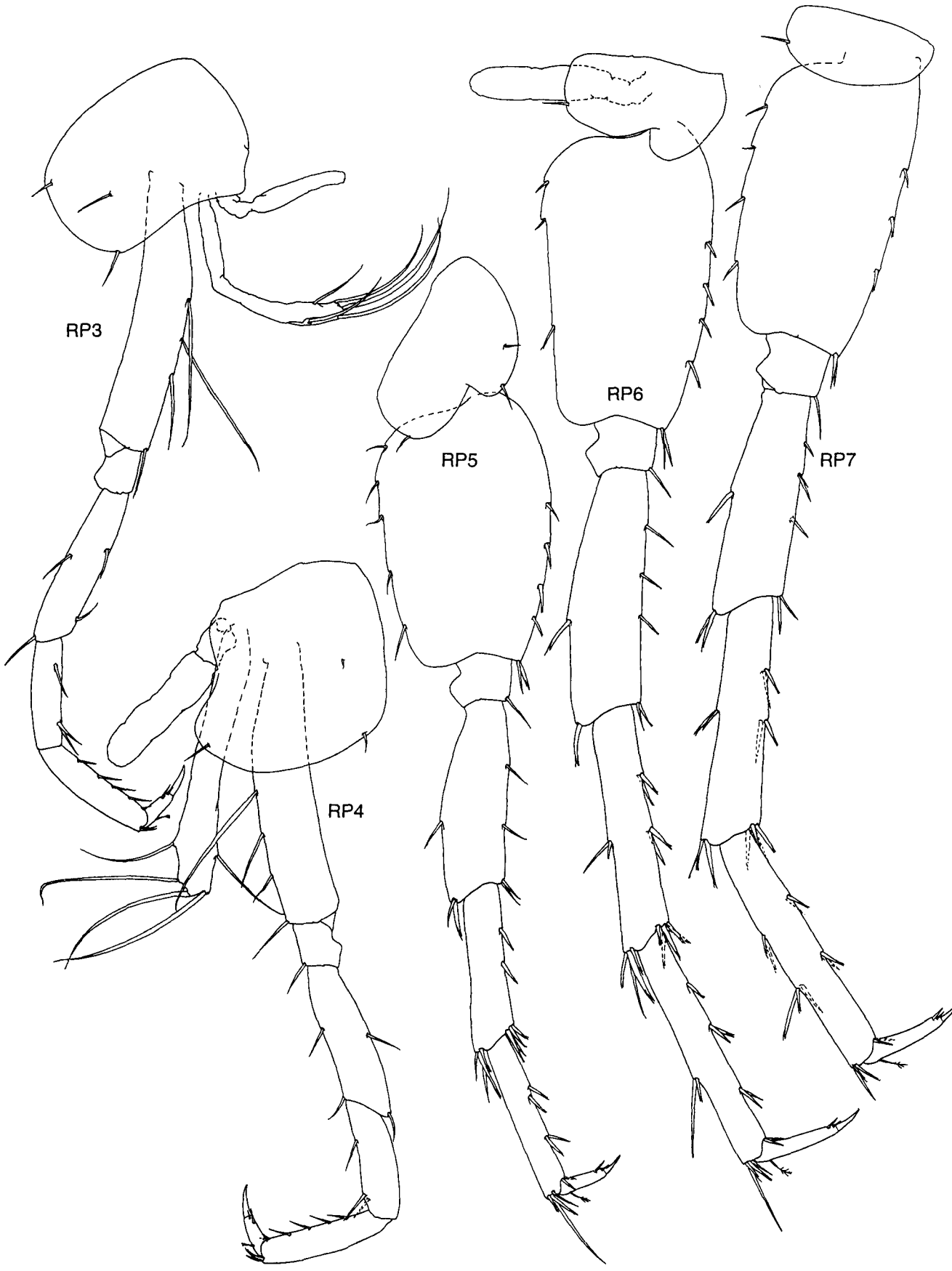

Fig. 27. *Neocrypta simoni* n.sp. holotype female "a" 4.0 mm; peraeopods.

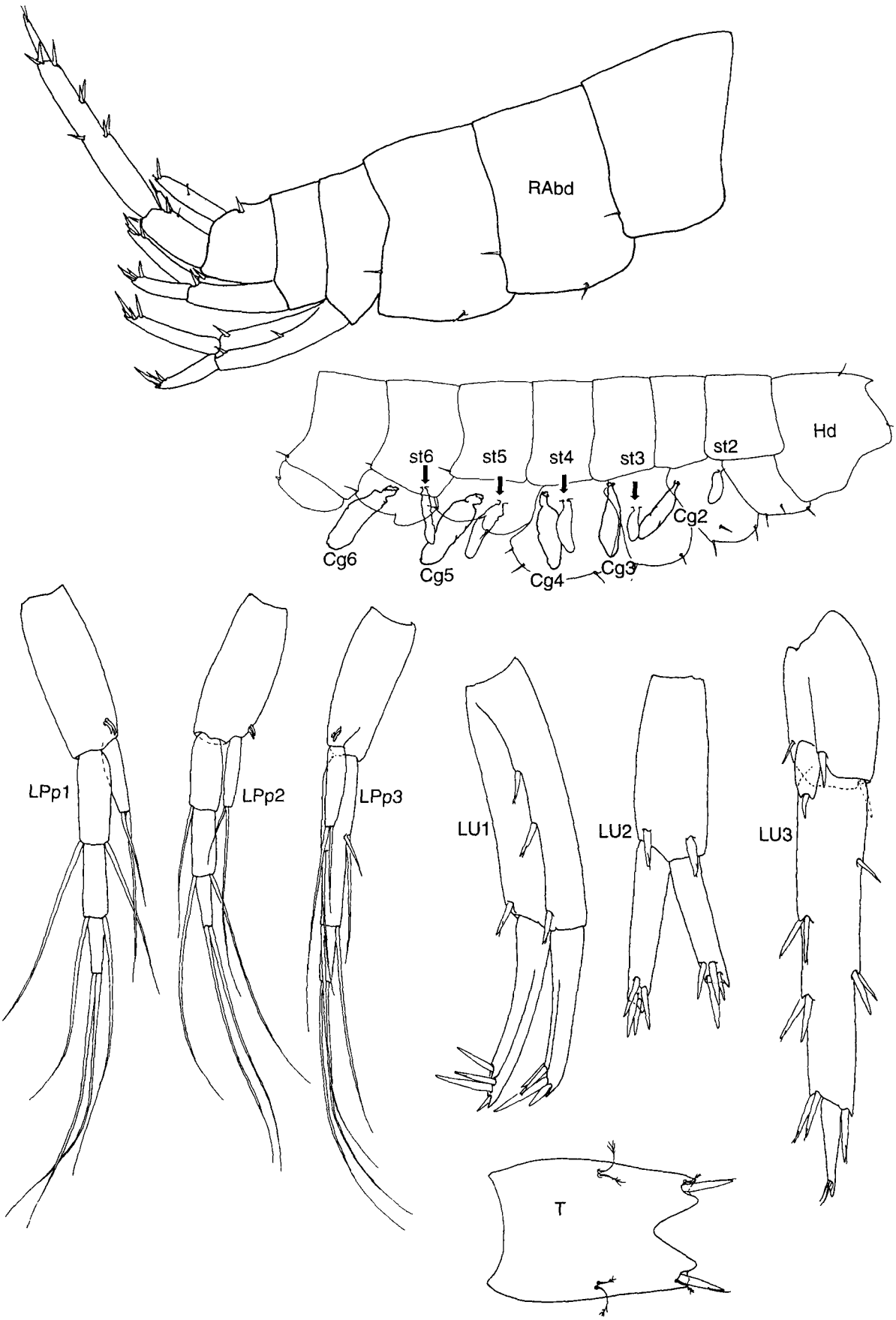

Fig. 28. *Neocrypta simoni* n.sp. holotype female "a" 4.0 mm; abdomen, gills, pleopods, uropods, telson.

seta; other peraeopods also less setose than female. *Pleopods*: similar to female, peduncles each with two retinacula, outer rami with 3-3-2 articles, inner rami each with one article. *Uropods*: first uropod peduncle with one lateral robust seta only; second uropod similarly naked; third uropod peduncle similar to female, outer ramus proximal article with only one lateral robust seta. *Telson*: similar to female.

Relationship. *Neocrypta simoni* differs from *N. primus* in: antennae shorter with few flagellar articles; second antenna bearing apical aesthetasc; mandibular palp with less D setae; left first maxilla palp narrow; article 2 of peraeopods 5–7 less broadly expanded; outer rami of pleopods with fewer articles; uropods 1 and 2 with fewer robust setae; telson cleft more deeply. *Neocrypta simoni* differs from *N. georginae* in: first antenna longest but with fewer articles, some aesthetascs paired; second antenna shorter, with aesthetasc on last article; mandibular palp with fewer D setae; palp of left first maxilla narrow; first gnathopod without facial rugosities; outer rami of pleopods with fewer articles; uropods less spinous; telson cleft more deeply.

Distribution. Paradox Cave (J48), Jenolan, New South Wales, 33°49'S 150°02'E.

Wombeyanus n.gen.

Etymology. Name refers to the type locality: Wombeyan Cave, New South Wales.

Type species. *Wombeyanus botulosus* n.sp.

Diagnosis. Pleonites with weak dorsal arms, rostrum small, lateral cephalic lobes weakly projecting, antennal sinus weak, without eyes. First antenna elongate, longer than the second, the ratio of peduncular articles 10:8:5, the accessory flagellum 2-articulate, calceoli present. The flagellum of the second antenna shorter than the peduncle, with prominent calceoli present. The ratio of lengths of articles of the mandibular palp equals 8:20:20 on the left mandible, 8:15:16 on the right, the second article poorly setose, the third weakly falcate, setae of the third article are BCDE. The labium lacks inner lobes. Inner plates of the maxillae are not setose medially, the first maxilla inner plate ovatotriangular with two apical plumose setae, the outer plate with seven terminal robust setae, the palps asymmetric. The second maxilla lacks an oblique row of facial setae but the two most medial setae of the inner plate are slightly sub marginal. The third article of the maxillipedal palp bears an extended rugose apical lobe. Coxae 1–4 moderately elongate, sparsely setose ventrally, coxae 1–3 without posterior robust setae, coxa 1 weakly tapering apically, coxa 4 moderately emarginate, coxae 5–7 much shorter than coxa 4. Gnathopods small, without sexual dimorphism, carpi short, with a strong posterior rugose lobe, articles 2–4 also bearing rugosities on the post-distal corner, palms transverse to slightly oblique, rugose post-distally, palmar robust setae not bifid nor dense nor bearing triggers, robust setae at palmar corner three or four. Peraeopods 3 and 4 with robust seta sets on the posterior of article 6 evenly spaced, peraeopods 5–7 moderately elongate, six longer than seven, article 2 of peraeopods 5–7 broadly expanded, least on six, ovate, and post-ventrally lobate, articles 4 with few setae, except for an elongate basodactylar seta on peraeopod 5, the anterior margins of article 6 with 5-6-5 robust seta sets as well as locking robust setae. Dactyls of peraeopods with one marginal and one facial setule. Gills present on coxae 2–6, absent from coxa 7. Sternal gills present on segments 2–6, simple sausage like, attached to the antero- or mid-lateral edge of each segment. Pleopods similar; each with two retinaculae, without accessory retinaculae; the rami subequal, medial setae of the inner ramus of each bifid. Epimera without posterior teeth; ventrofacial robust setae present on epimera two and three; the posterior margins with few setae. Robust setae of uropods 1 and 2 all short. Peduncles of uropods 1 and 2 with a single robust seta on the apico medial corner, the rami extending unequally, margins with few robust setae or setae, basofacial arms of the first uropod absent, the third uropod strongly extended, parviramous, the peduncle relatively short, robust setae of the outer ramus arranged in multiples in lateral and medial rows, the outer ramus with two articles, the second short, medial setae absent from the first article, without plumose setae , the inner ramus very short, with two apical robust setae. The telson short, cleft about 46%, the lobes not laterally tumid, with only apical spination, and a pair of lateral penicillate setules at M0.75

Additional description. Upper lip uniform, rounded but weakly asymmetrical below, mandible accessory blades (rakers) with interraker plumose setae, few additional penicillate setae beyond rakers riding onto the base of the molar, with two bent basal molarial ragged setae. The lower lip uniform, the inner lobes absent. Both plates of the second maxilla with long apical setae. Maxilla inner plates and the lateral margins of the second maxilla moderately pubescent. Maxillipedal inner plate with a distal row of a few plumose setae, three blunt naked robust setae, reduced medial row of plumose setae, the outer plate with a few distal plumose setae, continuous with a mediodistal row of blunt naked tooth like robust setae, palp articles 2 and 3 poorly setose laterally, well setose medially, article 3 with several long robust setae near the base of the dactyl. Dactyls of gnathopods without a recumbent inner tooth like robust seta, with stiff spinules or setules at the inner nail articulation, and without additional spinules along the inner dactylar margin. Gnathopod 1 without an enlarged rastellate seta on the fourth article. Pleopods similar, the peduncles with few or no setae, and rami extending subequally. Urosomite one at the base of the first uropod with a moderate ventrodistal robust seta.

Sexual attributes. Oostegites moderately broad, calceoli absent on female antennae. Sexual differences in appendages minor.

Relationship. The genus is most similar to *Neoniphargus*, but differs from that genus in lacking eyes, the first antenna is only moderately longer than the second, the first article of the mandibular palp is relatively longer, there are fewer robust setae at the palmar corners, robust setae along the palm are not dense nor bearing triggers, posterior expansion of the second article is least on peraeopod 6 rather than five, sternal gills are neither dendritic nor bearing lumps, marginal spination of the rami of the first and second uropods is reduced, the telson is cleft 46% rather than 60%, and the lateral penicillate setules are placed more posteriorly, the ventrodistal robust seta on the first urosomite at the base of the first uropod is moderately long rather than short, and in the female is paired on the right side. The genus differs from *Wesniphargus* in the absence of lumps on

sternal gills, presence of rugosities on the propodi of both gnathopods, lack of coxal gill 7, and asymmetry of the palps of the first maxillae. *Wombeyanus* differs from *Tasniphargus* in the absence of long, dense setae or cojoint first articles on the first antenna, as well as absence of dendricity of the sternal gills. *Wombeyanus* differs from *Yulia* in the lack of dense setae on the pleopod peduncles and absence of an elongate spur on the outer ramus of the first uropod of the male, as well as the absence of dendritic sternal gills. *Wombeyanus* differs from *Neocrypta* in the presence of calceoli on the flagellum of the second antenna; the first article of the mandibular palp is relatively short, the second slightly setose, the third bears B and C setae; coxa 4 is moderately rather than weakly emarginate; pleopods are not reduced, inner and outer rami being subequal; telson is short rather than long, and cleft 46% rather than 20% or less.

Wombeyanus botulosus n.sp.

Figs 29–32

Etymology. From Latin *botulosus*, meaning sausage; name refers to the simple, sausage-like sternal gills.

Type locality. Bullio Cave (2W2) part of the Wombeyan Cave system, New South Wales, 34°19'S 149°59'E.

Material examined. HOLOTYPE (Australian Museum P51370) male "x" 7.5 mm, ALLOTYPE (Australian Museum P51371) female "y" 7.5 mm, other in the type series; male 7.5 mm; collected by T. Dennis 5 April, 1986.

Diagnosis. As in the genus.

Description of holotype (male "x"). *Body* (Fig. 29): pleon not armed dorsally, pleonites 1-4 with few setae, pleonites 5 and 6 with one robust seta on each side, length 7.5 mm. *Head*: rostrum small, eyes absent. *First antenna* (Fig. 29): long, 0.55× body length, 1.9× the second antenna; the peduncle length less than the flagellum, the ratio of lengths 10:8:5, setae sparse, the third article bearing a single medial calceolus at M0.7; flagellum of 26 uniform, sparsely setulate articles, calceoli present on articles 2, 4, 5, 7 and 9, and aesthetascs on articles 3–26 excepting articles 8 and 25; accessory flagellum of two articles, extending to M0.7 of the second article of the primary flagellum. *Second antenna* (Fig. 29): length about 0.3× body, peduncle approximately 1.9× the length of the flagellum, peduncular articles 4–5 subequal in length, articles 3–5 bearing moderate ventral setation; flagellum of ten weakly setate articles of which articles 1–7 bear calceoli, the distal three with a single aesthetasc each. *Left mandible* (Fig. 31): palp articles 2 and 3 equal in length, article 2 with four inner marginal setae, article 3 weakly falcate, bearing 2B5C23D3E setae; incisor with five teeth; lacinia mobilis with four teeth and a few fine basofacial setae; three chisel robust seta accessory blades and three interraker plumose setae; molar bearing a moderate posterior pappose seta as well as two brushy and one naked basal setae. *Right mandible* (Fig. 31): palp articles 2 and 3 equal in length, article 2 bearing four medial setae, setae of article 3 2B6C23D3E; incisor bearing five teeth; lacinia mobilis bifid and denticulate with a few medial setules; accessory blades of two blunt chisel robust setae bearing distal rugosities, two bent brushy setae onto the base of the molar; molar barely triturative, bearing a long pappose posterior seta, and a few mediobasal setules. *Maxillae* (Fig. 29): left first maxilla; palp article 2 with a row of four apicomedial and apical slender robust setae, three facial robust setae and one plumose distolateral seta, the outer plate nine terminal robust setae most denticulate, and the inner plate two plumose setae; right first maxilla, palp article 2 with five thick apicomedial robust setae, one apicolateral plumose seta, and two sub terminal apicolateral facial setae, the inner plate with two plumose apical setae; second maxilla outer plate apical margin with one small spinule, inner plate apicomedial corner with two weakly submarginal plumose setae and one slender naked seta. *Maxilliped* (Fig. 29): palp article 3 without ranks of thin setae on the inner ventral face, with four elongate apicolateral setae, the apex strongly produced and rugose, the dactylar face and mediofacial area of article 3 also rugose; inner plate with three thick tooth like robust setae, six plumose setae, and a single naked facial sub terminal seta apically, a medial row of three plumose setae, lacking medial ventrofacial robust setae, the peduncle bearing four slender medial setae basal to the inner plate, and one lateral seta; outer plate with two facial and two ventrofacial setae at M0.4 and M0.6 respectively, a row of six submarginal medio distal blunt tooth like robust setae, one plumose one armed and one naked terminal setae, and one naked ventro distal seta. *First gnathopod* (Fig. 30): coxal plate with a sparse row of short apical setae; fourth article bearing a small barely rugose posterior hump; carpus short, strongly lobate, the lobe rounded, without apical setae, and rugose; propodus trapezoidal, slightly longer than wide, the posterior angle with three short medial robust setae and two long, strong lateral robust setae, rounded and thus bearing a small rugose lobe, palm transverse, slightly convex, the dactylus with accessory spinules on the inner margin, and reaching to the palmar corner robust setae. *Second gnathopod* (Fig. 30): slightly larger than the first; the carpal lobe broader; the palmar corner more lobate, with two short medial robust setae and three lateral robust setae, dactylus bearing inner margin accessory spinules, and reaching to the palmar corner robust setae; coxa sparsely setulose apically, bearing a sac like gill. *Peraeopods* (Fig. 31): coxa 3 with a sparse row of short apical setae, coxa 4 moderately emarginate with three anteroventral setae and five posterior setae, peraeopods 3 and 4 subequal in length, longer than the second gnathopod, articles 4 and 5 spinous posteriorly, article 6 of the third leg bearing 2-2-2-2-2 posterior robust setae, and of the fourth leg 1-2-2-2-2-2 posterior robust setae; peraeopods 5, 6 and 7 similar, the coxae each bearing a weak posterior robust seta, the second articles expanded posteriorly, that of the sixth leg slightly narrower than the other two, ovate, postventrally moderately lobate, with short marginal setae, the posterior margins of the propodi without long setae except at the base of the dactyls, the dactyls a single facial and medial setule and without additional setules. *Gills* (Fig. 32): coxae 2–6 each bearing a single, sac like gill; sternites 2–6 each bearing a single simple, non dendritic gill. *Epimera* (Fig. 32): 1–3 without post-ventral teeth, although the third slightly acuminate; the first epimeron with no ventral robust setae, the second with two—one on the mid-anterior margin and one posterior-, the third with two anteroventral and one mid-ventral slightly facial robust setae, the posterior margins sinuous and with few setae. *Pleon* (Fig. 32): pleonites 1–3, bearing 2-2-3 post-dorsal marginal setae as well as fine marginal teeth; urosomite one without dorsal armaments; urosomites 5 and 6 each bearing a single dorso lateral seta posteriorly. *Pleopods* (Fig. 32): each with two retinacula and no accessory retinacula; peduncles naked except for three small basofacial setules on the first, and two small setae distolateral on the third; first

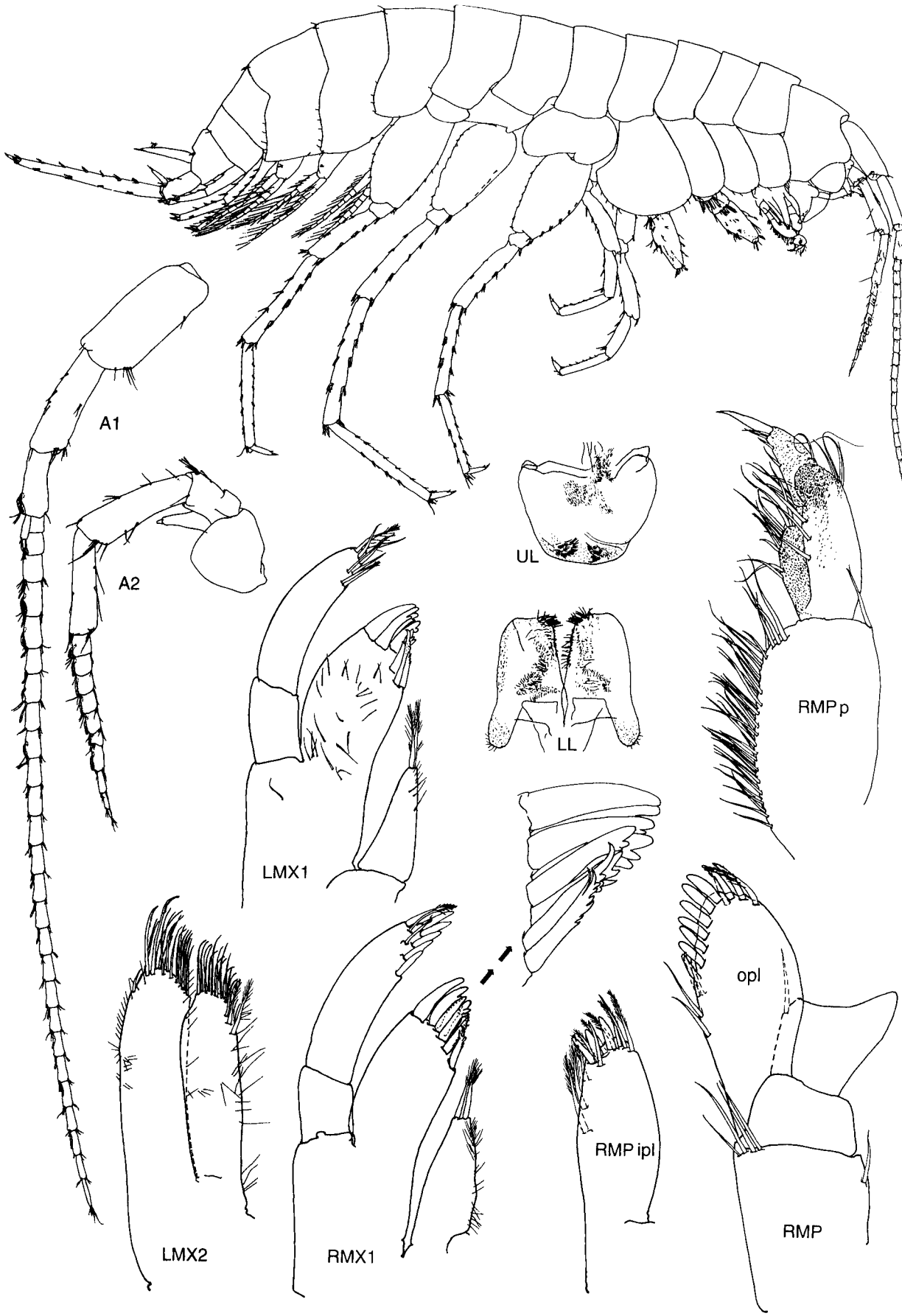

Fig. 29. *Wombeyanus botulosus* n.sp. holotype male "x" 7.5 mm; whole, antennae, mouthparts.

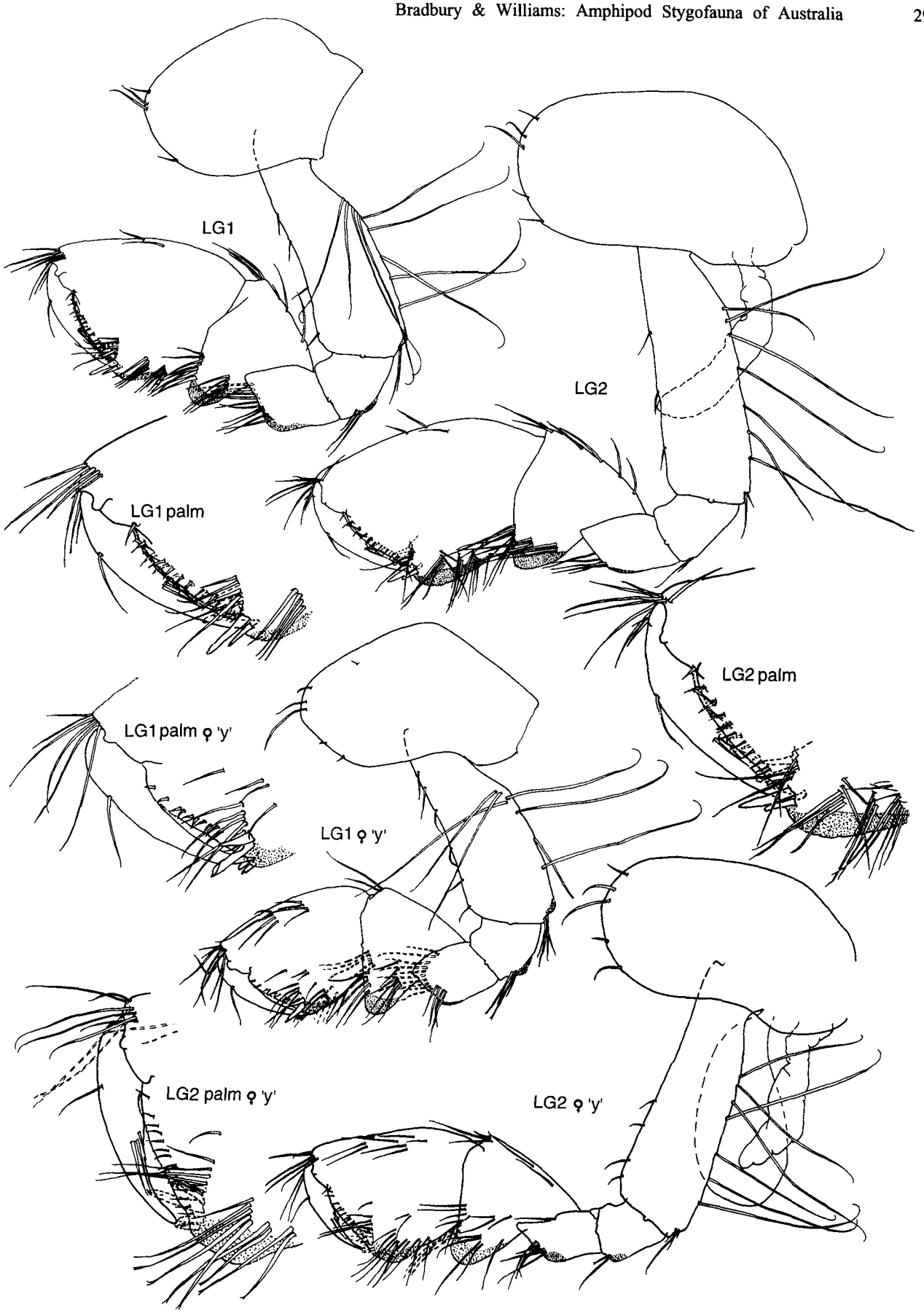

Fig. 30. *Wombeyanus botulosus* n.sp. holotype male "x" 7.5 mm; gnathopods (all drawings except those indicated). Allotype female "y" 7.5 mm gnathopods.

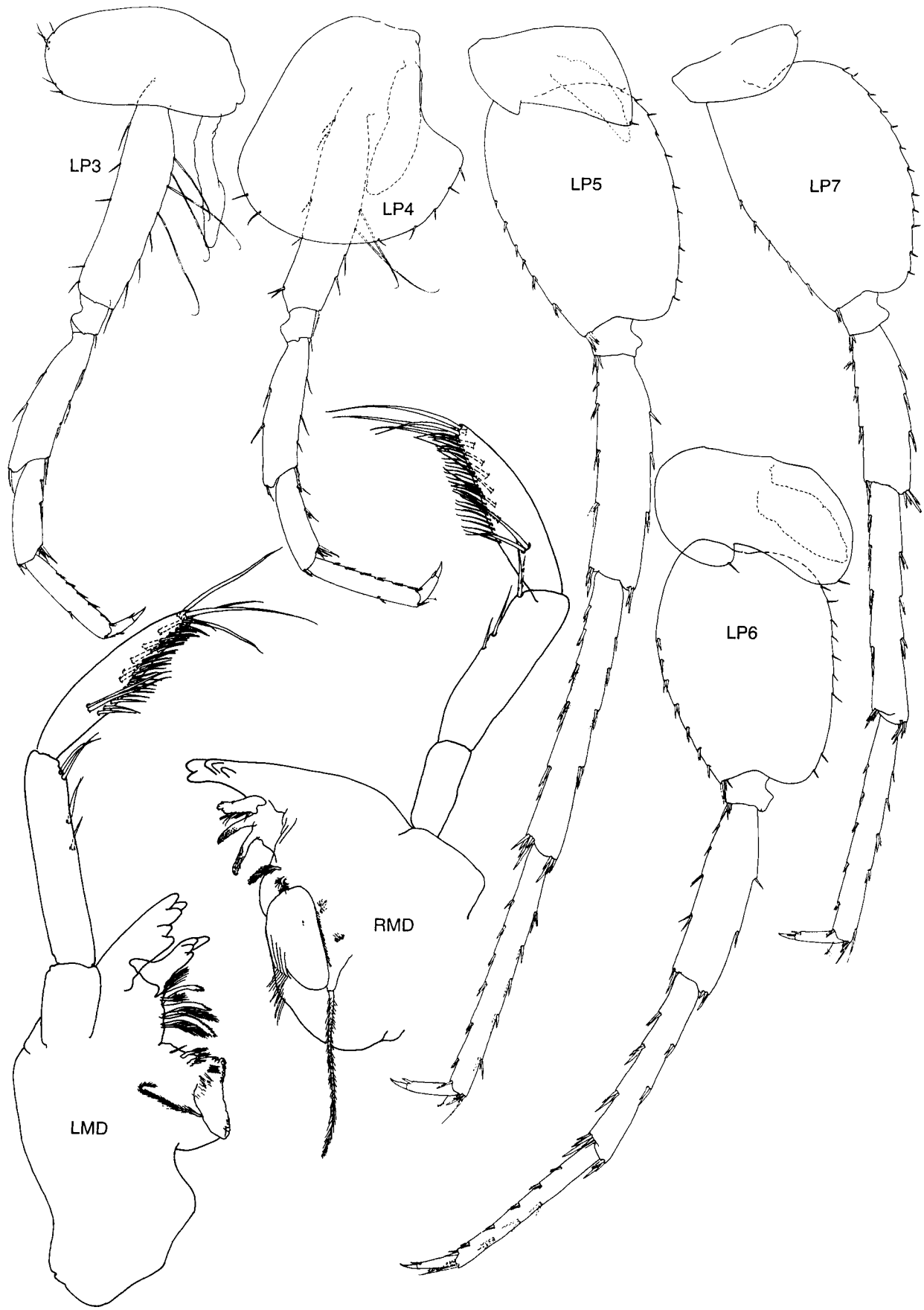

Fig. 31. *Wombeyanus botulosus* n.sp. holotype male "x" 7.5 mm; mandibles, peraeopods.

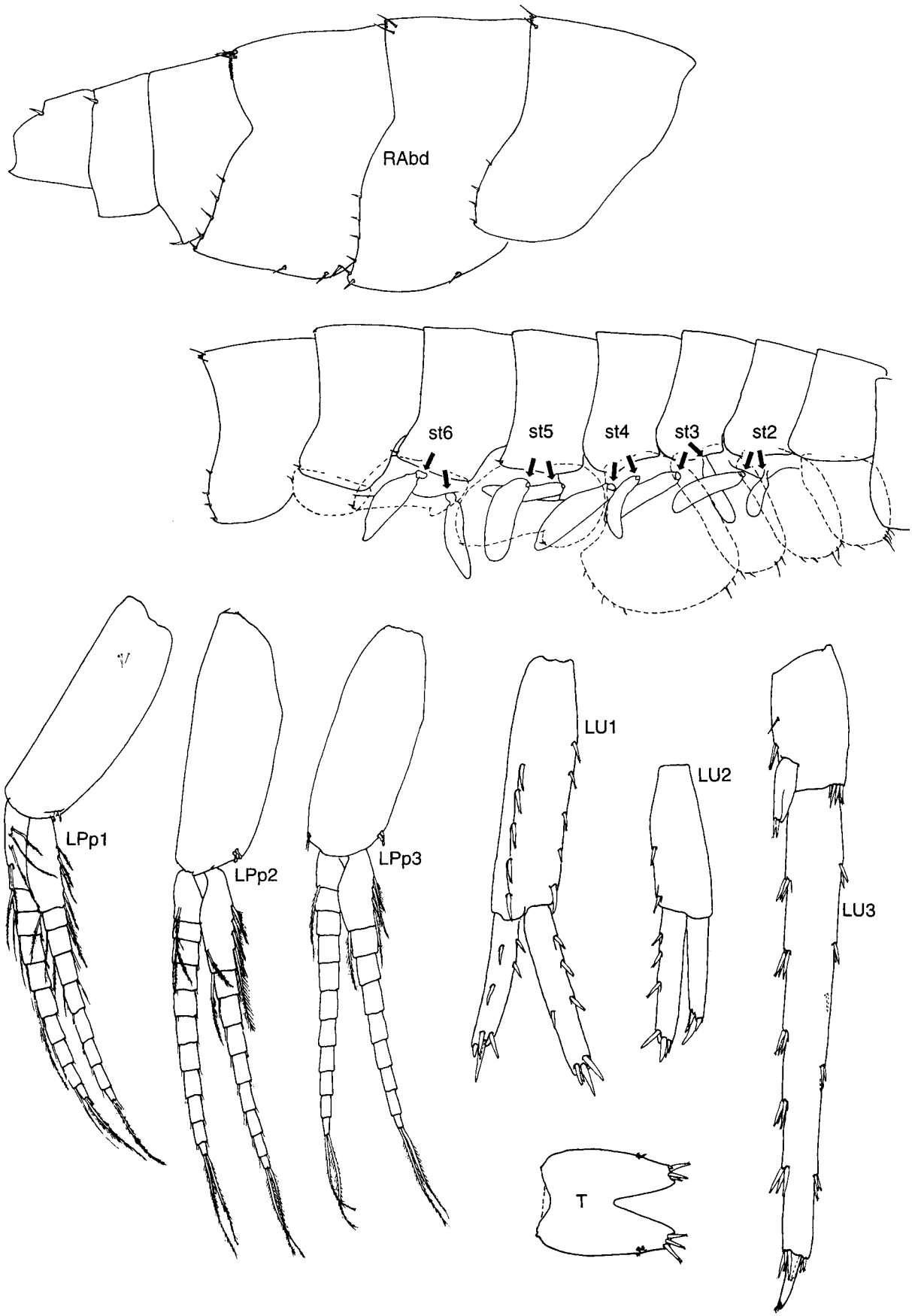

Fig. 32. *Wombeyanus botulosus* n.sp. holotype male "x" 7.5 mm; abdomen, gills, pleopods, uropods, telson.

article of the inner rami of each bearing terminally bifid basomedial setae and an additional ordinary plumose seta, rami of 9-9, 11-9, 11-9 lateral and medial articles respectively. *Uropods* (Fig. 32): third uropod extending well beyond uropods 1 and 2 in the whole animal; uropod lengths relative to uropod 1; uropod 2 0.65×, uropod 3 1.5×; first uropod peduncle length 1.4× medial and 1.8× lateral rami, the lateral margin without an apicodistal robust seta, with a row of five dorsal robust setae, the medial margin bearing five robust setae, rami of unequal length, both with two rows of short marginal robust setae, and four apical robust setae; second uropod peduncle approximately the same length as the medial ramus, with two short dorsolateral robust setae including the apical robust seta, outer ramus slightly shorter than the inner, only the medial ramus with three mediolateral robust setae, both rami with four terminal robust setae; third uropod peduncle as long as urosomite three, 0.5× the length of the outer ramus, bearing one facial and two distomedial robust setae and a distolateral row of five robust setae, the outer ramus of two articles, proximal article with transverse rows of robust setae arranged laterally 2-2-1-3-3 and medially 3-3-3-3-3, without setae, and lateral and medial groups of three terminal robust setae, the distal article short, approximately 0.12× proximal, three fine apical setules, the inner ramus short, 0.27× outer, with two simple apical setae only. *Telson* (Fig. 32): moderate length, approximately equal to the length of the peduncle of the third uropod, length 1.25× width; cleft 46%; apices with three short robust setae in a row, no other robust setae, and a pair of penicillate setules dorsolaterally at M0.75.

Description of allotype (female "y"). *Body*: length 7.5 mm. *First antenna*: peduncle ratio of lengths 10:9:6; primary flagellum of 23 articles, aesthetascs present on articles 4–20. *Second antenna*: peduncle articles 3–5 sparsely setulate, lengths of articles 4 and 5 equal; flagellum of eight articles. *Left mandible*: incisor with four teeth; lacinia mobilis four teeth, and a group of basofacial setae; accessory blades of thee chisel robust setae and three plumose setae; two bent brushy setae onto the base of the molar; molar triturative with a moderate posterior pappose seta; palp of three articles, ratio of lengths 8:20:21, article 2 with two medial setae, article 3 with setae 2B3C14D3E. *Right mandible*: incisor with four teeth; lacinia mobilis bifid and facially setose; accessory blades of two rakers and two plumose setae; three bent brushy setae onto the base of the molar; molar triturative, with a long posterior pappose seta; palp ratio of lengths of articles 8:22:23, second article with two medial setae, third article with setae 2B3C14D3E. *Left first maxilla*: palp with three slender apical robust setae, one with setules, two mediodistal and one apicofacial robust setae and two distofacial setae; outer plate with nine denticulate robust setae; inner plate with two apical plumose setae. *Right first maxilla*: palp with one stout setulate apical robust seta, an oblique distal row of five stout articulated robust setae, and a single apico facial slender seta. *First gnathopod* (Fig. 30): coxa with few apical setae; articles 2–4 with small posterior rugose lobes; carpus short with strong posterior rugose lobe; propodus trapezoidal, longer than wide, with small rugose posterior lobe, the rugosities extending to the corner robust setae; palmar corner with two small medial and two lateral robust setae, palm slightly oblique, straight, with few simple robust setae; dactyl with three accessory spinules on the inner margin and stiff spinules at the inner nail articulation. *Second gnathopod* (Fig. 30): coxa with few apical setae, bearing sac like gill and simple oostegite; articles 3 and 4 with small posterior rugose lobes; carpus with strong posterior rugose lobe; propodus with moderate posterior rugose lobe, palmar corner with two medial and three lateral robust setae, palm slightly convex and oblique, with moderate numbers of simple robust setae, dactylus with three accessory spinules on the inner margin and two stiff spinules at the inner nail articulation, and reaching the palmar corner robust setae. *Peraeopods*: peraeopod 3 similar to male, with few apical coxal setae, coxa bearing a broad oostegite; peraeopod 4 about the same length as three, coxa deeply emarginate, bearing a broad oostegite. *Pleopods*: peduncle of first ploepod naked, lateral ramus with 11 articles, inner with eight; second pleopod rami with ten and nine articles respectively; peduncle of third pleopod with two mid medial and two distolateral setae, rami of ten and eight articles respectively. *Uropods*: first uropod peduncle with three dorsomedial setae including the apical seta and four dorsolateral and one apicolateral setae, the outer ramus with two basomedial and two lateral robust setae, the inner with three medial and one lateral robust setae, each with four apical robust setae; second uropod peduncle with two dorsolateral and one apicolateral robust setae, and one dorsomedial and one apicomedial robust setae, each with four apical robust setae; third uropod parviramous, peduncle with three latero- and two mediodistal robust setae and four setae basal to the inner ramus; inner ramus short with only a single apical robust seta; outer ramus proximal article with transverse lateral robust seta groups 2-2-2-2-3 and three distolateral robust setae, the medial margin with 2-3-2-2-2-2 and five distomedial robust setae, distal article with a pair of small apical spinules, ratio of lengths of articles; peduncle 20, outer ramus proximal article 62, distal 8, inner ramus 10. *Telson*: similar to male, both lobes with two rather than three apical robust setae; lateral penicillate setules at M0.6.

Distribution. Bullio Cave, cave 2W2, Wombeyan Cave system, New South Wales, 34°19'S 149°59'E.

Jasptorus n.gen.

Etymology. Named for the type locality and the lumpy sternal gills; *torus* (Latin) protuberance or bulge.

Type species. *Jasptorus solepti* n.sp.

Diagnosis. Eyes absent; the first antenna long, peduncle article 1 subequal with article 2, calceoli present on peduncle and flagellum; second antenna peduncle longer than flagellum, calceoli present on flagellum. Second article of mandibular palp relatively short and poorly setose, setae of the third article BCDE. Inner plate of the first maxilla with two apical plumose setae, outer plate with nine robust setae, distal robust setae of the right palp articulated not fused. Coxae 1–4 sparsely setose ventrally; robust setae at the corner of the palm of both gnathopods 4 or more, palmar robust setae not crowded or bifid; dactyls of peraeopods without additional facial setules; coxal gill 7 absent, sternal gills on segments 2–6, and lumpy, not fully dendritic. Epimera without postventral teeth or facial robust setae or setae near the ventral margin. First uropod without an elongate robust seta at the apicomedial corner; both rami of first and second uropods with one robust seta row each, the third uropod strongly extended and without plumose setae. Telson of moderate length, cleft about 56%, the lobes moderately tumid, with only apical spination.

Additional description. Accessory blades (rakers) on mandibles with interraker plumose setae; additional penicillate setae

beyond rakers and riding onto base of molar, with ragged bent molarial setae and pappose seta. Lower lip uniform, inner lobes absent. Both plates of maxilla two with long apical setae; inner plate of maxilla one and outer plate of maxilla two covered with pubescence. Maxillipedal inner plate with a distal row of few plumose setae and two blunt naked robust setae, a medial basofacial to mid-facial row of five plumose setae and a pair of blunt naked tooth like robust setae; palp articles 2 and 3 naked laterally, well setose medially, article 3 with two pairs of non-comb robust setae near the base of the dactyl, the apex produced and rugose, the dactyl rugose. Dactyls of gnathopods without recumbent inner tooth like robust seta, with stiff spinules at the inner nail articulation, with additional spinules along the inner dactylar margin. Pleopods similar; peduncles bearing few setae, rami extending equally. Ventrodistal robust seta on urosomite one at the base of uropod 1 moderate to long.

Relationship. This genus bears lumpy sternal gills, a characteristic of *Wesniphargus* and is closest to that genus among the family. However, *Jasptorus* differs from *Wesniphargus* in: absence of eyes; shorter first peduncular article of the first antenna; sparse rather than moderate setation of the second article of the mandibular palp; asymmetry of the palp of the first maxillae; coxa 1 tapers apically, and the third coxa ovate rather than sub rectangular; propodi of gnathopods expanded apically, bearing posterior rugosities; palmar robust setae lacking triggers; second articles of peraeopods 5–7 moderately or weakly expanded posteriorly; third uropod distinctly parviramous, the outer ramus strongly extended and without medial plumose setae; telson cleft 56% rather than 85% and basally tumid. *Jasptorus* differs from *Tasniphargus* in the absence of eyes and of long dense setae and elongate basal flagellar articles on the first antenna, the presence of calceoli (on both antennae), presence of B and absence of A setae on the third article of the mandibular palp, nine rather than seven robust setae on the outer plate of the first maxilla; absence of triggers on palmar robust setae; coxal gill 6 not significantly reduced, sternal gills not dendritic; epimera without post-ventral teeth; clear asymmetry of rami of uropods 1 and 2; telson slightly tumid laterally. *Jasptorus* differs from *Neoniphargus* in the absence of eyes; sternal gills not dendritic; inner plate of first maxilla not ovate; dactyl of maxillipedal palp rugose as well as apex; palmar robust setae without triggers; corner robust setae of palms four or more rather than six or more; peraeopods elongate and slender; distodorsal robust setae of peduncles of uropods 1 and 2 sub apical; rami of uropods asymmetric, with few marginal robust setae; lobes of telson tumid basally. *Jasptorus* differs from *Yulia* in the absence of eyes; lack of long dense antennal setae; first antenna flagellar articles equal, not fused; C setae present on mandibular palp; inner plate of first maxilla with two rather than four apical setae; coxae poorly setose ventrally; robust setae of palmar corners four rather than eight; palmar robust setae not dense, bifid or with triggers; coxa 7 without gill; sternal gills lumpy rather than dendritic; peduncles of pleopods with no or very few setae; rami of uropods 1 and 2 unequal; third uropod strongly extended; telson moderately tumid.

Jasptorus solepti n.sp.

Figs 33–35

Etymology. Named for the slender form of the body: *soma* body, *leptos* thin.

Type locality. Cave WJ-10, Wee Jasper, New South Wales, 35°07'S 148°41'E.

Material examined. HOLOTYPE (Australian Museum P51372) male "a" 6.5 mm, other specimen in type series; male "b" 5 mm.

Diagnosis. As in the genus.

Description of holotype (male "a"). *Body* (Fig. 33): pleon with few dorsal arms, pleonites 1–4 with few setae, 5 and 6 with one dorsolateral robust seta each, length 6.5 mm. *Head*: rostrum small, eyes absent, lateral cephalic lobes prominent, antennal sinus moderate. *First antenna* (Fig. 33): length 0.8× body, 2.2× the second antenna, the peduncle shorter than the flagellum—64:151—with sparse setae; ratio of lengths of peduncular articles 10:9:6; flagellum of 25 uniform (excepting article 3 which is short), sparsely setulate articles; calceoli present on peduncle article 3 and flagellum articles 1, 2, 6, 8, 10, aesthetascs present on most flagellar articles; accessory flagellum 2-articulate reaching slightly beyond the end of article 1 of the primary flagellum. *Second antenna* (Fig. 33): length 0.36× body; peduncle 1.2× the flagellum, articles 4 and 5 subequal—22:23—and articles 3–5 with moderate ventral setation; flagellum of eight articles, weakly setose ventrally, calceoli present on articles 1–5. *Left mandible* (Fig. 33): palp relative lengths of articles 8:17:21; article 3 longer than 2, weakly falcate, with 1B3C21D5E setae, the second article bearing three inner marginal setae; incisor with four teeth and fine facial setae; lacinia mobilis with two weak teeth and an area of fine basofacial setae; accessory blades of three chisel robust setae and four plumose interraker setae; molar triturative with a long posterior pappose seta. *Right mandible* (Fig. 33): palp relative lengths of articles 8:23:27; third article longer than the second with 1B5C20D4E setae; incisor with four teeth; lacinia mobilis bifid, the anterior arm denticulate, the posterior with three teeth and an area of fine facial setules; two accessory blades (rakers), two plumose inter rakers, and three plumose and three hooked brushy setae onto the base of the molar; molar triturative without a posterior pappose seta. *Maxillae* (Fig. 33). Left first maxilla: palp article 2 with four submarginal mediodistal slender robust setae—three terminally armed and one naked—two armed and one naked distofacial robust setae and one distolateral plumose seta; outer plate with nine denticulate terminal robust setae and two short, slender, naked setae at the medio distal corner; inner plate with two apical plumose setae and one small naked medio distal seta. Right first maxilla: palp article 2 with five thick mediodistal to apical robust setae articulated to the segment, one apicolateral thin robust seta and one apicolateral rastellate seta; inner plate with two plumose apical setae. Second maxilla: outer plate with a small distolateral spinule; inner plate with two mediodistal (almost medial) plumose setae. *Maxilliped* (Fig. 33): palp article 3 with a row of thin setae on the inner margin, outer apex with three slender setae, apex face with two pairs of slender setae, dactyl with two medial and two sub terminal robust setae adjacent the nail, the apex strongly produced and rugose, as is the dactylar face; inner plate with two thick tooth like apical robust setae,

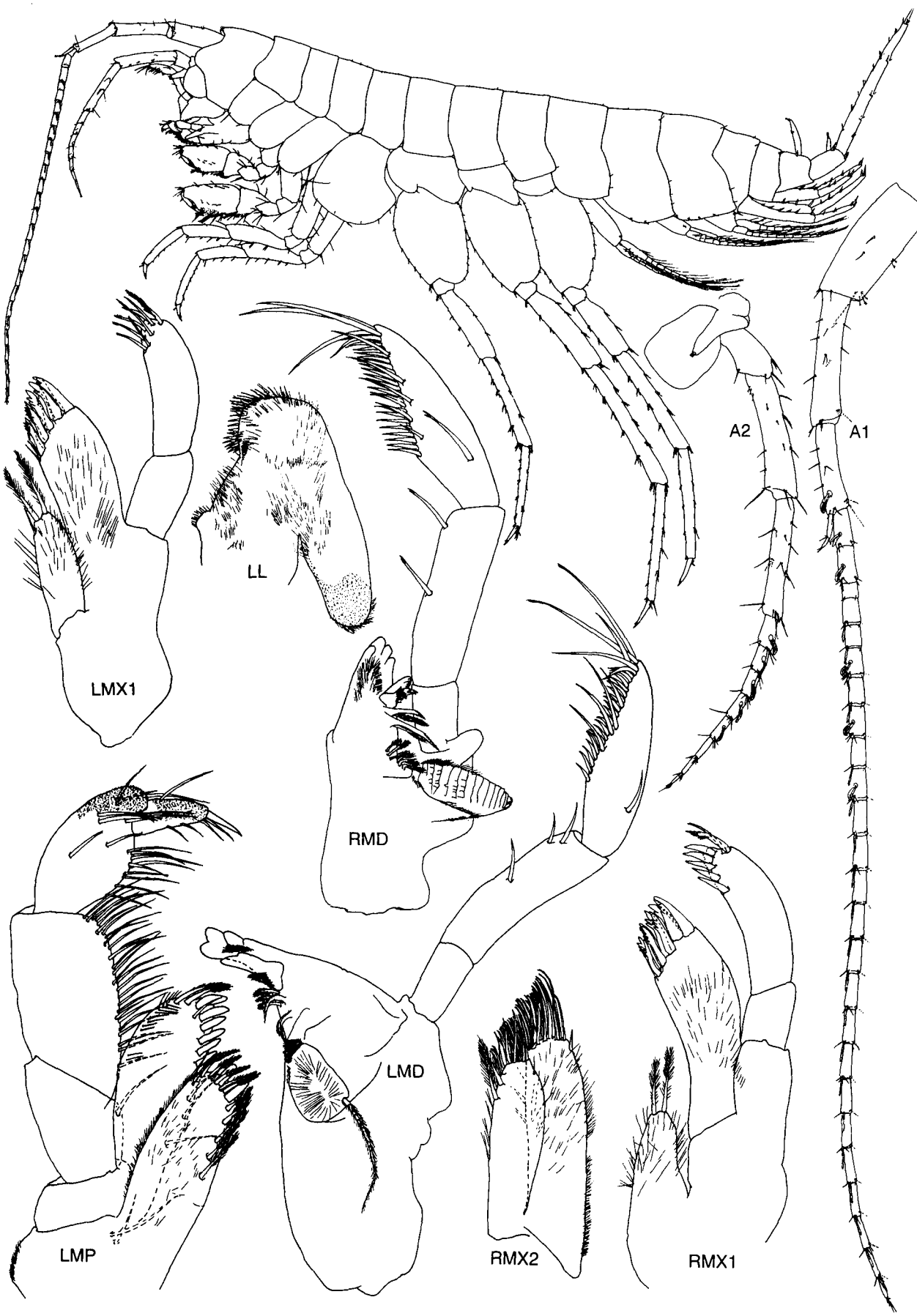

Fig. 33. *Jasptorus solepti* n.sp. holotype male "a" 6.5 mm; whole, antennae, mouthparts.

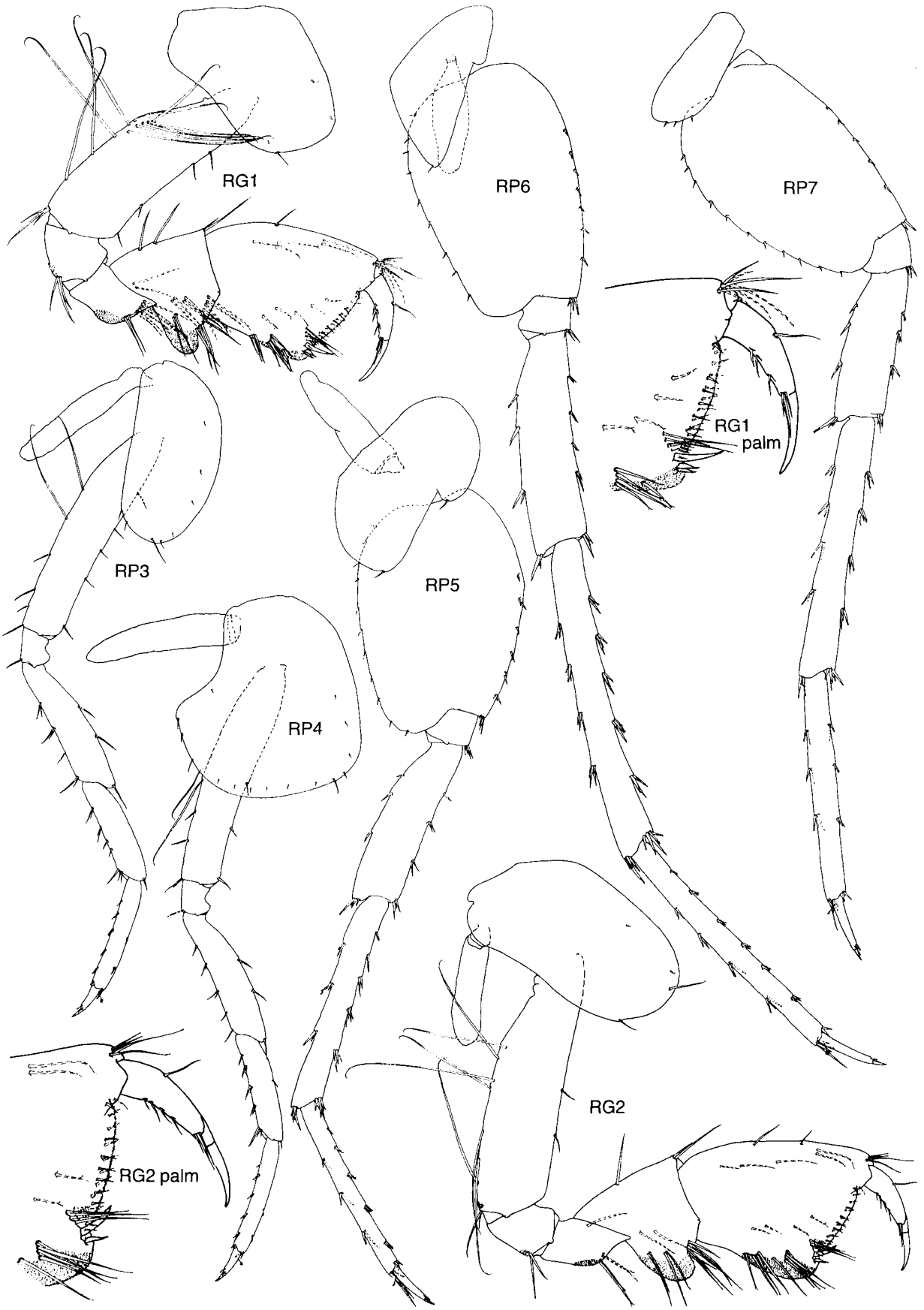

Fig. 34. *Jasptorus solepti* n.sp. holotype male "a" 6.5 mm; legs.

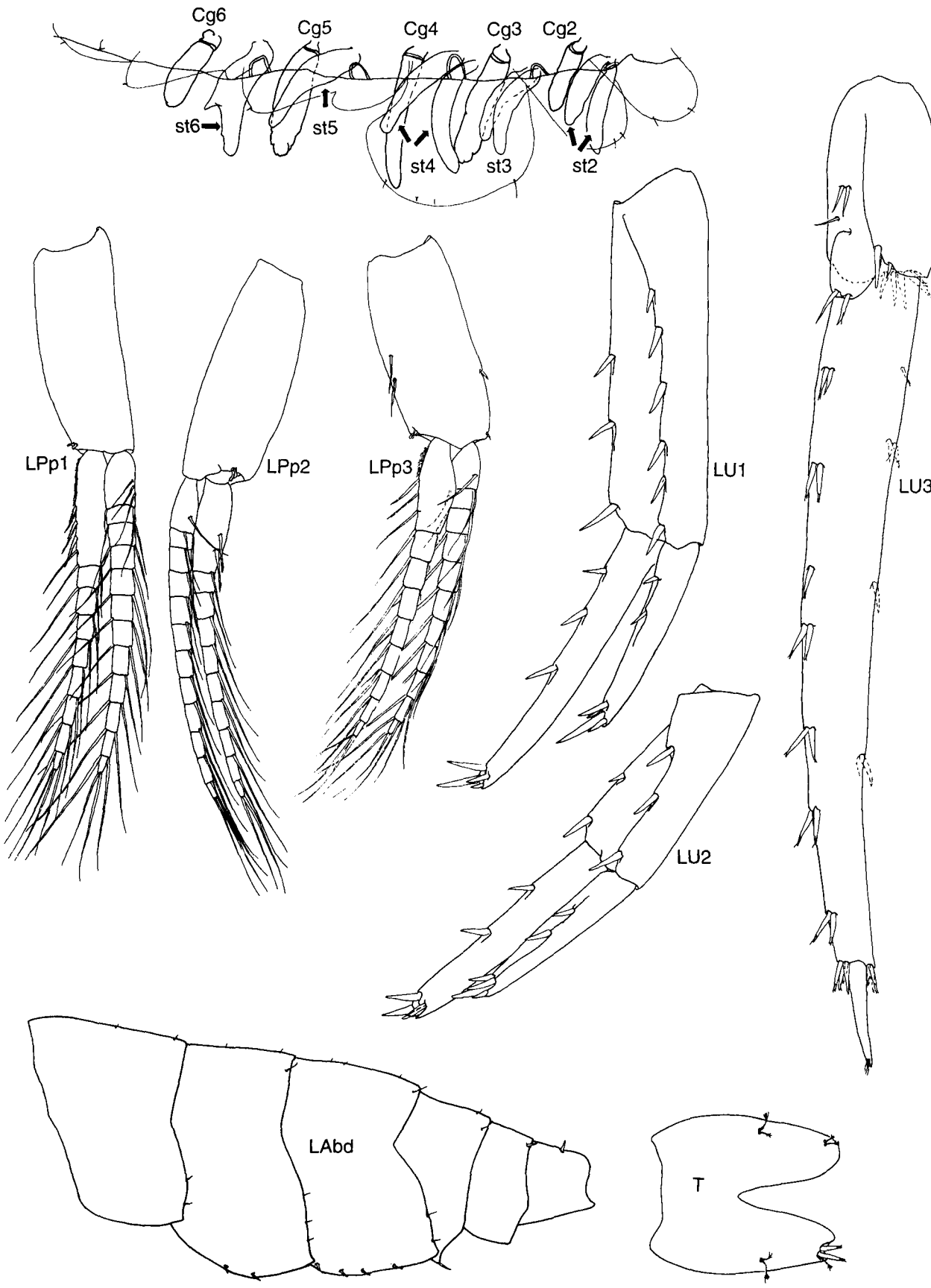

Fig. 35. *Jasptorus solepti* n.sp. holotype male "a" 6.5 mm; abdomen, gills, pleopods, uropods, telson.

several plumose and simple setae, and a row of medial submarginal plumose setae; outer plate with five basomedial slender setae, a row of naked tooth like robust setae medial sub marginal to mid distofacial, two distal plumose setae and a lateral sub marginal row of fine simple setae; peduncle bearing a pair of ventrofacial long setae basal to the inner plate. *First gnathopod* (Fig. 34): coxal plate with a single post-ventral seta only; article 3 with a small posterior rugose hump; article 4 with a moderate rugose hump; carpus short, strongly lobate and rugose, the lobe rounded and without setae; propodus trapezoidal, slightly longer than wide, posterior angle rounded, anteriorly prominent and rugose, the palmar corner marked by one medial and a long and two short lateral robust setae without bifurcations or triggers, the palm slightly oblique and convex, dactylus reaching to the corner robust setae, robust setae along the palm simple, not crowded. *Second gnathopod* (Fig. 34): slightly larger than the first, coxa bearing two apical setae, and a sac like gill; rugose carpal lobe larger than the first; rugose lobes of articles 2–4 smaller; posterior rugose lobe of the propodus more expanded than on the first gnathopod, the palmar corner marked by long and short lateral and medial robust setae, dactylus not reaching the palmar corner; the palm lined with simple setae. *Peraeopods* (Fig. 34): coxa 3 with few short and long apical setae; coxa 4 deeply emarginate with three anteroventral setae, one ventrofacial posterior seta, and several facial setules; peraeopods 3 and 4 subequal, longer than the second gnathopod, articles 4 and 5 posteriorly spinose, articles 6 with 2-2-2-2-2 and 1-2-2-2-2 robust setae respectively; peraeopods 5–7 similar, coxae with 1-1-3 robust setae on the ventral margins of the posterior lobes, the second article of each moderately expanded posteriorly (P5>P6>P7), with short sparse marginal setae and a moderate postero ventral lobe, posterior margins of propodi lacking long setae except for basodactylar setae, dactyls without accessory setules apart from the usual one medial and facial setules. *Gills* (Fig. 35): coxae 2–6 bearing simple sac like gills, coxa 7 without gill; sternites 2–6 each with a pair of lumpy, incipiently dendritic gills attached to the anterior lateral edge of each segment. *Epimera* (Fig. 35): without postventral teeth, although each slightly acuminate; posterior margins moderately convex, with 2-3-2 setae; with 0-2-4 ventrofacial robust setae. *Urosomite one* (Fig. 35): with a short robust seta at the base of uropod 1. *Pleon* (Fig. 35): pleonites 1–4 with few dorsal armaments; pleonite 5 with a single posterolateral robust seta, pleonite 6 with one mid dorsal robust seta. *Pleopods* (Fig. 35): similar, each with two retinaculae and no accessory retinaculae; peduncle of pleopod 3 only with two medial and two facial setae; rami with 12-9, 12-10, 11-9 lateral and medial articles. *Uropods* (Fig. 35): third uropod extending well beyond uropods 1 and 2 in the intact specimen; lengths relative to uropod 1—uropod 2 0.64×, uropod 3 1.54×; first uropod peduncle approximately equal to the third urosomite, length 1.9× lateral ramus, 1.2× medial ramus, the outer margin with a single subapical robust seta and a row of five short robust setae, the inner margin with a row of two short robust setae and a single distal robust seta; rami of unequal lengths, medial 1.3× lateral, both with a single row of dorsal robust setae—the lateral ramus with two lateral setae, the medial ramus with three medial setae-and each with four apical robust setae; second uropod peduncle 0.9× inner ramus, 1.2× outer ramus, with three short dorsolateral and two short dorsomedial robust setae, the outer ramus shorter than the inner—27:36—both with only one row of short robust setae—lateral ramus with two lateral robust setae and medial ramus with two medial robust setae, each with four apical robust setae; peduncle of the third uropod 0.26× length of outer ramus, as long as urosomite three, with three mediofacial setae, two mediodistal robust setae basal to the inner ramus, and a distal transverse lateral row of five robust setae; proximal article of the outer ramus with four transverse lateral robust seta rows of 1-2-1-1 robust setae, seven transverse medial rows of 2-2-1-2-2-2-2 robust setae and terminal lateral and medial rows of three and four robust setae basal to the distal article; distal article with three small terminal setules; inner ramus length 0.09× outer, with two apical setae only. *Telson* (Fig. 35): moderate length, equal to urosomite three, the length 1.1× width; cleft 56%; apices with two short setae set in a notch on the left side, no robust setae or notch on the right, but a pair of sub terminal penicillate setules; lobes moderately tumid, with paired dorsolateral penicillate setules at M0.6 on either lobe.

Description of male "b". *Body*: length 5 mm. Similar to male "a", except in the following. *First antenna*: left peduncle third article with mediodistal calceolus; accessory flagellum of two articles, extending to M0.8 of the second article of the primary flagellum; primary flagellum of 21 articles, with aesthetascs on articles 5–21; right primary flagellum of nineteen articles. *Second antenna*: left flagellum of seven articles with calceoli present on articles 1–4; right flagellum of seven articles, with calceoli on articles 3–5. *Mandibles*: both mandibular palp articles 3 with setae 1B3C11D3E. *Pleopods*: left first pleopod rami with four medial and five lateral articles; right first pleopod with seven and eight articles respectively; second pleopod with 7-8 and 9-7 articles respectively; third pleopod with 6-8 and 6-8 articles respectively. *Uropods*: peduncle of first uropod with three dorsolateral and one apicolateral and two dorsomedial and one apicomedial robust setae; outer ramus with one medial and one lateral robust setae; inner ramus with two medial and one lateral robust setae, both rami with four apical robust setae; peduncle of second uropod bearing one dorsolateral and one apicodorsal, tow dorsomedial and one apicomedial robust setae; outer ramus with one each medial and lateral robust setae, inner ramus with two each medial and lateral robust setae. *Epimera*: second epimeron with one rather than two facial robust setae near the ventral margin.

Distribution. Cave WJ10, Wee Jasper, New South Wales, 35°07'S 148°41'E.

Neoniphargus Stebbing, 1899

Neoniphargus Stebbing, 1899: 424.
Unimelita Sayce, 1901: 237–238.

Type species. *Neoniphargus thomsoni* Stebbing, 1899 (= *Niphargus montanus* Thomson, 1893, a homonym).

Relationship. For generic diagnosis, additional description, keys and discussion of relationships see Williams & Barnard (1988: 123–125).

Composition. This genus contains seven species. We here describe a further three species.

Neoniphargus coolemanensis n.sp.

Figs 36–38

Etymology. Named for the type locality.

Type locality. First water trap, Murray Cave (cave CP3), Cooleman Plain, Kosciusko National Park, New South Wales, 35°22'S 149°03'E.

Material examined. HOLOTYPE (Australian Museum P51373) female, 6 mm; collected by S. Eberhard; 20 January, 1994.

Diagnosis (female only): first peduncular article of the first antenna longer than the second; second antenna without calceoli; second article of the mandibular palp longer than the third, and moderately sotose, setae of the third article BCDE; palmar corners of gnathopods without special medial robust setae; fourth coxa deeply emarginate, dactyls of peraeopods 3–7 multispinous medially, articles 4–6 of peraeopods 3–7 moderately setose, with elongate basodactylar setae on legs 5–7, anterior margins of sixth article with 1-4-4 transverse robust seta sets (as well as locking robust setae); coxae 5–7 with 1-1-3 weak robust setae on the posterior lobe. Coxae 2–7 bearing gills, the seventh reduced; lumpy to barely dendritic gills present on sternites 2–6. Epimera without facial armaments, or postventral teeth; third uropod extends slightly beyond uropods 1 and 2 in the whole animal; robust setae of uropods 1 and 2 all short; peduncle of uropod 3 0.6× the length of the outer ramus; robust setae of outer ramus arranged in sets of 2-3-3 lateral, 1-2 medial, with no plumose setae; inner ramus bearing one apical robust seta, and no facial setae. Telson cleft about 60%, each lobe bearing three apical robust setae and a dorsal pair of robust setae.

Description of holotype (female). *Body* (Fig. 36): pleon with few setal dorsal armaments, the urosomite three bearing two pairs of dorsal robust setae, pleonites with few dorsal setae, length 6 mm. *Head*: small, eyes small. *First antenna* (Fig. 36): length 0.5× body, 1.4× the second antenna, peduncle less than the length of the flagellum, ratio of lengths of articles 50:33:23, setae sparse, calceoli and aesthetascs absent; accessory flagellum 2-articulate, extending to M0.2 of the second article of the primary flagellum; primary flagellum of nineteen uniform articles with very sparse setation. *Second antenna*: length 0.3× body, peduncle longer than the flagellum—1.5×, articles 4 and 5 subequal, articles 3–5 with moderate ventral setation, flagellum with nine articles, weakly setose ventrally, calceoli absent. *Left mandible* (Fig. 36): palp of three articles, ratio of lengths of articles 10:32:24, article 2 with ten inner marginal setae, article 3 weakly falcate, with 1B3C11D5E setae; incisor with five teeth; lacinia mobilis with three teeth; accessory blades of three chisel robust setae, three plumose robust setae; molar triturative, bearing a single brushy anterior seta and short posterior pappose seta. *Right mandible* (Fig. 36): palp article 2 with 12 medial setae, article 3 with 2B2C10D5E setae; incisor with five teeth; lacinia mobilis bifid and denticulate; two accessory blades and two inter-raker plumose setae; molar bearing long posterior pappose seta. *Maxillae* (Fig. 36). First maxillae: second article of the palp of the left first maxilla with six thin apical robust setae and two sub terminal facial setae; outer plate with nine robust setae, most denticulate; inner plate with two plumose apical setae; right first maxilla palp article 2 with four thick apicomedial robust setae articulated to the segment, one apicolateral thin robust seta and three thin ventro facial robust setae; outer plate with ten apical denticulate robust setae; inner plate with two plumose apical setae. Second maxilla: both plates with curved apical setae; inner plate with two medial sub apical plumose setae; outer plate with two subdistal naked lateral setae. *Maxilliped* (Fig. 36): palp articles 2 and 3 with ranks of setae on the inner margin and sub marginal face, and a few distolateral setae, apex of article 3 strongly produced and bearing rugosities, dactyl with four accessory spinules on the inner margin, and distofacially rugose; inner plate apex with three thick tooth like robust setae, two plumose setae and a naked seta, a submarginal medial row of five plumose setae, but no ventrofacial robust seta; outer plate with a medial oblique row of moderate to long naked robust setae distofacially, a row of six faciomedial to distomedial naked tooth like robust setae, apically a naked tooth like robust seta and armed tooth like robust seta, two raker setae and one plumose seta, and three slender disto lateral setae. *First gnathopod* (Fig. 37): coxal plate tapering apically, with an apical rows of moderate length setae; articles 2 and 3 each bearing a small rugose posterior lobe; articles 4–6 with strong rugose lobes; carpus shorter than propodus, posterior lobe well developed, rugose, rounded and not setose apically; propodus trapezoidal, slightly longer than wide, bearing paired posterior rugose lobes, corner of the palm with three short medial robust setae and two strong, armed lateral robust setae; palm transverse, slightly convex, with moderate numbers of non-bifid robust setae, dactylus reaching the palmar corner robust setae. *Second gnathopod* (Fig. 37): larger than the first; coxa sparsely setose apically bearing a sack like gill and a broad, naked oostegite; carpal lobe longer and more keel like than the first; propodus with a distinct pair of rugose lobes larger than in the first, palmar corner with three short medial and two long lateral robust setae, dactylus reaching the palmar corner robust setae, palm transverse, slightly convex, bearing moderate numbers of simple robust setae. *Peraeopods* (Fig. 37): coxa 3 with an apical sparse row of moderate length setae; coxa 4 deeply emarginate with three anteroventral setae and four posterior setae; peraeopods 3 and 4 longer than the second gnathopod, subequal in length, articles 4 and 5 spinose posteriorly, articles 6 with robust seta formula 1-1-2-2-3 and 1-1-3-2-3, respectively; peraeopods 5–7 similar, coxae bearing 1-1-3 weak robust setae on the posterior lobe, articles 2 expanded posteriorly (P5<P6<P7), and slightly to moderately lobate postventrally, with short and moderately slender posterior setae, propodus of leg five naked posteriorly, of 6 and 7 with sparse short and long setae, long setae present at the bases of the dactyls of peraeopods 6 and 7; dactyls three to seven each with several accessory setules (2-3-1-4-3) on the inner margin; coxae 2–5 each bearing an oostegite. *Gills* (Fig. 38): coxae 2–7 each with a simple sac

Fig. 36. *Neoniphargus coolemanensis* n.sp. holotype female 6 mm; whole, antenna, mouthparts.

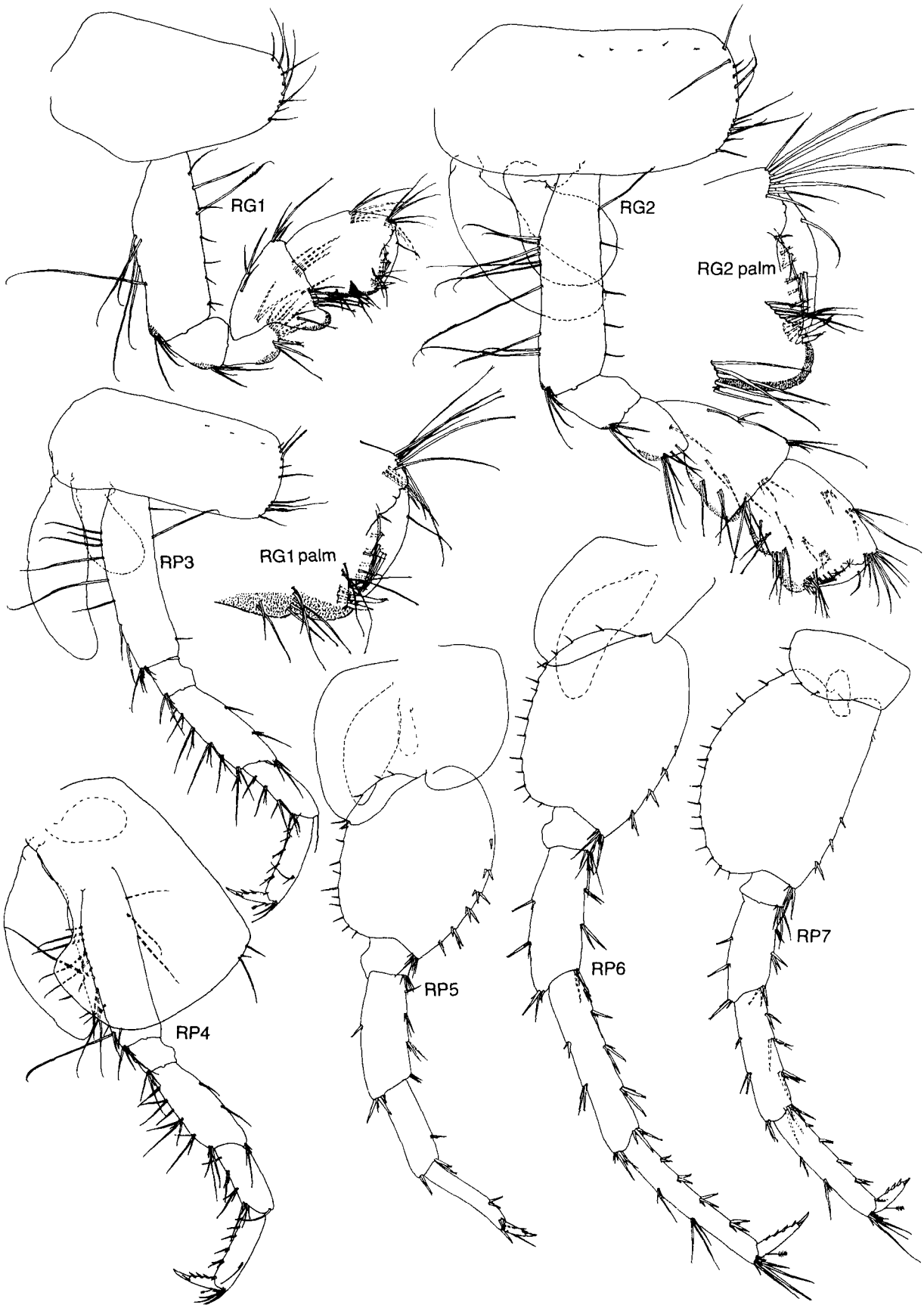

Fig. 37. *Neoniphargus coolemanensis* n.sp. holotype female 6 mm; legs.

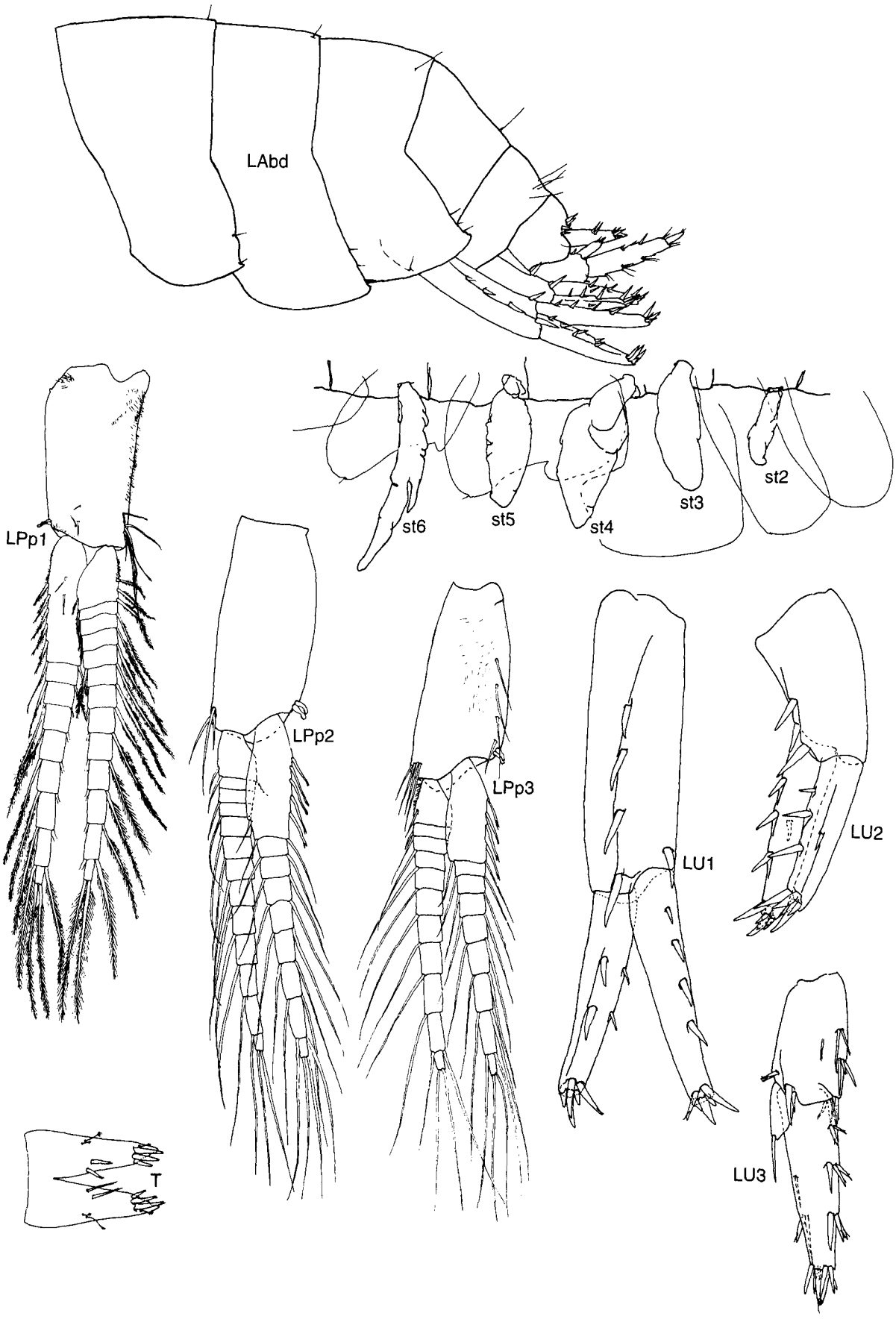

Fig. 38. *Neoniphargus coolemanensis* n.sp. holotype female 6 mm; abdomen, gills, pleopods, uropods, telson.

like gill, that of coxa 7 reduced; sternites 2–6 bearing budded or partially dendritic gills attached on the anterior lateral edge of each. *Epimera* (Fig. 38): without postventral teeth, the posterior margins slightly convex on E1, straight on E2 and concave on E3; all without ventral robust setae; posterior setae sparse—2-3-3. *Pleon* (Fig. 38): pleonites 1–5 with few dorsal setae or robust setae; pleonite 6 bearing a pair of dorsal and a pair of dorsolateral robust setae basal to the telson. *Pleopods* (Fig. 38): with two retinacula each, no accessory retinacula, the peduncles each with several setae; rami of nine medial articles each and 13-13-11 lateral articles respectively. *Uropods* (Fig. 38): third uropod extending slightly beyond the first and second in the whole animal, uropod lengths relative to the first—uropod 2 0.7×, uropod 3 0.6×. First uropod: peduncle length 1.2× the medial ramus, 1.5× lateral ramus, outer margin with one apicodistal robust seta and a row of short dorsal robust setae, medial margin with a single apicodistal robust seta; rami of unequal lengths, lateral ramus shorter and bearing two reduced rows of marginal robust setae the inner row short; and five apical robust setae; medial ramus with only a medial row of four robust setae, and four apical robust setae. Second uropod: peduncle approximately the same length as the rami, with three moderate length to long dorsolateral robust setae (including one apical robust seta); outer ramus slightly shorter than the inner, each with two rows of short marginal robust setae, apices with four and five robust setae respectively. Third uropod: parviramous, peduncle length approximately 0.5× outer ramus, as long as urosomite three, bearing two pairs of medial and two groups of dorsal robust setae, as well as a distal row of five robust setae basal to the outer article; outer ramus proximal article with three lateral transverse robust seta rows of 2-3-3 robust setae and an apical group of three robust setae, as well as two medial rows of 1–2 robust setae and a terminal group of three robust setae; distal article with a single small terminal setule; inner ramus short, 0.27× length of outer ramus, with a single moderately long terminal robust seta. *Telson* (Fig. 38): short, approximately the same length as urosomite three, length 1.4× width; cleft 77%; apices of each lobe with three sub distal robust setae and a single lateral penicillate setule, two dorsal robust setae medially at M0.4 to M0.5, and a submarginal lateral pair of penicillate setae at M0.4; lobes not tumid.

Relationship. This species differs from others of the genus in: ratio of lengths of peduncular articles of the first antenna 10:6.5:5.4, cf. 10:8:5 to 10:11:6, the second article being reduced; length of the first article of mandibular palp reduced, relative lengths being 8:39:30 cf. 8:25:23 to 8:20:24; robust setae at the palmar corner 5 or 6, rather than 6+; robust setae along the palm are not dense; dactyls of peraeopods are multi-spinous, but differ from *Neoniphargus spenceri*; robust setae of the inner rami of first and second uropods are reduced to one row; telson cleft 80% rather than 60%; lateral penicillate setules of the telson are at about M0.5 rather than M0.6; plumose setae are absent between rakers and base of the molar. This species keys to *N. spenceri* in Williams & Barnard (1988), but differs in: the small size of eyes; shorter first antenna; longer accessory flagellum; longer second antenna; mandibular palp second article more setose medially, third article with fewer BC setae and more E setae; second article of first maxilla with nine or ten robust setae, rather than seven; inner plate of maxilliped with three rather than two apical robust setae, but fewer plumose setae; first gnathopod coxa moderately setose apically, the fourth article with a moderate posterior rugose hump, articles 2 and 3 also with posterior rugosities and small hump, carpus moderately long, almost as long as propodus, propodus with fewer lateral corner robust setae, the palm slightly convex; peraeopods generally less spinous, dactyls bearing 2-3-1-4-3 accessory spinules; sternal gills are not fully dendritic; epimera without postventral teeth; uropod 3 not as strongly extended; telson longer than wide, cleft 77% rather than 56%, fewer dorsal robust setae, lateral penicillate setules more basal. This species differs from *N. secus* in: possessing eyes; the body more robust, and coxal plates longer; accessory flagellum is longer than the first article of the primary flagellum; flagellum of the second antenna is of nine rather than seven articles; the second article of the mandibular palp is more setose medially; coxae 1–3 are moderately setose distally; carpus of the second gnathopod relatively long; dactyls of peraeopods multispinous; coxa 7 bears a small gill; sternal gills are less dendritic; third uropod is only slightly extended beyond uropods 1 and 2; telson is more slender and more deeply cleft and bearing additional dorsal robust setae, the penicillate setules more basal. *Neoniphargus coolemanensis* differs from *N. richardi* in: possessing eyes; the body is less slender; coxal plates larger; flagellum of second antenna longer; second article of mandibular palp bearing more setae; mandibular palp more spinous, the inner plate less pubescent; carpus of second gnathopod relatively longer; dactyls of peraeopods multispinous; coxa 7 with a small gill; sternal gills less dendritic; third uropod shorter; telson slender and not tumid, with dorsal robust setae as well as more apical robust setae.

Distribution. Murray Cave (cave CP3), Cooleman Plain, Kosciusko National Park, New South Wales, 35°22'S 149°03'E.

Neoniphargus secus n.sp.

Figs 39–41

Etymology. From *secus* (Latin); otherwise or different.

Type locality. Gurangah Cave, cave 321, Wombeyan Cave system, New South Wales, 34°19'S 149°59'E.

Material examined. HOLOTYPE (Australian Museum P51374) female "a" 8 mm, PARATYPE (Australian Museum P51375) female "b" 5 mm, three other small females in the type series; collected by S. Eberhard; 17 March, 1993.

Diagnosis. Article 1 of the peduncle of first antenna slightly longer than article 2, calceoli absent from both antennae, mandibular palp article 2 longer than article 3 with very few setae (3R2L ventral, 1L1R dorsal), BCDE setae present on article 3. The fourth coxa moderately emarginate, dactyls of legs three to seven with only one medial and one facial spinules, legs 5–7 , articles 4–6 without slender setae except for a few short basodactylar setae, and articles 6 anterior margins with one, five and four robust seta sets respectively, coxae 5–7 with 3-1-2 weak robust setae on the posterior lobe.

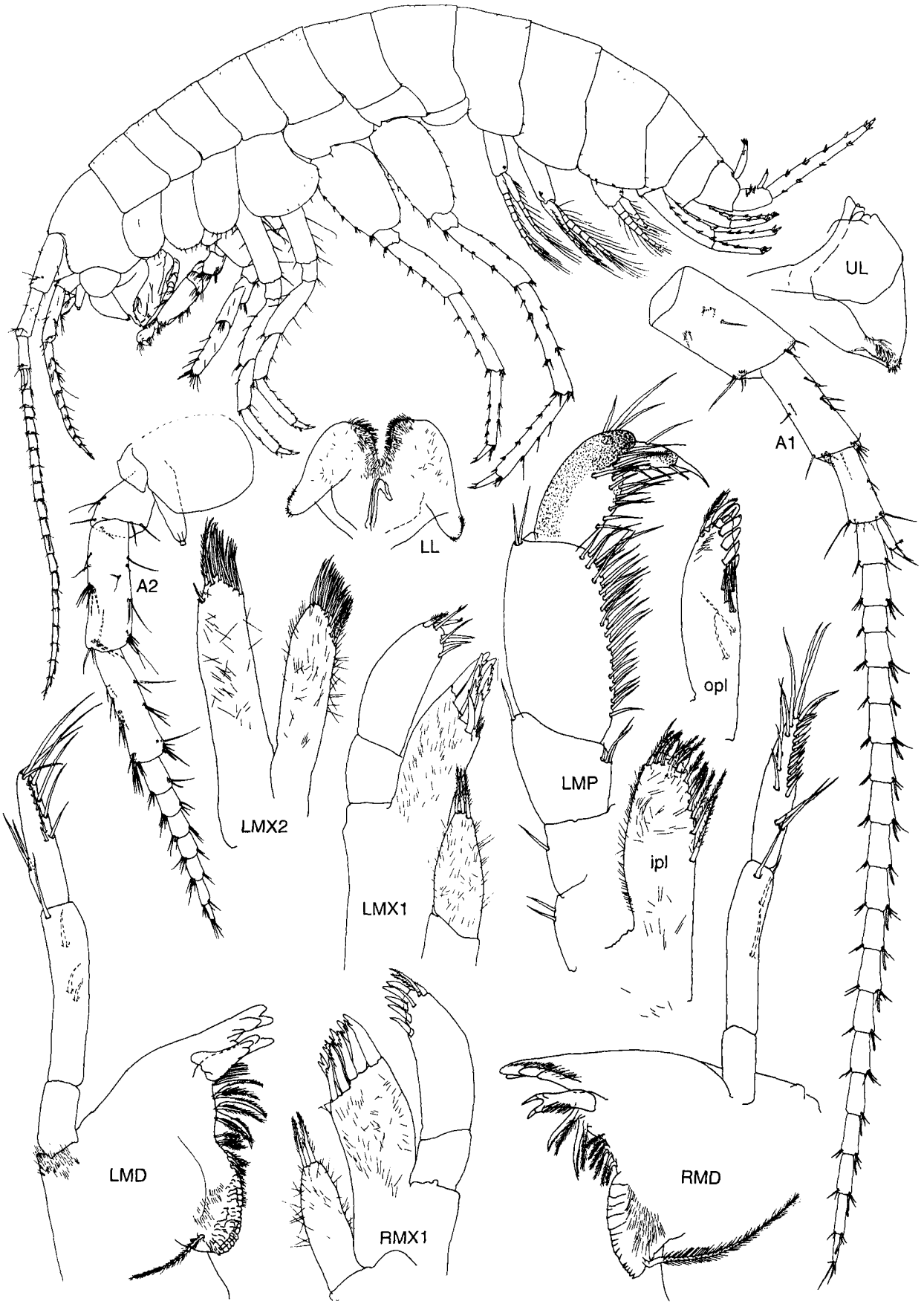

Fig. 39. *Neoniphargus secus* n.sp. holotype female "a" 8 mm; whole, antennae, mouthparts.

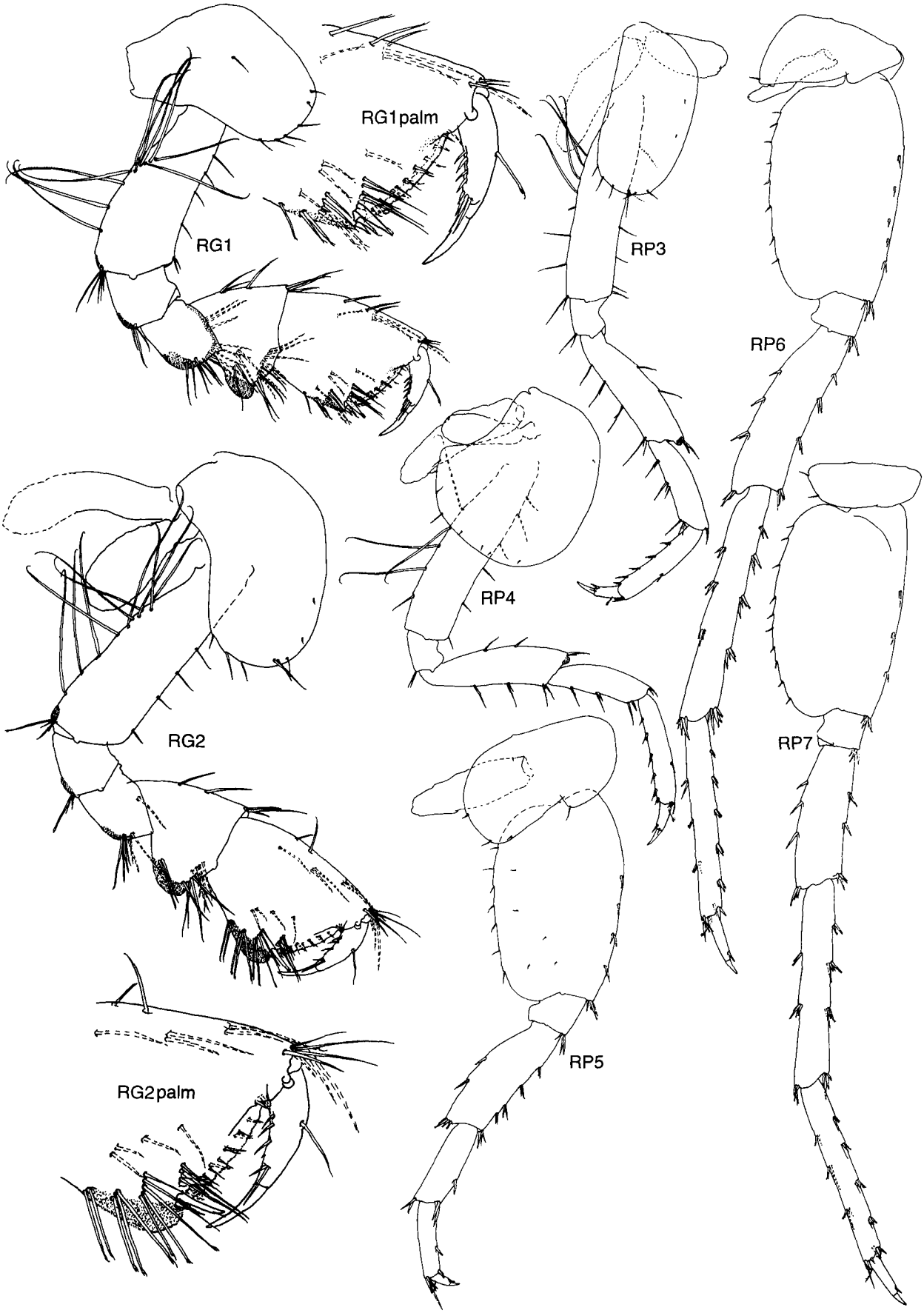

Fig. 40. *Neoniphargus secus* n.sp. holotype female "a" 8 mm; legs.

Gills present on coxae 2–6, and dendritic sternal gills present on sternites 2–6. Epimeron three only bearing ventrofacial robust setae. Uropod 3 extends well beyond uropods 1 and 2 in the intact specimen, all robust setae of uropods 1 and 2 short, the peduncle of uropod 3 0.3× the length of the outer ramus, which bears robust setae arranged in rows both laterally (1-2-2-3) and medially (2-3-2-2), without plumose setae; the inner ramus with a single apical robust seta, lacking other arms. The telson cleft 40%, each lobe bearing three sub apical robust setae only.

Description. *Body* (Fig. 39): pleon not armed dorsally, with few setae, pleonites 5 and 6 bearing no dorsal robust setae, length 8 mm. *Head*: rostrum small, eyes absent. *First antenna* (Fig. 39): length 0.5× body, 2.3× the second, flagellum of nineteen articles, peduncle shorter than the flagellum, ratio of lengths 10:8:6, setae sparse, calceoli absent, aesthetascs present on flagellum articles 2–18, flagellar segments uniform, sparsely setulate; accessory flagellum 2-articulate, equal to article 1 of the primary flagellum. *Second antenna* (Fig. 39): length 0.25× body, peduncle 1.7× the flagellum, articles 4 and 5 subequal, articles 3–5 moderately setate ventrally, flagellum 7-articulate, weakly setulose, without calceoli, but bearing small aesthetascs on flagellar articles 2–6. *Left mandible* (Fig. 39): palp article 3 shorter than article 2, weakly falcate, almost linear, bearing 2B3C9D4E setae, article 2 with two medial and one lateral setae; incisor with five teeth; lacinia mobilis with four teeth; accessory blades of three chisel robust setae with four interraker plumose setae plus five additional plumose setae beyond the rakers onto the base of the molar; molar bearing moderate posterior pappose seta without brushy basal setae. *Right mandible* (Fig. 39): palp with 2B4C12D5E setae; incisor with five teeth; lacinia mobilis bifid and denticulate; accessory blades of two chisel robust setae and two plumose robust setae plus six additional plumose setae onto the base of the molar; molar bearing a long posterior pappose seta. *Maxillae* (Fig. 39): article 2 of the palp of left first maxilla with four thin apicomedial robust setae, two subterminal facial setae and a stout setulate laterodistal robust seta; outer plate with nine mostly denticulate robust setae; inner plate with three apical plumose setae; palp article 3 of the right first maxilla with a mediodistal row of four stout robust setae, two armed slender facial robust setae and one distolateral stout setulate robust seta; the outer plate bearing nine denticulate robust setae, the inner plate two plumose apical setae; both plates of the second maxilla bearing long curved apical setae, outer plate with a single small disto lateral seta, inner plate with two medio distal plumose setae. *Maxilliped* (Fig. 39): palp article 3 with moderate numbers of setae on the inner face, a row of six setae at the base of the dactyl, the apex strongly produced, the lateral face of the article, apex and inner distal face of the dactyl all rugose, dactyl with three accessory spinules on the inner edge, the nail naked; inner plate apex with two facial and one ventral stout, naked tooth like robust setae, five facial and two ventral plumose setae and one naked seta, the inner margin with a row of seven plumose and one naked setae; outer plate with three mid-medial rows of 2-1-5 long setae, a distofacial row of five stout naked tooth like robust setae, one plumose and two rastellate laterodistal robust setae in a row and a small naked apical seta. *First gnathopod* (Fig. 40): coxal plate with a sparse apical row of short setae; articles 2, 3 and 4 with small posterior rugose lobes; carpus short, with a large rugose posterior lobe rounded and not setose apically; propodus trapezoidal, longer than wide, with a distinct rugose palmar corner bearing three lateral and one medial robust seta, the palm transverse to slightly oblique, moderately convex, palmar robust setae simple and not crowded; dactylus reaching the end of the palm, with several accessory spinules along the inner margin, and stiff spinules near the inner nail articulation. *Second gnathopod* (Fig. 40): larger than the first; coxa bearing few apical setae, a sac like gill and broad oostegite; articles 2–4 bearing small posterior rugose lobes; carpal lobe similar to the first gnathopod; palmar corner expanded by presence of a rugose lobe, corner robust setae being two short medial and four lateral, the dactyl reaching the inner edge of the lobe, bearing small recumbent inner tooth like robust seta at M0.6. *Peraeopods* (Fig. 40): coxa 3 with short sparse apical setae; coxa 4 moderately emarginate, with four anteroventral setae, without posterior setae; peraeopod 3 subequal with four, longer than the second gnathopod, articles 4 and 5 spinose posteriorly, articles 6 with 2-2-2-2 and 1-2-2-2-2 robust setae respectively; peraeopods 5–7 similar—five shortest, six longest; coxae 5–7 bearing 1-1-2 setae on the posterior lobe, the second article of each expanded posteriorly, slightly to moderately post-ventrally lobate with short posterior setules, posterior margins of the propodi lacking long setae except for long subdactylar setae; dactyls of legs three to seven with only a single facial spinule and small medial spinule. *Gills* (Fig. 41): simple sac like gills present on coxae 2–6; dendritic gills present on sternites 2–6, attached to the anterior lateral edge of each. *Epimera* (Fig. 41): 1–3 without postventral teeth, posterior margins slightly convex to straight, each with two small setae, posteroventral margin of the third epimeron with three small robust setae. *Pleon* (Fig. 41): pleonites 1–6 with sparse dorsal setation; pleonite 5 with a single distal dorsolateral robust seta. *Pleopods* (Fig. 41): peduncles each with two retinacula, pleopod 1 with a single accessory robust seta; peduncles without setation except pleopod 3 which bears three basomedial and two distolateral setae; rami with 10-7, 9-7 and 10-8 lateral and medial articles respectively. *Uropods* (Fig. 41): third uropod elongate, extending well beyond uropods 1 and 2 in the intact specimen, uropod lengths relative to uropod 1—uropod 2 0.64×, uropod 3 1.16×; first uropod peduncle length 1.5× outer ramus, outer margin with one apicodistal robust seta and a row of four short dorsal robust setae, the inner margin with three short robust setae and a moderate length apical robust seta; rami unequal in length (inner ramus 1.2× outer), the inner ramus with two weakly represented rows of short setae, the outer ramus a lateral row only, both rami with four apical robust setae; second uropod peduncle approximately the same length as the inner ramus, longer than the outer ramus, with two medial and three laterodorsal robust setae; rami each with two poorly represented rows of short marginal robust setae and four apical robust setae; peduncle of the third uropod as long as the third urosomite, 0.3× the length of the outer ramus, bearing four facial setae, two robust setae basal to the inner ramus and a transverse distolateral row of four robust setae; outer ramus proximal article with transverse lateral and transverse medial rows of 1-2-2-3 and 2-3-2-2 robust setae respectively, each side with distal clusters of three robust setae; distal article small, 0.1× proximal, with small apical setules; inner ramus small, 0.16× outer ramus, naked except for a single apical seta. *Urosomite one* (Fig. 41): at the base of uropod 1 bearing a small articulated robust seta. *Telson* (Fig. 41): short, 1.2× as long as broad; cleft 40%; subapices of each lobe bearing three short robust setae, the right lobe with a small additional seta distolaterally; a pair of dorsolateral penicillate setules at M0.6 on either lobe.

Female "b" 5.5 mm and two other small females. Essentially as for female "a", with minor differences only.

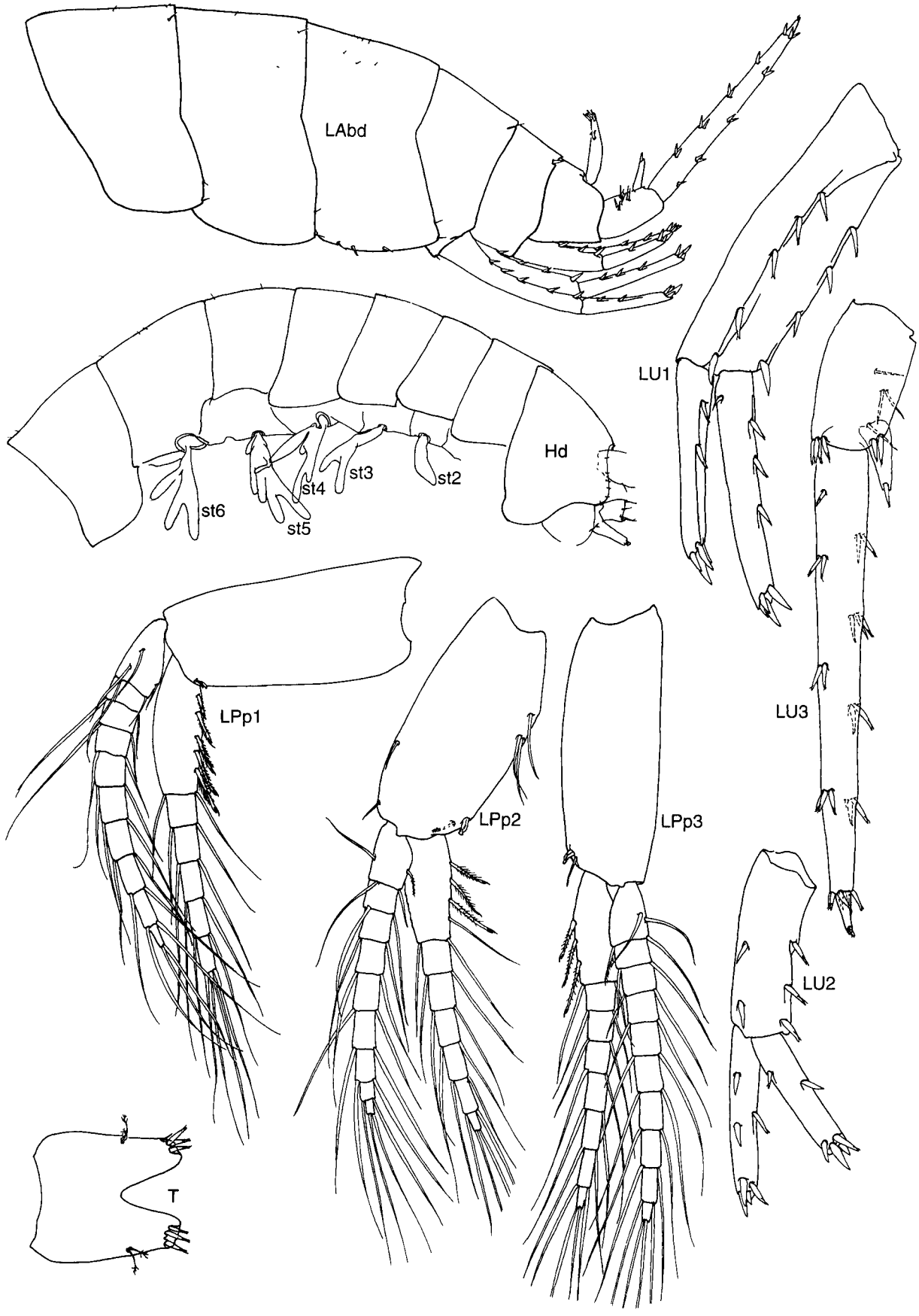

Fig. 41. *Neoniphargus secus* n.sp. holotype female "a" 8 mm; abdomen, gills, pleopods, uropods, telson.

Relationship. This species differs from others of the genus *Neoniphargus* in that eyes are totally absent; the first article of the mandibular palp is relatively longer; palmar corner robust setae are fewer and palmar robust setae less dense and without triggers; no accessory retinaculum is present but the third pleopod bears an accessory seta adjacent the retinacula; the telson is less cleft. *Neoniphargus secus* differs from *N. richardi* in: lower lip without posterior rugosities; mandibular palp with more E setae; first maxilla palps with fewer apical teeth; second maxilla more slender; maxilliped palp article 3 more rugose, outer plate bearing mediofacial comb rows of robust setae, inner plate with fewer naked apical tooth like robust setae and more medial plumose setae; dactyls of gnathopods bearing more inner accessory spinules, second gnathopod dactyl with small recumbent inner tooth like robust seta; peraeopods 3 and 4, article 4 bearing small anterodistal rugose lobe; peraeopod 5 shorter and less spinose; peduncle of pleopod 1 without basolateral pubescence; urosomite one at the base of uropod 1 bearing a small rather than moderate to large articulated robust seta; telson cleft 40% rather than 50%, each lobe bearing three apical robust setae rather than one.

Distribution. Gurangah Cave, cave 321, Wombeyan cave system, New South Wales, 34°19'S 149°59'E.

Neoniphargus richardi n.sp.

Figs 42–45

Etymology. Named for the second son of the second author in recognition of his indirect contribution to amphipod studies.

Type locality. Among tree roots, River Cave Spring (Cave W47) Wombeyan Caves system New South Wales, 34°19'S 149°59'E.

Material examined. HOLOTYPE (Australian Museum P51376) female "a" 6.5 mm, ALLOTYPE (Australian Museum P51377) male "b" 5 mm, in the type series; one other female 6.5 mm, two juveniles 2.5 mm; collected by S. Eberhard; 16 March, 1993.

Diagnosis. Article 1 of the peduncle of first antenna longer than article 2; calceoli present on the second antenna of the male; mandibular palp article 2 longer than article 3, sparsely setose, setae of article 3 BCDE. Palmar corners of both gnathopods without special medial robust setae. Coxa 4 deeply emarginate in both sexes. Dactyls of peraeopods 3–7 with only one facial and one medial setule, legs 5–7 without fine setae except for an elongate basodactylar seta on each propodus, propodi bearing 4-4-1 posterior robust seta sets. Coxae 5–7 with only weak robust setae on the posterior lobe. Coxal gills present on legs 2–6. Epimera two and three with two and three ventro facial robust setae. Uropods with only short robust setae, the third uropod strongly extended posteriorly beyond the first and second in the whole animal, the peduncle 0.5× the length of the outer ramus, the outer ramus bearing robust setae arranged in multiples in several medial and lateral rows, without plumose medial setae, the second article short; the inner ramus with a single apical robust seta and without facial setae. The telson cleft about 50%, each lobe with single sub apical robust setae and paired lateral penicillate setules at M0.57.

Description of holotype (female "a"). *Body* (Fig. 42): weakly armed dorsally, pleonites 1–4 with few setae, pleonites 5 and 6 with two and three dorsal and dorso lateral strong robust setae, length 6.5 mm. *Head*: rostrum small, eyes absent, lateral cephalic lobes strongly projecting, antennal sinus moderate. *First antenna*: long, 0.5× the length of the body, 1.4× the second antenna, peduncles shorter than the flagellum, article 1 longest, ratio of lengths 30:25:16, calceoli and aesthetascs absent from the female, the accessory flagellum 2-articulate, extending to M0.9 of article 1 of the primary flagellum, primary flagellum of 17 sparsely setose articles—articles 3, 8 and 9 being longer. *Second antenna*: approximately 0.25× body length, peduncle longer than the flagellum—about 1.5×—peduncular articles 4 and 5 subequal, articles 3–5 with moderate ventral setation, the flagellum of nine articles, weakly setose ventrally, calceoli and aesthetascs absent from the female. *Left mandible* (Fig. 42): palp of three articles, the second longest, bearing eight inner marginal setae, the third weakly falcate, bearing 2B3C10D3E setae, rugose lobe on the mandible basal to the palp; incisor with five teeth, lacinia mobilis four teeth, accessory blades of three chisel robust setae and three plumose setae, molar bearing a moderate posterior pappose seta, with three brushy basal setae. *Right mandible* (Fig. 42): palp article 3 setae 2B3C10D3E, basal to the palp a rugose lobe; the incisor with four teeth, the lacinia mobilis bifid, denticulate on one face, four teeth and a cluster of fine basal setules on the other; accessory blades of two chisel robust setae and two plumose setae, with three brushy setae leading to the molar, molar triturative, with a long posterior pappose seta. *Maxillae* (Fig. 42): left first maxilla palp with four thin apical robust setae and two slender sub terminal facial setae, all armed with spinules or setules; outer plate with five denticulate terminal robust setae, and a small distomedial area of setules; inner plate bearing two plumose apical setae; right first maxilla palp second article with a mediodistal row of four naked tooth like robust setae, one distolateral armed robust seta and two slender facial setae; outer plate with five denticulate robust setae and two distomedial thin setae; inner plate bearing two plumose apical setae. Second maxilla: both plates with long curved distal setae; outer plate bearing a lateral sub apical short seta; inner plate with two distal mediofacial armed setae. *Maxilliped* (Fig. 42): palp third article with stout medial and facial setae and a group of three short and two small apicolateral setae, apex strongly produced and rugose, dactyl rugose and bearing three accessory spinules, the nail naked; inner plate with three apical naked tooth like robust setae, several plumose and naked setae and a medial marginal row of four plumose setae; outer plate bearing a distomedial to apical row of five progressively facial robust naked robust setae, an apical group of three slender armed setae, two ventrofacial short setae and a basomedial row of slender setae. *First gnathopod* (Fig. 43): coxal plate with sparse apical setae; articles 2–4 with small posterior rugose lobes; carpus short, strongly lobate, the lobe rounded, rugose, without apical setae; propodus trapezoidal, longer than wide, the posterior angle rounded and rugose, palmar corner bearing two medial and two lateral robust setae, palm transverse, slightly convex, palmar robust setae simple, dactylus with accessory spinules, and reaching to the palmar corner robust setae. *Second gnathopod* (Fig. 43): larger than the first; coxa sparsely setose apically, bearing simple sac like gill and broad long oostegite; articles 2–4 all bearing small posterior areas of rugosity;

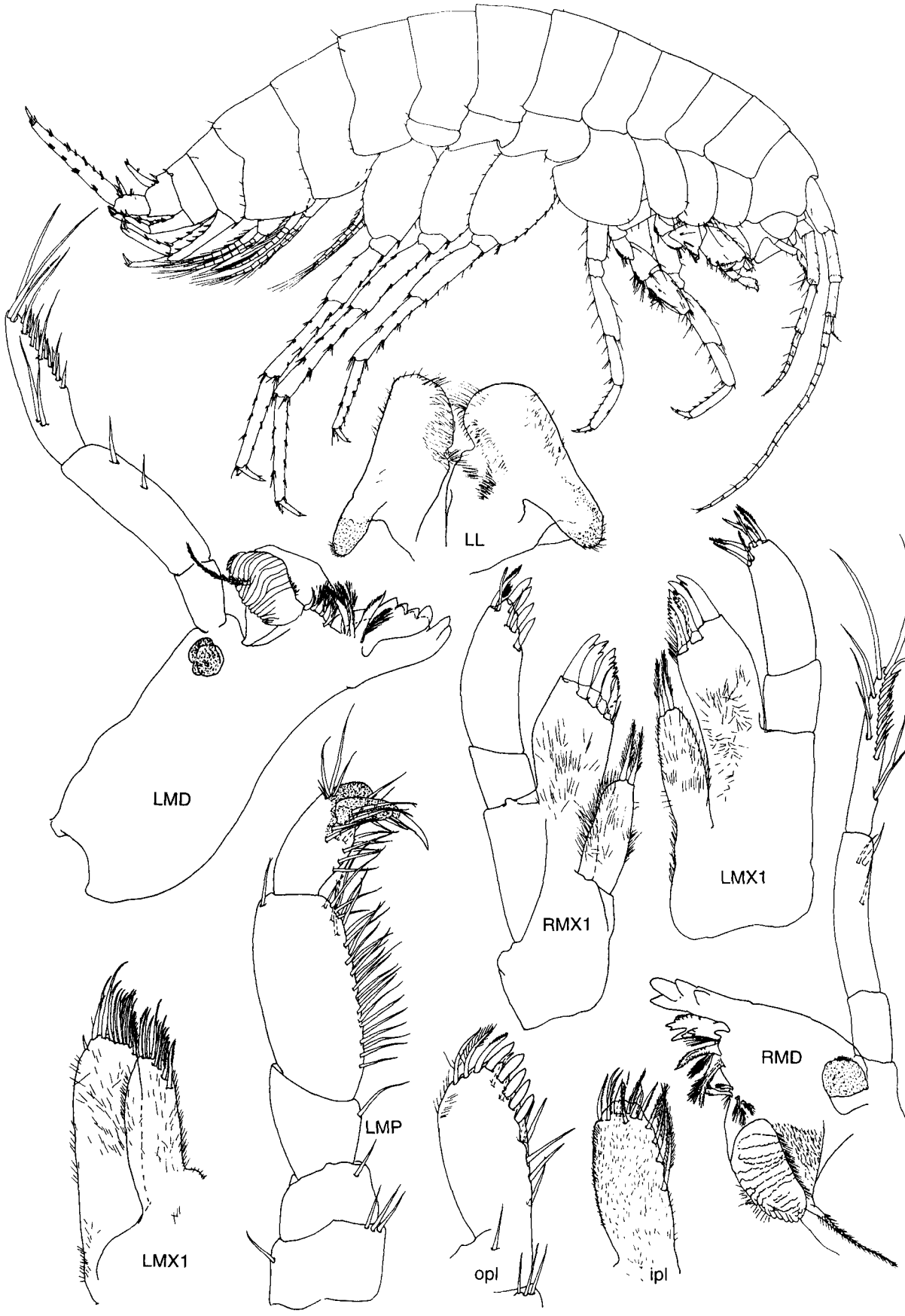

Fig. 42. *Neoniphargus richardi* n.sp. holotype female "a" 6.5 mm; whole, mouthparts.

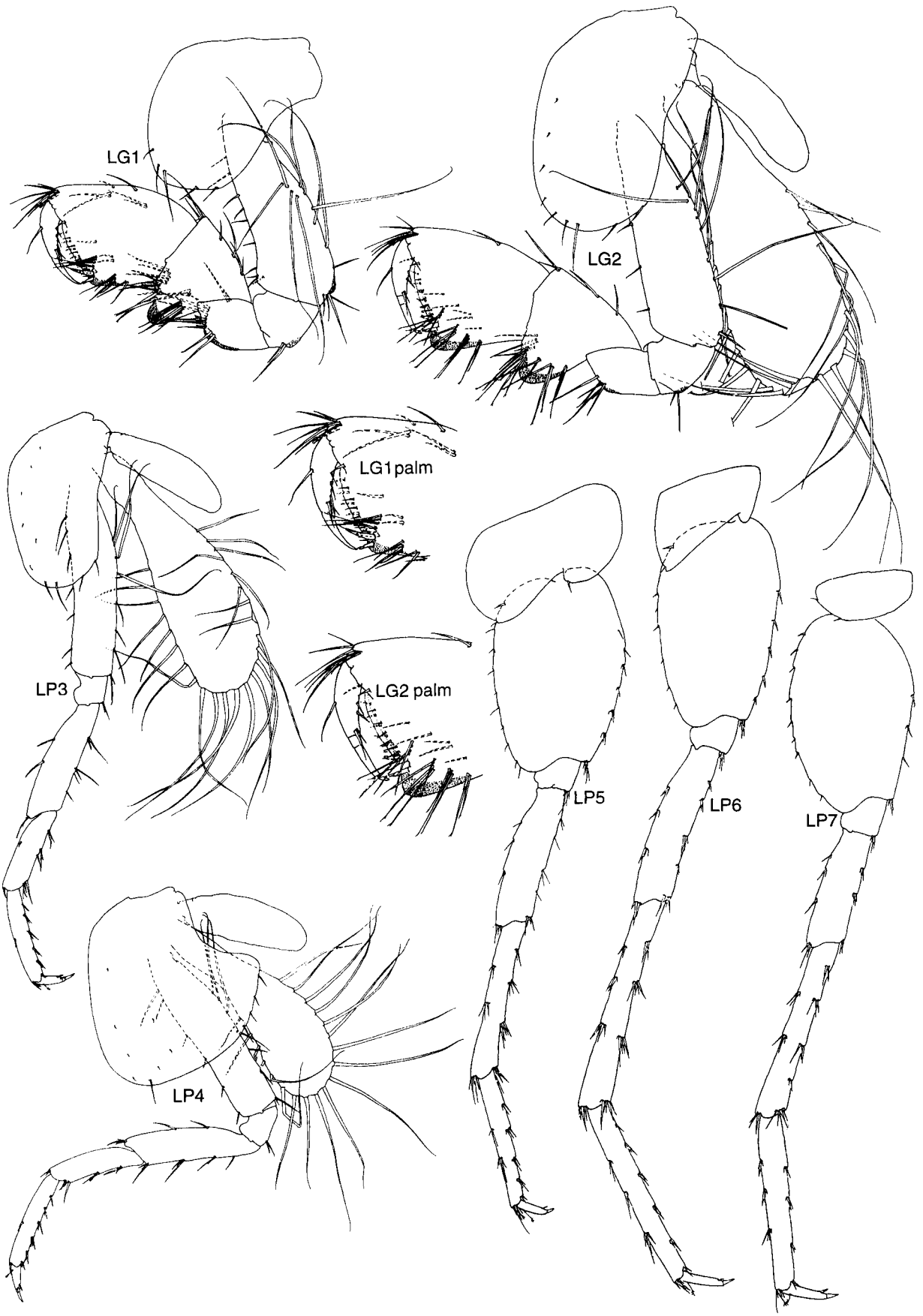

Fig. 43. *Neoniphargus richardi* n.sp. holotype female "a" 6.5 mm; legs.

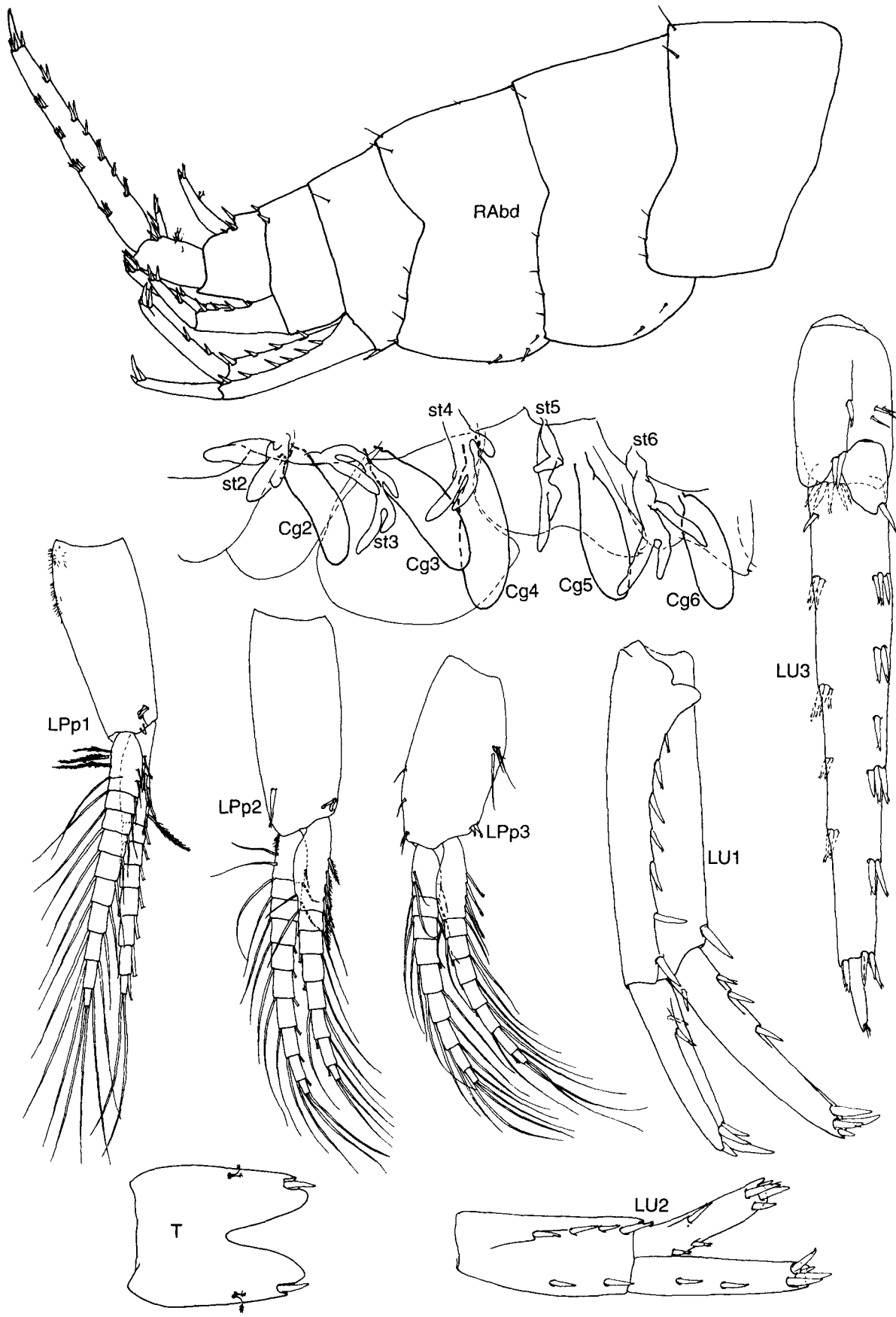

Fig. 44. *Neoniphargus richardi* n.sp. holotype female "a" 6.5 mm; abdomen, gills, pleopods, uropods, telson.

carpal lobe broader but not deeper than of the first gnathopod; propodus posterior corner lobate, larger than for the first gnathopod, rugose, the palmar corner with two lateral and one medial stout robust setae, dactylus reaching palmar corner robust setae. *Peraeopods* (Fig. 43): coxae 3 and 4 with few apical setae, coxa 4 moderately emarginate, both bearing simple sac like gill and broad, long oostegite; peraeopods 3 and 4 subequal in length, longer than the second gnathopod, articles 4 and 5 posteriorly spinose, posterior robust seta formulae of article 6 are 1-2-2-2-2 and 1-2-2-3-2 respectively; peraeopods 5–7 similar, leg six longest, coxae with 1-1-2 posterior weak robust setae, coxa 7 with no gill, articles 2 expanded posteriorly, weakly lobate post-ventrally, with small marginal setae, article 2 of peraeopod 6 slightly narrower; propodi with moderately long basodactylar setae. *Gills* (Fig. 44): coxae 2–6 bearing simple sac like gills; sternites 2–6 with pairs of fleshy, dendritic sternal gills attached to the posterolateral to mid lateral of each segment. *Epimera* (Fig. 44): second epimeron with a small post-ventral tooth, posterior margins of each convex to slightly sinuous bearing few setae, anterior ventro face of epimera two and three bearing two and three small robust setae. *Pleon*: few dorsal armaments; pleonites 5 and 6 with dorsal and dorsolateral robust setae; pleonite 6 bearing an additional robust seta basolateral to the telson. *Pleopods* (Fig. 44): similar, each with two retinacula; peduncle one with three small accessory setules, and short basolateral pubescence; peduncle two with a single distolateral strong seta; peduncle three with four lateral and four mid medial setae; rami of 10-8, 10-8, 9-8 articles respectively. *Uropods* (Fig. 44). Third uropod extending well beyond uropods 1 and 2 in the intact specimen; uropod lengths relative to uropod 1—uropod 2 0.7×, uropod 3 1.3×. First uropod: peduncle length 2.3× medial ramus, 2.9× lateral, lateral margin with a distal, subapical robust seta, and a dorsomarginal row of six short to moderate length robust setae, the mediodorsal face with a single subapical robust seta; rami unequal, outer ramus with one medial and one lateral robust seta and four apical robust setae; inner ramus with one basolateral robust seta, three medial robust setae and four apical robust setae. Second uropod: shorter than the first, peduncle bearing three dorsolateral and one subdistal short robust setae, and two medial robust setae; inner ramus longer than outer, with two medial robust setae and four apical robust setae; outer ramus with two medial, one lateral, and four apical robust setae. Third uropod: parviramous, peduncle length 0.3× length of the outer ramus, as long as urosomite three, bearing three dorsofacial robust setae, one mid medial and two medial robust setae basal to the inner ramus, and a distolateral row of five robust setae; outer ramus proximal article with four trans-lateral robust seta rows of 3-4-2-3 robust setae and five trans medial robust seta rows of 3-2-1-3-2 robust setae, two medial and three lateral distal robust setae basal to the second article; distal article bearing three small apical setules; inner ramus short, 0.13× outer ramus, with a single apical seta. Urosomite one at the base of uropod 1 bearing a moderate to large articulated robust seta. *Telson* (Fig. 44): short, about the same length as urosomite three, slightly longer than broad; cleft 50%; with a single subapical lateral robust seta on either lobe and paired dorsolateral penicillate setules on either lobe at M0.57.

Description of male "b". *Body*: length 5 mm. *First antenna* (Fig. 45): peduncle with sparse setae, relative lengths of articles 10:8:5, 0.5× flagellum length; accessory flagellum of two articles, small, reaching to M0.9 of first article of primary flagellum; primary flagellum long, of nineteen articles with sparse setae, aesthetascs present on articles 2–19. *Second antenna* (Fig. 45): short, 0.5× antenna one; peduncle 1.7× flagellum, articles 4 and 5 subequal, with sparse setation; flagellum of eight articles, moderately setate, calceoli present on articles 1–5. *Mandibular palp*: left palp article 3 setae 1B3C11D3E; right palp article 3 setae 2B4C12D3E. *First gnathopod* (Fig. 45): coxal plate with few apical setae and several small anterofacial setae; articles 2, 3 and 4 with small rugose posterior keels; carpus short, bearing a strong posterior rugose lobe; propodus with small rugose posterior keel; robust setae of palmar corner two medial, two lateral, palm slightly oblique and convex, palmar robust setae moderately crowded and simple; dactyl bearing three inner margin accessory robust setae, nail reaching to palmar corner robust setae. *Second gnathopod* (Fig. 45): coxa bearing sac like gill, with few apical or facial setae; articles 2–4 with tiny posterodistal rugose keel; carpus with prominent posterior rugose lobe; propodus with moderate to strong rugose posterior lobe, palmar corner with one medial and two lateral robust setae, palm slightly oblique, almost straight, palmar robust setae simple; dactyl with three inner margin accessory robust setae, nail reaching slightly beyond palmar corner robust setae. *Peraeopods* (Fig. 45): similar to female, except propodi of legs 5–7 with long basodactylar setae extending almost to or beyond the dactyl. *Epimera* (Fig. 45): without postventral teeth; with 0-2-3 ventrofacial robust setae; posterior margins convex, sinuous, and straight, all weakly setulate. *Pleon* (Fig. 45): pleonite 5 bearing a single dorsolateral robust seta; pleonite 6 with a dorsal robust seta basal to the telson. *Pleopods* (Fig. 45): peduncles each with two retinacula; third peduncle with a small distolateral slender seta and four setae on the mid posterior margin; rami with 5-9, 7-9, 5-8 medial and lateral articles respectively. *Uropods* (Fig. 45). First uropod: peduncle with four dorsolateral and one apicolateral robust seta, and three dorsomedial and one apicomedial robust seta; medial ramus with two lateral and four apical robust setae; lateral ramus with one lateral and four apical robust setae. Second uropod: peduncle with two laterodorsal and two apicolateral robust setae, and one apicomedial robust seta; medial ramus with one lateral, two medial and four apical robust setae; lateral ramus with one lateral and four apical robust setae. Third uropod: peduncle longer than urosomite three, bearing no marginal robust setae, and two apicolateral robust setae; inner ramus length 0.5× peduncle, 0.15× outer ramus, bearing one apical robust seta; outer ramus of two articles; proximal article length 5× distal, with transverse lateral robust seta rows of 2-2-2 and four distal robust setae, and transverse medial robust seta rows of 1-3-2-2 and one distal robust seta; distal article with one small apical setule. *Telson* (Fig. 45): longer than urosomite three; one apical robust seta on either lobe; lateral penicillate setules at M0.6 on either side.

Description of female "c" (6.5 mm), juveniles (2.5 mm.): essentially as for female "a".

Relationship. This species differs from others of the genus in the following ways: eyes absent; outer plate of first maxillae with five denticulate robust setae, rugosities absent from the posterior angle of article 4 of the second gnathopod of the male; palmar corner of first gnathopod with two or three robust setae rather than six or more; palmar robust setae not dense, or with triggers; the second article of peraeopods 5–7 least expanded on leg six rather than five; accessory seta

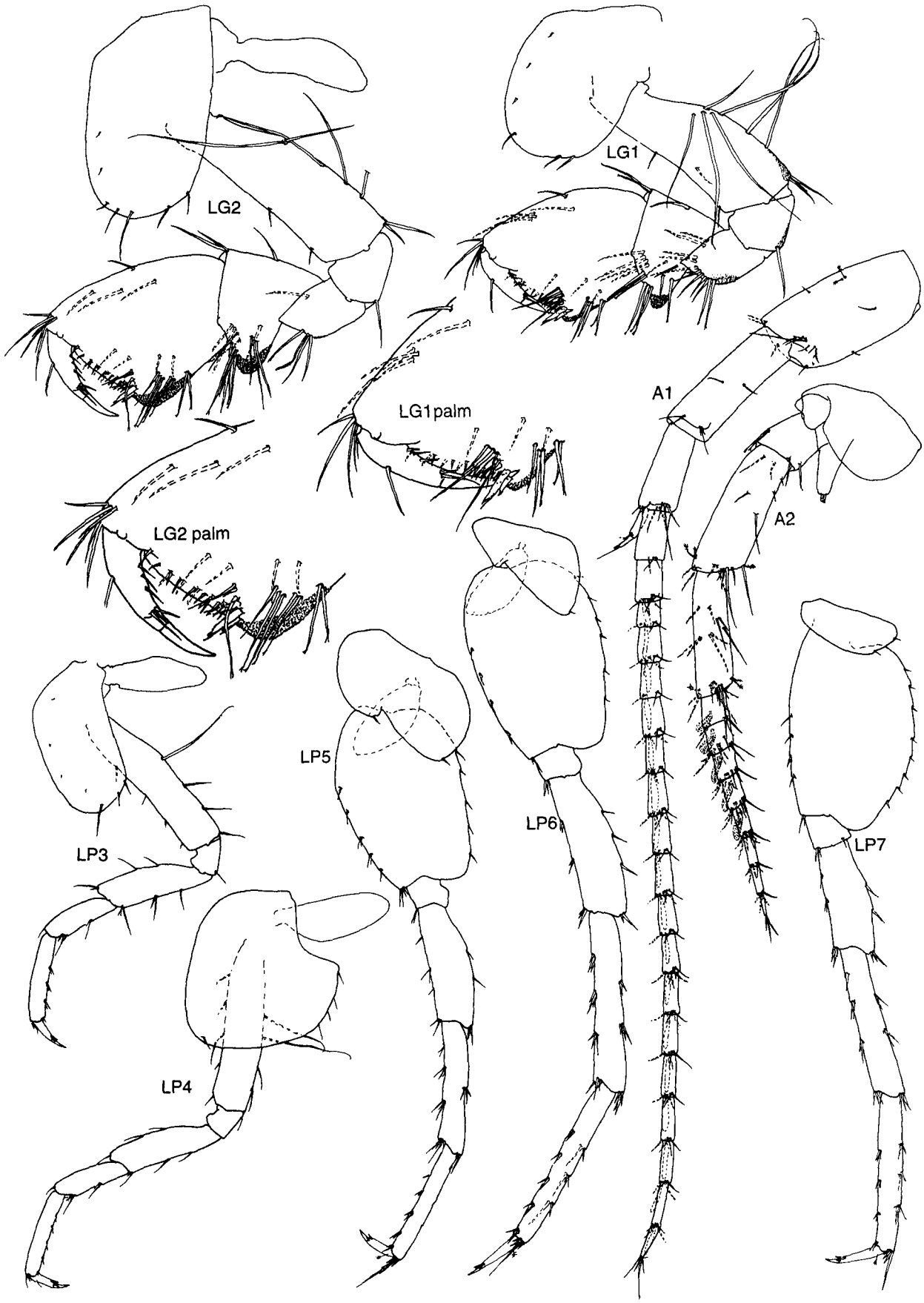

Fig. 45. *Neoniphargus richardi* n.sp. allotype male "b" 5.0 mm; antennae, legs.

present adjacent retinaculum of the first pleopod; one robust seta row on the inner ramus of uropod 2; setae absent from the inner margin of the ramus of uropod 3; telson cleft 50% rather than 60%.

Differences between *N. richardi*, and *N. coolemanensis* and *N. secus* are set out within discussion of those species.

Distribution. River Cave Spring, cave W47, Wombeyan cave system, New South Wales, 34°19'S 149°59'E.

Wesniphargus Williams & Barnard

Wesniphargus Williams & Barnard, 1988: 160–161

Type species. *Neoniphargus nichollsi* Straškraba, 1964.

Composition. This genus was monotypic, but we now add a further species, *W. yanchepensis*, from a cave in Western Australia.

Diagnosis. Williams & Barnard (1988) re-examined the incomplete holotype of *W. nichollsi* and provided both a generic diagnosis of *Wesniphargus* and a partial redescription of the type species, *W. nichollsi*, based on this examination and the original description and drawings of Straškraba (1964). Even so, the generic diagnosis was incomplete. The discovery of a further species that can be assigned unequivocally to the genus, and an examination of fresh material that can be assigned to *W. nichollsi*, permits completion of the generic diagnosis with some minor changes.

Pleonites with weak dorsal arms, rostrum small or obsolescent, lateral cephalic lobes weakly to moderately projecting, antennal sinus weak to moderate. Eyes present or absent. First antenna elongate, longer than second, ratio of peduncular articles 10:7:5 to 10:9:5, accessory flagellum 2-articulate. Second antenna flagellum length equal to or less than length of peduncle, with very large calceoli in male. Ratio of articles of mandibular palp 8:22:22 to 8:28:26, second article moderately setose, article 3 moderately to barely falcate, setae BCDE. Labium without inner lobes. Maxillae not medially setose on inner plates except in some one or two marginal plumose setae on the second; maxilla one inner plate sub rectangular with two apical plumose setae, the outer plate with seven robust setae, palps weakly asymmetric. Second maxilla inner plate lacking oblique row of facial setae, the apicomedial edge with one plumose medial seta. Maxillipedal palp article 3 with or without rugose apical lobe, marginally pubescent or bearing fine setae. Coxae 1–4 elongate, sparsely setose ventrally, coxae 1–3 lacking a row of posterior robust setae, coxa 1 subquadrate or tapering below, coxa 4 emarginate. coxa 5 much shorter than four. Gnathopods small; carpi shorter in male, lobate; articles 4 and 5 with or without rugosities; propodi not expanded apically, palms weakly oblique, lacking rugosities in some, robust setae symmetrically bifid or not, bearing short terminal triggers; robust setae at corner of palm four, with small sub apical triggers; robust setae along palm moderately dense, with or without triggers. Peraeopods 3 and 4, article 6, posterior robust seta sets evenly spaced, legs 5–7 moderately elongate, articles 2 of legs 5–7 broadly expanded, ovate, postventrally lobate. Dactyls of legs three to seven with one facial and one marginal setule. Gills borne on coxae 2–6, simple sac like, those of 5 and 6 slightly reduced in some. Thoracic segments 2–6 with lateral sternal gills of incipient dendritic form but fingers only small lumps. Pleopods; basomedial setae of inner rami bifid, branches dissimilar, of different length and shape, occasionally one branch of diamond head shape or both simple; two to four retinaculae each peduncle, with or without accessory retinaculae or robust setae. Epimera with small, blunt postventral extensions, but not forming teeth, some with facial robust setae, with or without setae near the ventral margin, posterior margins weakly setulate. Uropods: apicolateral corner of the peduncle of uropods 1 and 2 with one robust seta; outer rami of both uropods 1 and 2 shorter than the inner, the margins spinous; uropod 1 lacking basofacial arms. Uropod 3 extended, parviramous or magniramous and dispariramous, the peduncle short; outer ramus 2-articulate, medial setae moderately dense and plumose, article 2 short to very short; inner ramus short to aequiramous, sparsely setulate or with moderately dense plumose setae. Telson length moderate to elongate, cleft 75–85%, the lobes laterally tumid in some, with apical spination or both apical and dorsal robust setae, no major setation, no basolateral arms except for a pair of lateral penicillate setules at M0.6 to M0.7 on either side.

Additional Description. Upper lip uniform, rounded below. Accessory blades of mandibles with few interraker plumose setae, several to many additional setae beyond rakers onto the base of the molar, pappose posterior seta on either or both molars. Inner plates of maxillae weakly to moderately pubescent on inner margins. Maxilliped inner plate with distolateral row of one to three plumose setae, with additional robust setae and plumose setae; outer plate with a distal row of few plumose setae, with a medial submarginal row of blunt naked tooth like robust setae and facial robust setae; palp articles 2 and 3 poorly setose laterally, article 2 moderately to strongly setose medially, article 3 of some with a row of non comb robust setae near the base of the dactyl, the apex slightly produced, rugose in some, marginally pubescent or with fine setae. Gnathopod 1 without one seta of article 4 enlarged and robust seta like; dactyls without recumbent inner tooth like robust seta, with stiff spinules at the inner nail articulation, without additional spinules along the inner dactylar margin. Pleopods similar, peduncles naked, rami extending equally or subequally. Urosomite one with or without a robust seta of moderate length at the base of uropod 1.

Wesniphargus yanchepensis n.sp.

Figs 46–48

Etymology. Named for the type locality.

Type locality. Yanchep Cave, Western Australia, 31°33'S 115°41'E.

Material examined. HOLOTYPE (WAM 520-97) female "a", 8 mm, ALLOTYPE (WAM 521-97) male "b", 7 mm. Also in the type series: juvenile "c" 4 mm (WAM 522-97), Western Australian Museum, collected by W.F. Humphreys, M.S. Harvey, C. Rippon, from freshwater pool in limestone cave, with hand net, 19 April, 1991, Yanchep Caves, Western Australia, 31°33'S 115°41'E.

Diagnosis. Pleonites with weak dorsal arms. Head; rostrum obsolescent, lateral cephalic lobes moderately projecting, moderate antennal sinus. Antenna one elongate longer than second antenna, ratio of peduncular articles 4:3:2; accessory flagellum 2-articulate; second antenna flagellum length less

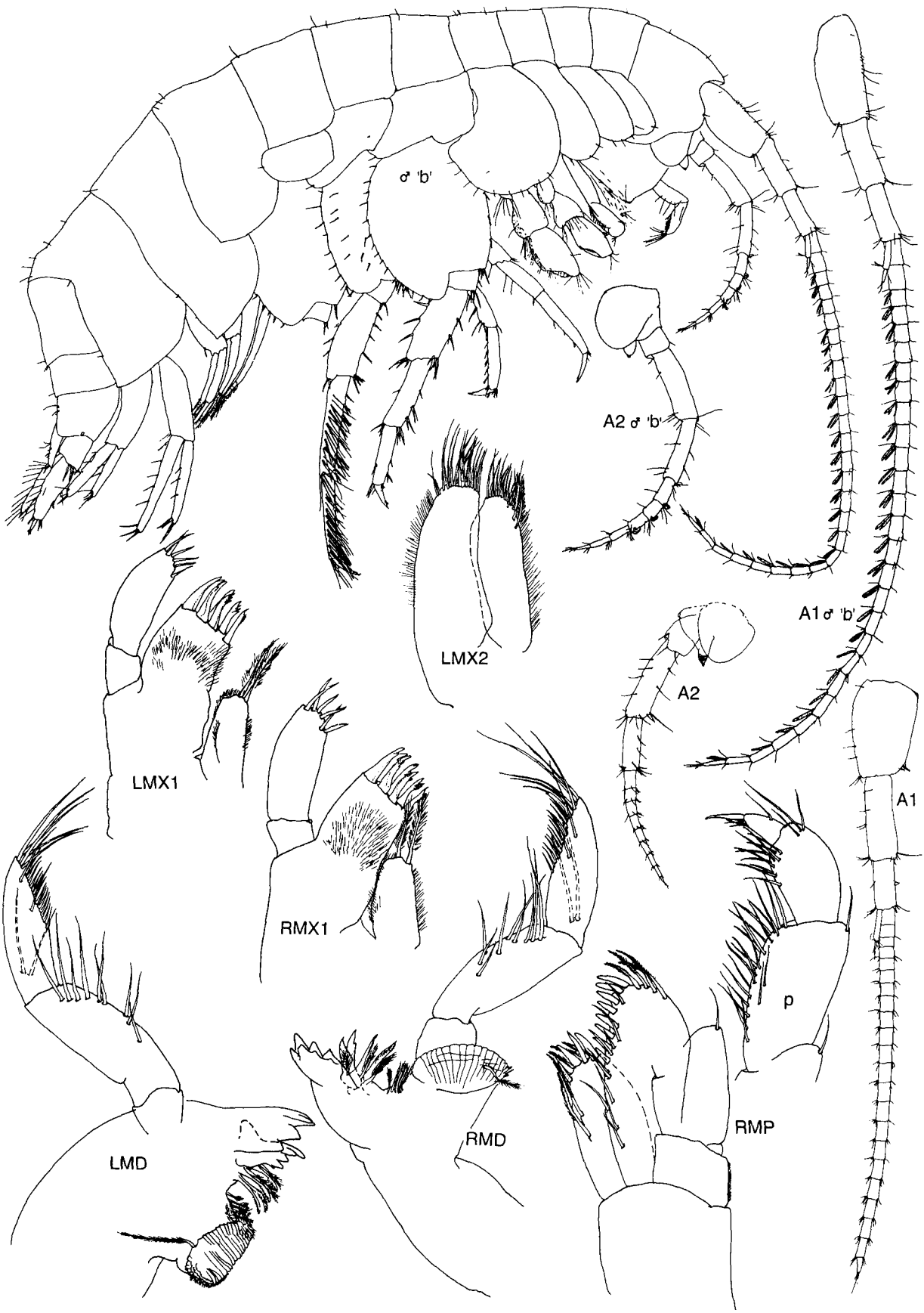

Fig. 46. *Wesniphargus yanchepensis* n.sp. holotype female "a" 8 mm; whole, antennae, mouthparts (all drawings except those indicated). Allotype male "b" 7 mm whole specimen, antennae.

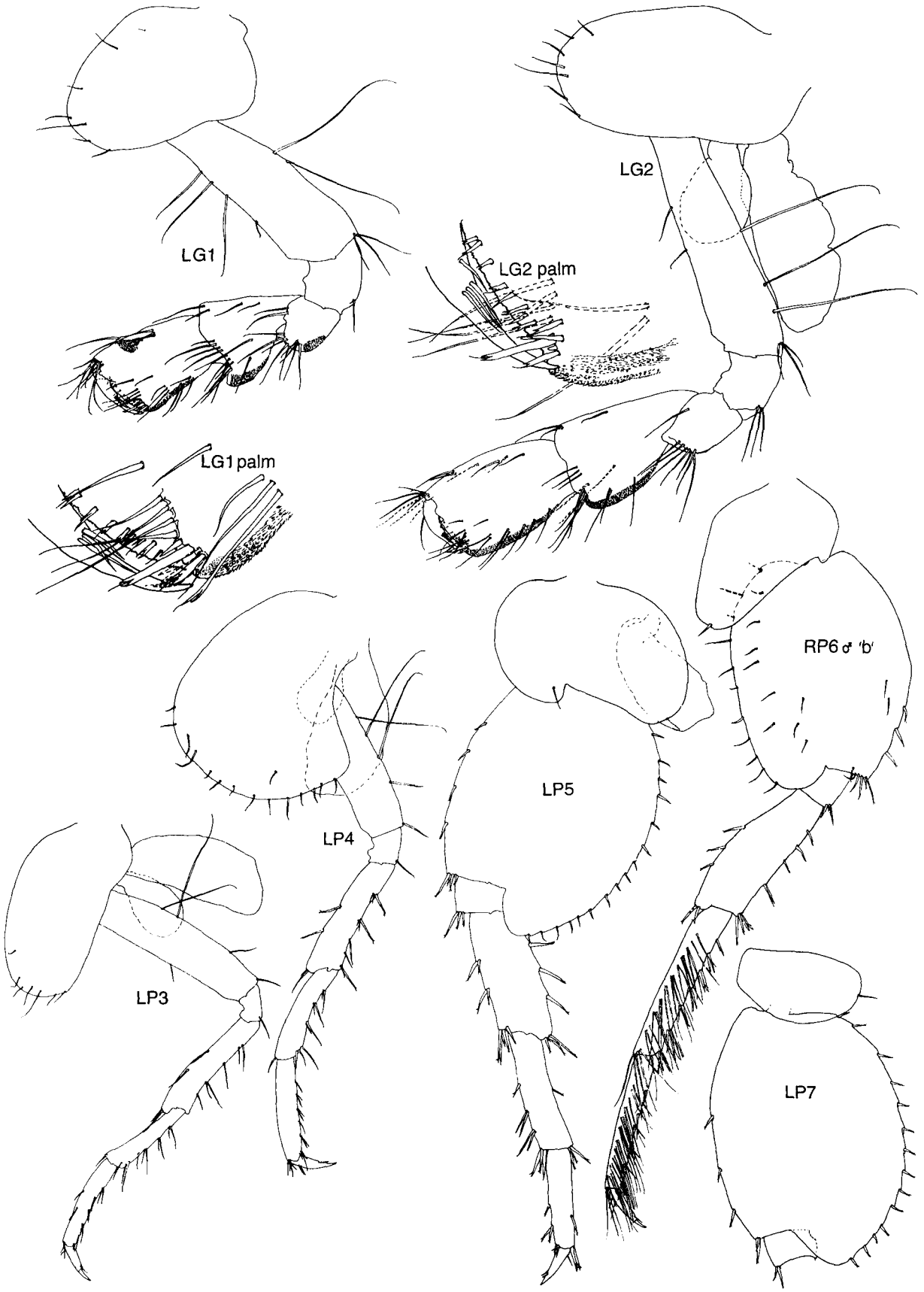

Fig. 47. *Wesniphargus yanchepensis* n.sp. holotype female "a" 8 mm; legs (all drawings except those indicated). Allotype male "b" 7 mm R peraeopod 6.

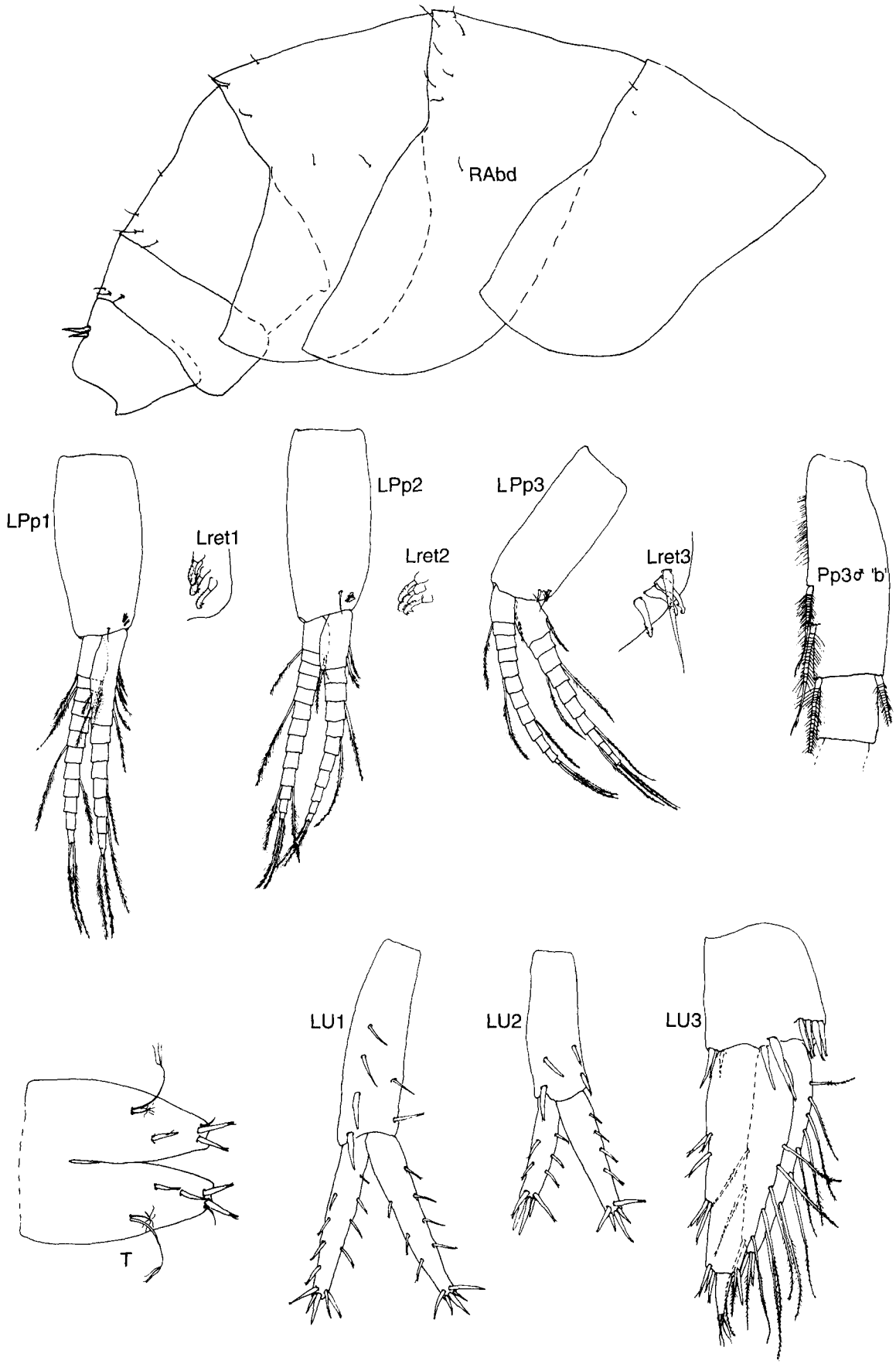

Fig. 48. *Wesniphargus yanchepensis* n.sp. holotype female "a" 8 mm; abdomen, gills, pleopods, uropods, telson (all drawings except those indicated). Allotype male "b" 7 mm articles 1 and 2 inner ramus, pleopod 3.

than peduncle. Mandibular palp ratio of articles 7:25:23; article 2 moderately setose, article 3 barely falcate, setae BCDE. Labium with no inner lobes. Maxillae not medially setose on inner plates except for two marginal plumose setae on second maxilla at M0.8; first maxilla inner plate sub rectangular, with two apical plumose setae; outer plate with seven denticulate robust setae, palps almost symmetric—left side with thin apical robust setae, right palp with mix of stout and slender robust setae. Second maxilla: inner plate lacking an oblique row of setae on the face, apicomedial margin with two plumose medial setae. Maxilliped: palp article 3 with a slight apical lobe bearing fine marginal setules. Coxae 1–4 elongate, sparsely setose ventrally; coxae 1–3 lacking a row of posterior robust setae; coxa 1 tapering below; coxa 4 emarginate; coxa 5 shorter than coxa 4. Gnathopods small, not sexually dimorphic in the palmar spination, carpi longer in female (0.7–0.8× propodi), lobate; articles 4–6 of gnathopods bearing post-marginal rugosities; article 4 of gnathopod 1 bearing a rugose margin; propodi not expanded apically; palms weakly oblique and convex; robust setae symmetrically bifid, also bearing short terminal triggers; robust setae at corner of palm two long and two short, bifid and with small triggers; robust setae along palm moderately dense with triggers on most. Gnathopod 1: propodus posterior margin arms of a single robust seta in tandem, with an additional submarginal transverse row of three robust setae at M0.5. Peraeopods 3 and 4 article 6 with posterior robust seta sets evenly spaced; peraeopods 5–7 moderately elongate; article 2 broadly expanded, ovate, postventrally lobate; peraeopods 3–7 dactyls with one marginal and one facial setule. Oostegites present on female coxae 2–4. Coxae 2–6 with sac like gills; gills 5 and 6 not reduced. Thoracic segments 2–6 with lateral sternal gills; small, lumpy, but not dendritic. Pleopods 1–3 with basomedial setae, bifid, branches dissimilar, of differing length and shape, some with one branch of diamond head, this organ borne at about M0.5 of the branch; retinaculae 4-3-3 respectively, accessory retinaculae 0-1-1. Epimera: post-ventrally bearing very small rounded extensions: blunt, without a tooth; none with facial robust setae, without setae near the ventral margin; posterior margins weakly setulate. Uropods; apicolateral corner of peduncle of uropods 1 and 2 with one robust seta, with a pair of mediomarginal robust setae at M0.7, and at M0.9; outer rami shorter than inner, margins spinose; uropod 1 lacking basofacial arms; all rami with two robust seta rows; uropod 3 extended, magniramous, dispariramous, peduncle short, outer ramus lanceolate, 2-articulate, medial setae moderately dense and plumose; article 2 very short, inner ramus dispariramous, lanceolate, with moderately dense plumose medial setae. Telson of moderate length; cleft 75%; lobes moderately tumid laterally, with apical and dorsal spination; no major setation; no basolateral arms, except for a pair of lateral penicillate setules at M0.6 on the dorsolateral face.

Additional characters. Upper lip uniformly rounded below; accessory blades (rakers) usually with few interraker plumose setae; many additional (penicillate) setae beyond rakers onto base of molar; large basal ragged molarial seta on R mandible; no other apical molarial seta. Lower lip uniform, inner lobes absent; medial margins of inner plates of maxillae moderately pubescent, both plates with long apical setae; inner plate with three distal plumose setae, apical robust setae and mid-facial plumose setae; outer plate with a distal row of plumose setae, medial submarginal teeth and facial robust setae; palp articles 2 and 3 poorly setose laterally, basally naked; article 2 strongly setose medially, article 3 without a row of non comb robust setae near the dactylar base, apex only slightly produced, not rugose, marginally pubescent or with fine setae. Dactyls without small recumbent inner tooth like robust seta on either gnathopod, with stiff spinules or setules at inner nail articulation line, without additional spinules along inner dactylar margin. First gnathopod without seta of the fourth article enlarged and scythe like. Pleopods similar, peduncles naked, rami extending equally. Urosomite one, at the base of uropod 1 without a robust seta.

Description of holotype (female "a"). *Body* (Fig. 46): pleon sparsely armed dorsally, few setae on pleonites 1–5; moderately setose distolaterally, pleonite 5 without robust setae on each side, pleon six with a pair of dorsolateral robust setae each side, length 8 mm. *Head*: rostrum absent, eyes absent. *First antenna* (Fig. 46): length 0.46× body, 1.8× second antenna; peduncle much shorter than flagellum, ratio of lengths of articles 21:18:11 (= 3.8:3.2:2), flagellum of 22 articles, without aesthetascs or calceoli; articles not uniform, proximal articles 3–6 shorter than distal articles, article 3 shortest; sparsely setulate; accessory flagellum 2-articulate, extending to M0.6 of article 3 of the primary flagellum. *Second antenna* (Fig. 46): length 0.25× body, flagellum of nine articles, the peduncle longer than the flagellum; article 4 longer than five, articles 3–5 with sparse ventral setation, without calceoli or aesthetascs. *Upper lip*: apical margin evenly rounded. *Left mandible* (Fig. 46): ratio of lengths of palp articles 8:28:26, article 2 with nine long naked medial to distofacial setae, article 3 without pubescence, setae 2B2C14D5E; incisor with four teeth; lacinia four large and one small teeth; three setose accessory blades and three plumose interraker setae, a row of plumose setules leading to base of the molar; molar bearing posterior pappose seta, without other penicillate basal setae. *Right mandible* (Fig. 46): incisor with two rows of cusps of four large and three small teeth; lacinia mobilis bifid, both blades acuminate, the medial blade with a medial marginal pair of small teeth at M0.75, the lateral blade bearing weak facial cusps and a row of setae; accessory blades of two rakers and two plumose robust setae; palp article 2 bearing nine facial setae; setae of palp article 3 2B2C13D6E; molar bearing large posterior pappose seta. *Lower lip*: without inner lobes; bearing slender robust setae apically on outer lobes; facially and marginally pubescent; posterior protuberances also marginally pubescent. *Maxillae* (Fig. 46). Left first maxilla: palp article 2 with five thin apical robust setae and one mediodistal robust seta, without other setae; outer plate with seven robust setae, most denticulate, facially pubescent; inner plate with two apical plumose setae borne on the distomedial margin, outer distal and inner margins pubescent, with a mid-facial row of pubescence. Right first maxilla: palp article 2 bearing four slender terminal robust setae and two mediodistal robust setae, one armed on the medial margin with short setules, the other naked, slender; outer plate bearing seven denticulate terminal robust setae, facially pubescent; inner plate with two apical plumose setae, borne on the medial margin; medial and lateral margins as well as a small laterofacial area pubescent. Second maxillae: similar; most robust setae of both plates long, curved; outer plate apex bearing many long, curved robust setae, lateral margins pubescent; inner plate subapical medial corner bearing a short row of plumose setae, apex bearing many long, curved setae; medial margin pubescent. *Maxilliped* (Fig. 46): palp laterally pubescent basally, articles 2 and 3 poorly setose laterally, article 2 strongly setose medially, article 3 without comb robust setae basal to the dactyl, the apex slightly produced bearing a few short marginal setules, and a transverse subapical facial row of three long setae; inner plate bearing three distal plumose setae, four apical stout naked robust setae, two medial subapical robust setae and two facial

plumose setae at M0.4 and M0.6; outer plate bearing a distolateral row of four plumose setae, a submarginal medial row of eight naked tooth like robust setae extending from M0.6 to the mid apex, the medial margin thus robust setae absent beyond M0.6, a discontiguous mediofacial row of eight slender robust setae extending from M0.2 to M0.9 and two slender medial robust setae at M0.4 and M0.55. *First gnathopod* (Fig. 47): coxal plate with four slender apical and three facial anterior setae; articles 2 and 3 without rugosities; article 4 with small posterior rugose hump; carpus short, lobate—lobe tilted apically—and rugose; propodus sub rectangular, slightly expanded apically, longer than wide, length to width ratio; 48:33, bearing an anterior facial area of rugosities, palmar corner rounded, with a narrow rugose posterior keel, the corner marked by two medial and two lateral bifid robust setae which also bear short triggers; one lateral robust seta slightly elongate; palm weakly oblique, slightly convex, dactylus without recumbent inner tooth like robust seta, reaching end of palm. *Second gnathopod* (Fig. 47): coxa moderately setose apically, bearing sac like gill and long naked oostegite; articles 2 and 3 without posterior rugosities, article 4 with a small rugose keel; carpus longer than gnathopod 1, with a long rugose posterior lobe; propodus longer and narrower than on gnathopod 1, length to width ratio; 80:130; posterior margin a long rugose keel; palmar corner rounded, marked by four lateral robust setae; dactyl bearing three stiff setules at inner nail articulation line and a single, more proximal robust seta, reaching slightly beyond the robust setae of the palmar corner. *Peraeopods* (Fig. 47): coxa 3 with six apical setae as well as a single anterior seta; coxa 4 emarginate, ventrally and post-ventrally bearing fourteen setae and one ventrofacial seta; peraeopods 3 and 4 weakly setose posteriorly, three less setate than four; articles 6 and 7 post-marginal robust seta formulae 3-2-2-2-1 plus two locking robust setae and 1-2-2-1-2 plus three locking robust setae, respectively; peraeopod 5 article 6 with few posterior robust setae; peraeopod 6 articles 5 and 6 with many robust setae and setae; peraeopods 3–7 dactyls with one medial and one facial setules; coxa 5 only with a single ventromarginal robust seta; coxae 6 and 7 naked ventrally with a single post-ventral robust seta at the posterior corner, coxa 7 also with a single posterior robust seta; article 2 broadly expanded, ovate, lobate postventrally, with short to moderate posterior setules. *Gills* (Fig. 48): coxae 2–6 with sac like gills, 5 and 6 not reduced; sternites 2–6 with pairs of fleshy sternal gills bearing small lumps, of incipient dendritic form, attached between centre and lateral edge of each segment. *Oostegites* (Fig. 47): present on female coxae 2–5, broadly ovate on coxae 2–4, more slender on coxa 5; margins without elongate setae. *Epimera* (Fig. 48): 1–3 without postventral teeth; each with a small blunt protrusion, not acuminate, smallest on epimera three; posterior margins almost straight, without ventral robust setae, adjacent each post-ventral margin a single seta dorsal to the margin. *Pleon* (Fig. 48): with few dorsal setae or robust setae; dorsolateral posterior margin of pleonites 1–6 with setae: 6-11-9-6-4-0, and robust setae: 0-0-0-0-0-2. *Pleopods* (Fig. 48): similar, without peduncular arms, with 4-3-3 retinacula and an associated or accessory robust seta; basal setae of inner ramus bifid with similar and dissimilar branches, rami of 12-9, 13-11, 12-11 articles respectively. *Uropods* (Fig. 48). Uropod 3 extending beyond uropods 1 and 2 in entire animal. Uropod lengths relative to uropod 1; uropod 2 0.65×, uropod 3 1.1×; most robust setae of uropods bearing short subdistal triggers. First uropod: peduncle length 1.1× inner ramus, 1.1× outer ramus; outer margin without apical robust seta, and with weak row of four dorsolateral robust setae, the most distal being medio-subapical; medially 2 weak robust setae; the lateral ramus slightly shorter than medial (35:37); both with two rows of marginal robust setae, both apices with five terminal robust setae. Second uropod: peduncle about 1.2× length of inner ramus, with two medial and two lateral dorsal robust setae; outer ramus shorter than inner (22:26), with two rows marginal robust setae; inner ramus without a lateral row of robust setae; apices of both rami with five terminal robust setae. Third uropod: peduncle length 0.5× length of first article of outer ramus, 0.75× urosomite three, with a subdistal medial transverse row of four trigger robust setae, a pair of apicodorsal robust setae, two dorsal and one ventral apicolateral robust setae; outer ramus proximal article with four lateral trigger robust seta clusters: discontiguous; lateral robust setae proximal to distal 0-2-1-0-3-0-3; medial margin with six plumose setae and one distal robust seta; distal article small, much shorter than proximal (28:133); apex with four sub terminal dorsal short stiff setae; inner ramus length approximately 0.7× length of outer ramus, bearing on the inner margin a row of eight plumose setae; outer margin with three plumose setae; apex with one plumose seta and two trigger robust setae. *Telson* (Fig. 48): moderately long, 1.2× length urosomite three; cleft 75% of length; lobes moderately tumid laterally; apex notched, both apices blunt, rounded; dorsal subapices each with two large robust setae and a small lateral penicillate setule; a single dorsal robust seta on the right lobe at M0.7, two dorsal robust setae on the left lobe at M0.7 and M0.8; each lobe with a pair of penicillate setules dorsolaterally at M0.6.

Description of allotype (male "b"). Similar to female except in the following. *Body*: length 7 mm. *First antenna* (Fig. 46): length 0.67× body, 2.5× second antenna; ratio of lengths of peduncular articles 4:2.5:2; flagellum of 27 articles all except basal and ultimate article with aesthetascs; calceoli absent. *Second antenna* (Fig. 46): 0.26× body length, flagellum of six articles, without aesthetascs, articles 1–3 bearing large type nine calceoli. *Mandibles*: left palp article 2 with five moderate mediodistal setae, article 3 with setae 1B2C9D4E; right palp article 2 with five moderate mediodistal setae, article 3 with setae 2B2C10D4E. *Gnathopods*: carpi short, about 0.5× propodi. *Pleon*: pleonites 5 and 6 with two distolateral robust setae. *Pleopods* (Fig. 48): peduncles each with two retinacula, one and three with a single small mediodistal robust seta; rami with 6-9, 8-9, 7-10 medial and lateral articles respectively, inner setae of first article of medial ramus apically bifid. *Uropods*: peduncle of uropod 1 with three dorsolateral and two dorsomedial robust setae, margins each with one apical robust seta, outer ramus with three medial, two lateral and five apical robust setae, inner ramus with two medial one lateral and five apical robust setae; peduncle of second uropod with one dorsomedial and one apical robust seta one each side, outer ramus with one lateral, two medial and five apical robust setae, inner ramus with two lateral, two medial and five apical robust setae. *Telson*: slightly longer than urosomite six; two apical robust setae on either lobe plus a dorsal robust seta on each at M0.75, and a pair of lateral penicillate setules at M0.6.

Description of juvenile "c". *Body*: length 4 mm. Similar to female "a".

Relationship. *Wesniphargus yanchepensis* differs from *Wesniphargus nichollsi* in: eyes absent; flagellum of first and second antennae with more articles; flagellum of first antenna with paired aesthetascs on several articles; second article of mandibular palp relatively shorter; third article of mandibular palp without pubescence, bearing

more E setae; lower lip posteriorly pubescent; palps of first maxilla with fewer setae, and outer plate facially pubescent; third article of maxillipedal palp without rugosities, outer and inner plates bearing more setae; propodi of both gnathopods bearing rugosities; carpus of second gnathopod long; coxae of peraeopods 5–7 each bearing a post-ventral robust seta; peraeopod 6, articles 5 and 6 bearing many setae; coxal gills 5 and 6 not reduced; epimera without post-ventral teeth; pleopods bearing 4-3-3 retinacula (cf. two each); third uropod aequiramous, and bearing medial setae; telson broader and bearing dorsal robust setae additional to paired apical robust setae.

Distribution. Yanchep Cave, Western Australia, 31°33'S 115°41'E.

Wesniphargus nichollsi (Straškraba)

Figs 49–53

Diagnosis. As set out by Williams & Barnard, 1988

Description. As described by Williams & Barnard, 1988.

Material Examined. Western Australian Museum: female "a", 5 mm (WAM 523-97) and male "b", 2.8 mm (WAM 524-97), outflow of Mammoth Cave, Western Australia, 34°03'S 115°01'E; male "d", 2.8 mm (WAM 525-97), from a pool of black water beside the Yellingup to Augusta Road near Margaret River, Western Australia, 33°54'S 115°20'E; all collected by K. Davies, C.M. Austin, B. Knott on 29 August, 1991. This material can be assigned without equivocation to the taxon *W. nichollsi*: it conforms in all essential features to the redescription of this taxon provided by Williams & Barnard (1988). Given the incomplete nature of that redescription (see above), and the provenance of some of the fresh material, the opportunity is taken to fully describe this fresh material.

Description of male "b". *Body*: pleon sparsely armed dorsally; pleonites 1–4 moderately setose distolaterally; pleonite 5 with four lateral robust setae; pleonite 6 with two lateral robust setae; length 2.8 mm. *Head*: rostrum absent; eyes large, dark, reniform. *First antenna* (Fig. 49): length 0.45× body, 1.8× antenna two, peduncle much shorter than flagellum, ratio of lengths of articles 10:7:5, flagellum of fifteen articles, without calceoli, articles 3–11 and 14–15 each with one aesthetasc, articles not uniform, proximal articles shorter than distal, article 3 shortest; accessory flagellum 2-articulate, extending to M0.5 of the second article of the primary flagellum. *Second antenna* (Fig. 49): length 0.25× body; peduncle longer than flagellum, article 4 longer than five, articles 3–5 with sparse ventral setation; left flagellum 6-articulate, right five, weakly setose ventrally, bearing giant calceoli on articles 1–4 of the left flagellum, articles 1–3 of the right, and distal aesthetascs on antepenultimate and ultimate articles of each. *Upper lip*: apical margin rounded evenly. *Left mandible* (Fig. 49): palp article 3 shorter than 2, ratio of lengths 8:35:20, article 2 with long ventrofacial setae and mid-marginal pubescence; article 3 short, falcate, ventrobasally pubescent, setae 0C6D6E; incisor six toothed; lacinia mobilis with five teeth; three setose accessory blades and two plumose interraker setae, several brushy setae onto the base of the molar. *Right mandible* (Fig. 49): ratio of palp article lengths 8:25:20, article 2 ventromedially and facially pubescent, bearing two medial marginal and five submarginal to facial long setae; incisor with four teeth, lacinia mobilis bifid, the anterior branch with 11 peg like, terminally rounded denticles and terminating in a tooth, the posterior branch with seven peg like denticles; accessory blades of two rakers and plumose setae; molar strongly triturative with posterior pappose seta. *Lower lip* (Fig. 49): without inner lobes, bearing elongate blunt robust setae apically on the outer lobes, facially and marginally pubescent; posterior protuberances marginally pubescent. *Maxillae* (Fig. 49). Left first maxilla: palp article 2 narrow, with five thin apical robust setae and two sub apical facial setae; outer plate with seven strong denticulate robust setae; inner plate with two plumose apical setae. Right first maxilla: palp article 2 broad with one apicolateral long stout robust seta distomarginally setulose, two subterminal facial setae, one armed, two stout naked distal robust setae and one small distomedial robust seta; outer plate bearing seven denticulate terminal robust setae; inner plate with two apical plumose setae. Second maxilla: with long distally curved, blunt and flattened apical setae; outer plate mediolateral submarginal face with a short row of two or three long robust setae; inner plate distomedial corner with a slightly submarginal thick plumose seta. *Maxilliped* (Fig. 49). Palp: article 3 with several thick setae on the inner edge, two ventral submarginal setae, a row of four robust setae basal to the dactyl and the adjacent margin pubescent, three strong distolateral robust setae, the apex weakly produced and rugose; dactyl unguiform with a nail, and two accessory marginal spinules; article 2 well setose medially. Inner plate: bearing three stout naked apical robust setae, a short discontinuous row of three plumose submarginal facial setae extending apically from M0.6, and facially distolaterally a single plumose seta and a naked robust seta. Outer plate: with three slightly submarginal mediodistal naked tooth like robust setae, one apical naked tooth like robust seta and three distolateral pappose robust setae. *First gnathopod* (Fig. 50): coxal plate with few apical setae; articles 3–5 with posterior rugose lobes, small on article 3, moderate on articles 4 and 5; carpus short; propodus sub rectangular—length to width ratio 92:65—not expanded apically, palmar corner sub rectangular, not rugose, with two medial and two lateral naked blunt robust setae, palm very weakly oblique, slightly convex, dactylus without accessory marginal spinules, nail long, reaching to palmar corner. *Second gnathopod* (Fig. 50): coxal plate poorly setose apically with three long and three short setae, bearing a long simple sac like gill; articles 2–4 with small posterior rugose margins, carpus longer than the first gnathopod, the lobe much reduced; propodus longer and narrower than the first—length to width ratio 92:50—palmar corner three lateral and one medial stout robust setae, palm with moderately dense simple robust setae. *Peraeopods* (Figs 50, 52): coxa 3 with three long and six short apical setae and a facioanterior row of four moderate setae; coxa 4 emarginate, moderately setose apically and facially; peraeopods 3 and 4 weakly spinose posteriorly, articles 6 with posterior robust setae 1-1-1-1 and 1-1-2-2 plus two locking robust setae, respectively; posterior lobes of coxae of peraeopods 5–7 dominant, with few ventromarginal robust setae (1-1-2), articles 2 strongly expanded, very broadly lobate postventrally, with short posterior setules. *Gills*: coxae 2–6 with sac like gills, those of 5 and 6 reduced slightly; sternites 2–6 with pairs of fleshy lumped gills attached to the lateral edge of each segment. *Epimera*: postventral teeth small blunt protrusions, not acuminate, smallest on the third; posterior margins almost straight; second epimeron with three anteroventral submarginal robust setae, the third with two. *Pleon*: with few dorsal setae and robust setae; pleonites 1–6 with setae 9-6-9-4-0-0, pleonites 5 and 6 with 4-2

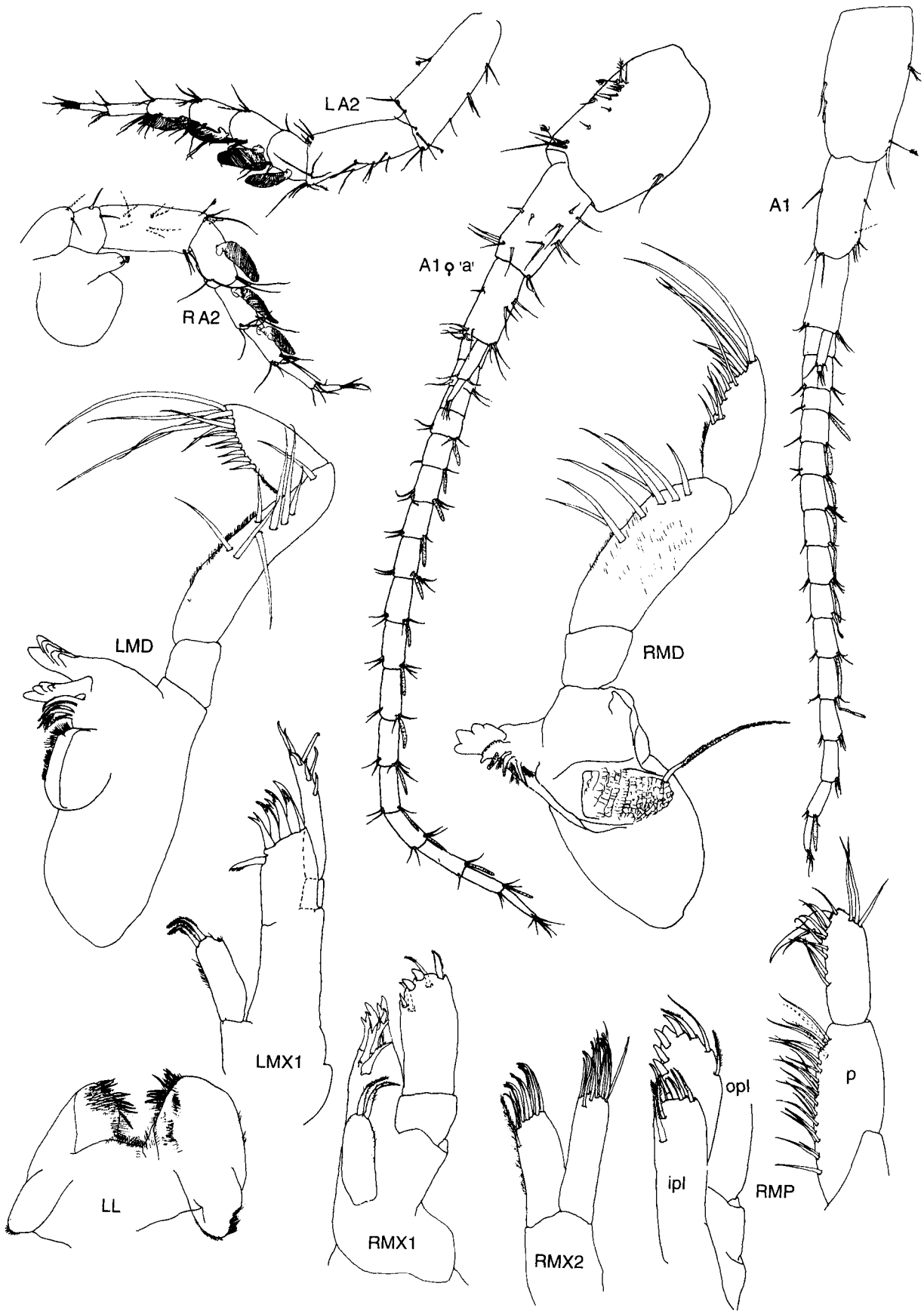

Fig. 49. *Wesniphargus nichollsi* (Straškraba) male "b" 2.8 mm; antennae, mouthparts(all drawings except those indicated). Female "a" 5.0 mm first antenna.

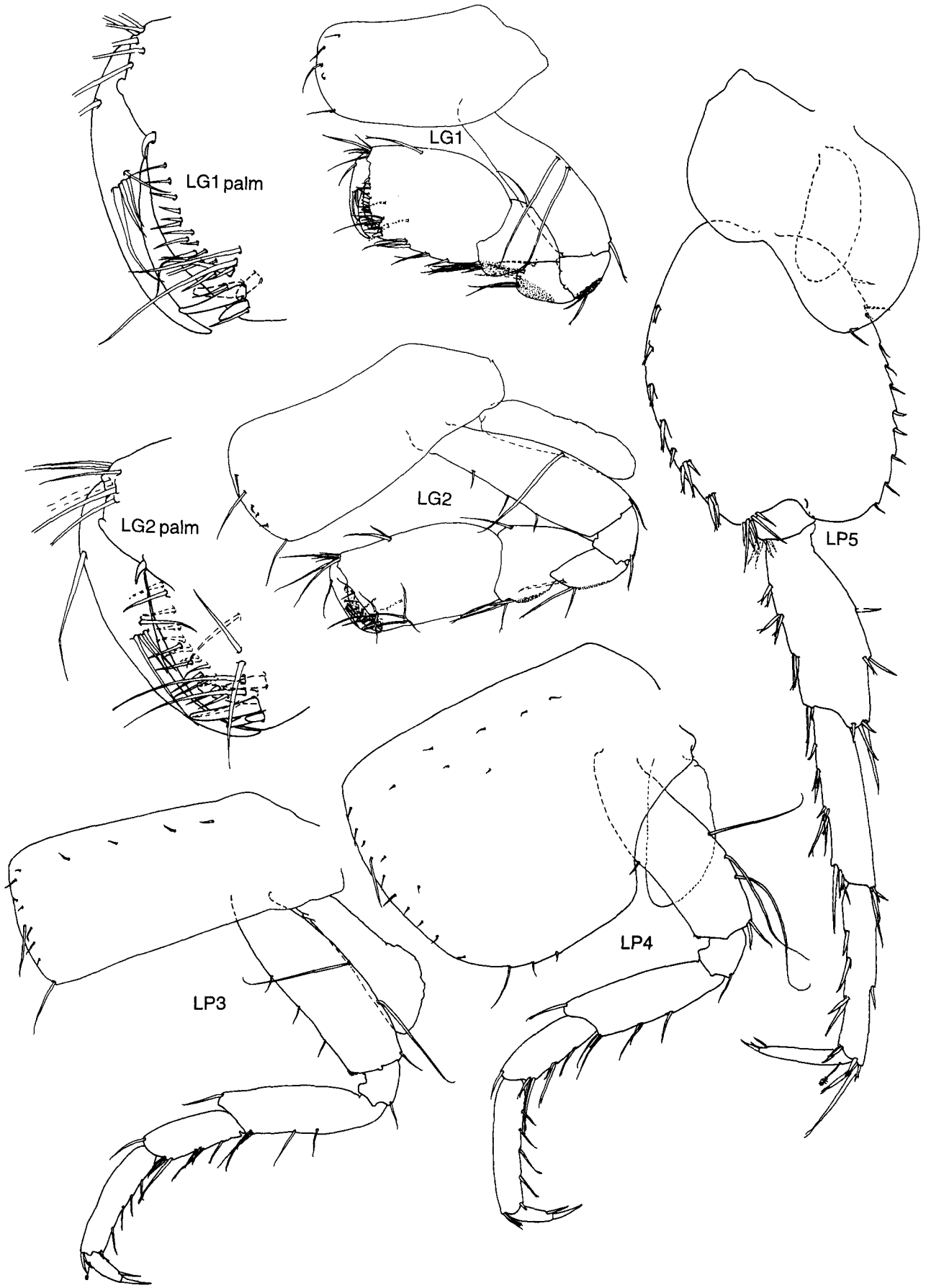

Fig. 50. *Wesniphargus nichollsi* (Straškraba) male "b" 2.8 mm; gnathopods.

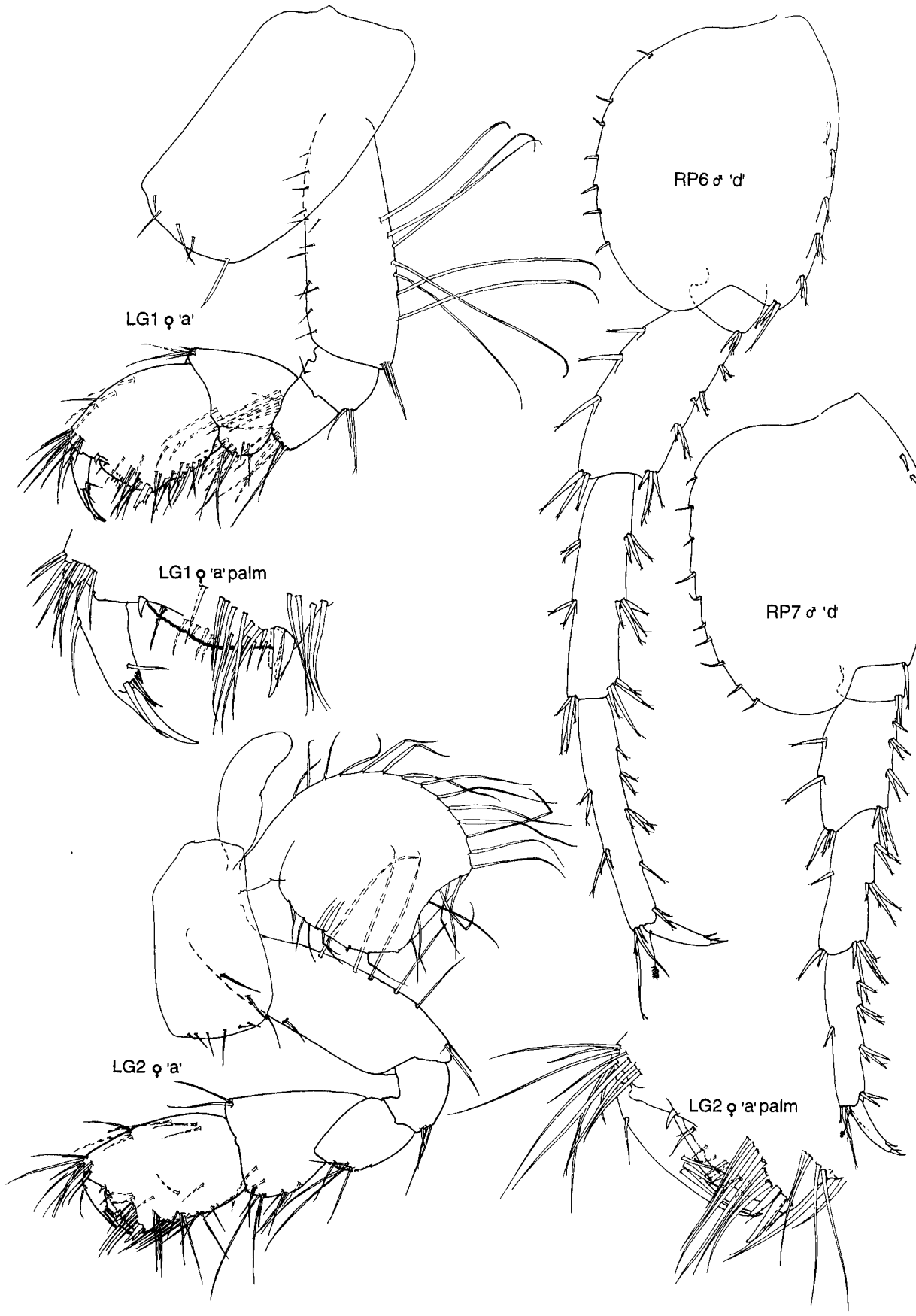

Fig. 51. *Wesniphargus nichollsi* (Straškraba) female "a" 5.0 mm gnathopods 1 and 2, male "d" right peraeopods 6 and 7.

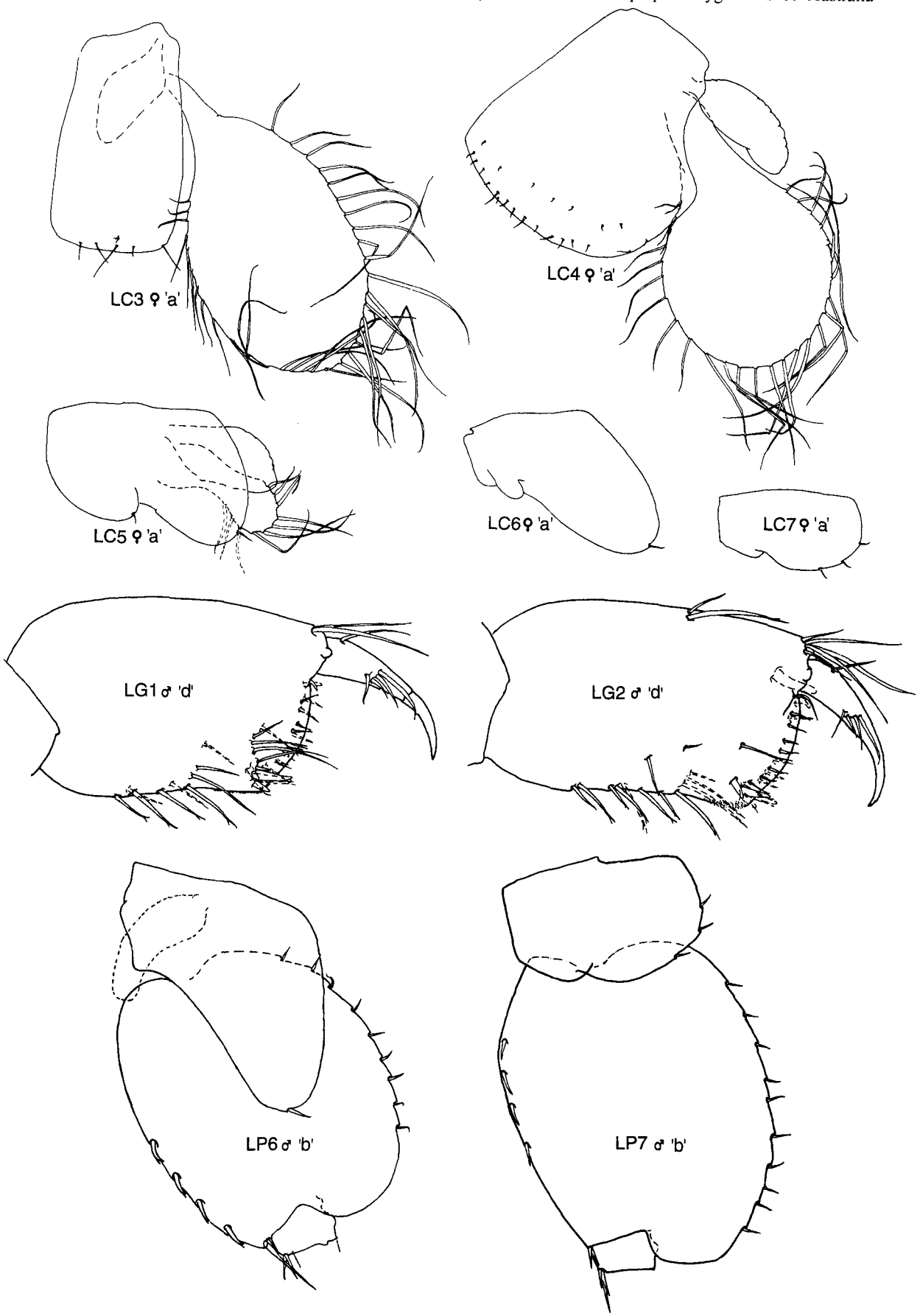

Fig. 52. *Wesniphargus nichollsi* (Straškraba) male "b" 2.8 mm peraeopods 6 and 7 (part), male "d" 2.8 mm dactyls of gnathopods 1 and 2, female "a" 5.0 mm coxae 3–7.

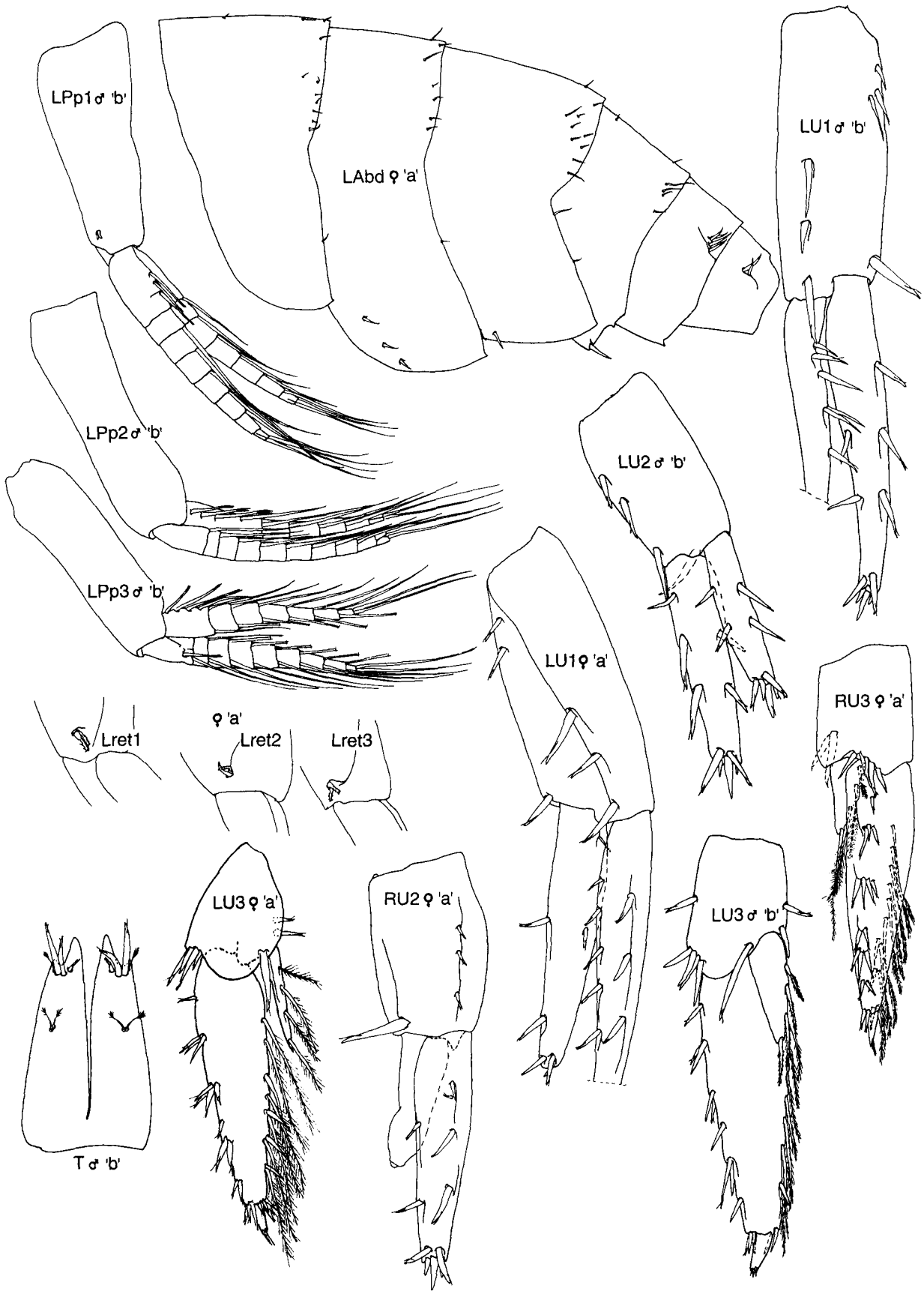

Fig. 53. *Wesniphargus nichollsi* (Straškraba) male "b" 2.8 mm pleopods, left uropods and telson; female "a" 5.0 mm abdomen, retinacula, uropods.

distolateral robust setae. *Pleopods* (Fig. 53): similar; peduncles naked except for a pair of retinaculae; rami moderately long of 8-7, 10-7, 9-7 lateral and medial articles respectively; basal article of the inner rami armed with several terminally bifid setae with asymmetrical apices, some with "diamond" heads, some symmetrical. *Uropods* (Fig. 53). Third uropod: extending beyond first and second in the intact specimen; uropod lengths relative to uropod 1 uropod 2 0.7, uropod 3 0.75. First uropod: peduncle length 1.1× outer ramus, 0.85× inner; outer margin with one apical robust seta and two dorsal robust setae, medial margin with three small basal robust setae and one apical robust seta; lateral ramus shorter than medial, both with two rows of marginal robust setae, the lateral apex with four robust setae, the medial with five. Second uropod: peduncle 0.8× length of the inner ramus with one apicodorsal robust seta and three medial robust setae; outer ramus shorter than the inner—70:100—both rami with two strong rows of marginal robust setae, apices with five robust setae. Third uropod: peduncle length 0.4× outer ramus, much longer than urosomite three—2.9×—with an apicolateral cluster of four faciosubdistal robust setae and a long dorsal robust seta, single mid-medial and mid-lateral robust setae; outer ramus proximal article with six lateral robust seta clusters of 1-2-2-1-2-1 robust setae, the medial margin with a row of seven setae and one distal robust seta; distal article small, 0.14× proximal, with three dorsal sub apical short setae; inner ramus length 0.3× outer, with three medial plumose setae and one apical plumose seta. *Telson* (Fig. 53): elongate, longer than urosomite three; cleft 85%; apices extended mediodistally as short lobes, subapices each with three robust setae in a transverse row, plus a single penicillate setule arising at the base of the largest, most lateral, robust seta; each lobe with a pair of penicillate setules dorsolaterally at M0.6.

Description of female "a". As for male "b" except in the following: *Body*: 5 mm. *First antenna* (Fig. 49): flagellum with seventeen articles, aesthetascs present on articles 4–17; accessory flagellum extending to M0.6 of third article of primary flagellum. *Second antenna*: flagellum without calceoli. *Gnathopods* (Fig. 51): coxal plate of second gnathopod with four long and three short apical setae; carpi longer than male—0.7 to 0.8× propodus; robust setae at corner of palm three (rather than four); posterior margin of propodus with an additional submarginal robust seta; dactyls with two recumbent robust setae on the inner margins *Peraeopods*: coxa 3 with three long and two short apical setae, no row of facial setae; coxa 4 emarginate with 12 short and two long ventral setae and two posterior setae on the anterior face; coxa 5 anterior lobe strongly reduced with one posterior seta on the anterior lobe and one posterior seta on the posterior lobe; coxa 6 with one posterior seta only, coxa 7 with two postventral setae and one posterior seta. *Oostegites* (Fig. 52): present on coxae 2–5; oostegites two to four broadly ovate with long, strong regularly spaced marginal setae; oostegite five more slender, otherwise similar. *Epimera* (Fig. 53): with sparse posterior setation, ventral face of epimeron two with three robust setae, of epimeron three with one robust seta. *Pleonites* (Fig. 53): 1–4 with small posterior robust setae, 5 and 6 bearing strong lateral spination. *Urosomite one* (Fig. 53): with strong articulate ventrodistal robust seta at the base of uropod 1. *Pleopods* (Fig. 53): each bearing pair of retinacula, without accessory retinacula or robust setae. *Uropods* (Fig. 53): rami of first uropod both with four apical robust setae; peduncle of third uropod with five (rather than four) apicolateral robust setae; outer ramus proximal article with 1-3-4-2-3-2 lateral robust setae, distal article with two sub terminal setae.

Description of male "d". *Body*: length 2.8 mm. *Gnathopods* (Fig. 52): subrectangular, similar size, less spinous than female "a". *Peraeopods* (Fig. 51): peraeopod 6 much longer than seven—1.3×—both with long basodactylar setae as long or longer than dactyl; peraeopods without other setae; article 2 of peraeopod 6 with moderate single posterior robust setae, anterior robust setae stronger, several paired; article 2 of peraeopod 7 with small to moderate posterior robust setae, few anterior robust setae, none paired; anterior robust setae of both peraeopods 6 and 7 dominant to posterior.

Distribution. Mammoth Cave, and near Margaret River, Western Australia, 34°03'S 115°01'E.

Paramelitidae Bousfield, 1977

***Pilbarus* n.gen.**

Etymology. Named for the type location.

Type species. *Pilbarus millsi* n.sp.

Diagnosis. Pleonites with moderate, mostly posterior transverse dorsal setation, rostrum obsolescent, lateral cephalic lobes moderately projecting, antennal sinus strong. Eyes absent. Antenna one elongate, longer than antenna two, ratio of lengths of peduncular articles about 3:2:1.5, accessory flagellum 4-articulate; second antenna peduncle longer than flagellum—85:74; flagellum of male bearing large calceoli. Mandibular palp of three articles, ratio of lengths about 2:3:2 to 2:4:3, articles 1 and 2 naked laterally, article 2 with distal oblique row of five strong rastellate setae, article 3 falcate, setae CDE. Labium with weak inner lobes. Maxillae without medial setae: first maxilla inner plate linear, apically tapered, with two plumose apical setae; outer plate with nine left, ten right denticulate apical robust setae; palps asymmetric, left palp with slender apical robust setae, right with 2-articulated elements but mostly broad robust setae fused to the article. Second maxilla inner plate without oblique setae, with two plumose mediodistal setae slightly submarginal, both plates with long curved apical setae. Maxillipedal palp with few lateral setae, with dense medial and medioventral setae, article 3 with a row of setae basal to the dactyl, but no comb row. Coxae 1–4 moderately elongate, coxa 3 with a few weak posterior setae, coxa 1 subquadrate, not expanded apically, coxa 4 moderately emarginate, coxae 5–7 posteriorly dominant, shorter than four. Gnathopods small, propodus of first gnathopod of male expanded, wider; carpus of the second relatively long, articles 3 and 4 of the first and four of the second with long posterior scythe robust seta, not lobate; propodus rectangular, palms weakly oblique, robust setae at the corner of the palm two and three, along the palm moderately crowded, without triggers. Posterior robust seta sets on article 6 of peraeopods 3 and 4 evenly spaced, legs 5–7 elongate, second article moderately to broadly expanded posteriorly and lobate, dactyls of peraeopods 3–7 without additional setules. Coxae 2–6 with sac like gills, thoracic segments without sternal gills. Basomedial setae of inner rami of pleopods bifid, branches simple; retinacula two each peduncle with one or two accessory robust setae. Pleonites with dorsal setae or robust setae. Epimera without postventral robust setae, with ventrofacial robust setae and sparse posterior setae. Rami of uropods 1 and 2 extending unequally; each with two rows of robust setae; uropod 1 without basofacial robust setae; uropod 3 extended beyond 1 and 2 in the intact specimen;

peduncle short, variramous; outer ramus 2-articulate, the second article short, the inner ramus reaching to M0.4 or less in the female, to M0.7 of outer ramus of male; poorly armed. Telson moderate length, about the same length as urosomite three, without dorsal setation, tumid, cleft more than 80%, with apical and dorsal spination.

Additional Description. Flagellum of first antenna lacking major arms. Upper lip apical marg evenly rounded. Mandibular accessory blades (rakers) with interraker plumose setae, additional penicillate setae beyond rakers riding onto base of molar; molar with pappose apical seta, palp article 3 shorter than 2, article 2 without sparse basoanterior setae with few facial apicoanterior setae. Maxilla two both plates with rows of long distal setae. Maxillipedal palp article 3 with ranks of thin setae on inner edge, and a row of three long setae facial, basal to the dactyl; dactyl with two accessory spinules basal to the nail; the apex weakly produced, pubescent; the outer plate with a row of setose robust setae distally, continuous with a row of teeth medially, the inner plate with three thick robust setae and plumose setae apically and a long medial row of plumose setae. Dactyl of gnathopods reaching ends of palms, some with small recumbent inner tooth like robust seta fused to dactyl, and several setules at inner nail articulation line, leg six longer than seven, legs 5–7 article 2 posterior setae small, regularly spaced. Sternal processes absent, epimera without postventral teeth. Pleopods similar, rami subequal. Apicolateral corner of peduncle of first uropod with one robust seta, rami of uropods 1 and 2 subequal, with four and five apical robust setae. Third uropod with or without facial robust setae, rami without plumose medial setae, ventrodistal robust seta on urosomite one at the base of uropod 1 long and strong, longer than *Austrocrangonyx*.

Relationship. This genus differs from other Paramelitidae, except *Antipodeus*, in the absence of sternal gills. Despite this it is closest to *Austrogammarus* in the form of the antennae, palp of first maxilla, gnathopods, and third uropod. *Pilbarus* differs from *Austrogammarus* in the absence of eyes, longer first article of the mandibular palp which lacks A setae but bears C setae, absence of medial setae on the first maxilla inner plate, absence of long straw like pubescence on the second maxilla, absence of dense lateral setae on the maxillipedal palp, presence of inner lobes on the labium, reduction of the palmar robust setae, more expanded and lobate second articles of peraeopods 5–7, absence of coxal gill 7 and of sternal gills, absence of marginal setation on the third uropod and of dorsal setation on the telson, and the presence of a long and strong robust seta on the first urosomite at the base of the first uropod. *Pilbarus* differs from *Austrocrangonyx* in absence of medial setae on the maxillae, reduced numbers of retinacula and presence of accessory retinacula, greater numbers of ventrofacial robust setae of the epimera, and presence of single rather than paired apicolateral robust setae on the peduncle of the first uropod. *Pilbarus* is similar to *Uroctena* in the absence of eyes, poor setosity of the mandibular palp, asymmetry of the palps of the first maxilla, weakly oblique gnathopodal palms, broad ovate expansion of the second article of peraeopods 5–7, form of the first and second uropods and length of the outer ramus of the third uropod, and absence of posteroventral epimeral teeth, but differs in that lateral cephalic lobes project moderately, accessory flagellum of the first antenna is no more than 4-articulate, second antenna is not pediform and calceoli are present on the male antenna, first article of mandibular palp relatively long, third article strongly rather than weakly falcate, with CDE setae only, labium bearing inner lobes, inner plate of first maxilla linear rather than ovatotriangular, outer plate with nine or ten (cf. 11) apical robust setae, medial setae of maxillipedal palp dense rather than moderate, apex of the third article pubescent, coxae 1–4 moderately long rather than short, coxa 1 not expanded apically, carpus of second gnathopod long, dactyls of peraeopods without additional spinules, thoracic segments without sternal gills, pleopods bearing spinous accessories to the retinacula, third uropod variramous being parviramous in the female and almost magniramous in the male, telson without dorsal setation but with additional dorsal spination. The genus is similar to *Hurleya* in the presence of only sparse lateral setae on the maxillipedal palp; coxal gill 6 is not reduced; but differs in many ways, including the ratio of lengths of peduncular articles of the first antenna; coxa 1 not short; gnathopods are not large, but are sexually dimorphic and bear scythe robust setae; palmar robust setae are reduced and simple; peraeopod 6 is longer than seven; articles 2 of peraeopods 5–7 are expanded and lobate; dactyls of the legs are not lobate; accessory retinaculae are present on the pleopods; third uropod is extended and variramous; telson is cleft 83% rather than 63% and has both apical and dorsal spination. *Pilbarus* is similar to *Antipodeus* in the fusion of strong palp setae of right the first maxilla; the small size of gnathopods; broad expansion and presence of postventral lobes of article 2 of peraeopods 5 and 7; broad oostegites; and differs in absence of eyes; greater number of accessory flagellum articles; presence of calceoli in the male; longer first article of the mandibular palp and poor setation of the second palp article, and lack of A setae; presence of inner lobes of the labium; absence of trigger robust setae on the gnathopodal palms; absence of coxal gill 7; uropod 3 variramous; telson with basofacial arms; and the ventrodistal robust seta on urosomite one long and strong. The new genus is similar to *Chillagoe* in the asymmetry of the palps of the first maxilla; the absence of a gill on coxa 7 and lack of reduction of gill 6; but differs in that lateral cephalic lobes do not project strongly; flagellum of antenna two is not shorter than peduncle; first article of mandibular palp is relatively short article 2 poorly setose, and C setae present; inner lobes present on labium; coxa 4 moderately emarginate; palms not strongly oblique; palmar robust setae reduced; oostegites are not slender; third uropod has an inner ramus; telson cleft more than 70% and with four rather than one apical robust seta. *Pilbarus* is similar to *Toulrabia* in the terminal setae of the mandibular palp are CDE; palps of first maxilla are similarly asymmetric; palmar robust setae of gnathopods are simple; coxae 2–6 bear gills, the sixth not reduced; peduncles of pleopods bear two retinacula and accessory spinules; but differs in the third peduncular article of antenna one is relatively long; flagellum of the second antenna not

greatly shorter than peduncle; second articles of peraeopods 5–7 ovate rather than pyriform; dactyls of peraeopods not multi-spinose; coxae 2–4, rather than 2–5, bear oostegites; uropod 3 is moderately extended rather than poorly, am d the outer ramus has two rather than one article; the telson is longer than broad, cleft 83% rather than 60%, without setae, but with basolateral spination. *Pilbarus* is similar to *Protocrangonyx* in that eyes are absent; the flagellum of antenna two is not much shorter than peduncle; palps of the first maxillae are asymmetric; coxae 2–6 bear gills; and differs in that the body is not sub vermiform; the accessory flagellum of antenna 1 is 4- rather than 2-articulate; ; calceoli occur on the second antenna; third article of mandibular palp is falcate, and C setae are present; the labium has inner lobes; coxae are moderately long, not short, and coxa 4 emarginate; gnathopodal palms are slightly not strongly oblique; palmar corner robust setae are reduced and palmar robust setae without triggers; leg seven is shorter than six and articles 2 of peraeopods 5–7 ovate and moderately lobate; uropod 3 is strong, not feeble, is extended, variramous, and the outer ramus 2-articulate; telson cleft, moderately long, and with dorsolateral as well as apical spination; peduncles of pleopods weakly to moderately setose, the outer rather than inner rami shortened; ventrodistal robust seta at the base of uropod 1 present and strong and long.

Pilbarus millsi n.sp.

Figs 54–57

Etymology. Named for the type locality.

Type locality. Deep Reach Pool, Pilbara Springs, Millstream, northern Western Australia, on the Fortescue River, 21°37'S 117°06E.

Material Examined. HOLOTYPE (Australian Museum P51378) female "a", 9 mm. ALLOTYPE (Australian Museum P51379) male "b", 7 mm. Others in the type series: females "c" 7 mm and "d" 6 mm, several small juveniles 3–5 mm. Collected by W. Ponder and W. Edgecomb, Deep Reach Pool, Pilbara Springs, Millstream, Western Australia, September, 1987. Australian Museum Collection P38475.

Diagnosis. With the characteristics of the genus

Description of holotype (female "a"). *Body* (Fig. 54): pereon with sparse setation; pleon with strong transverse posterodorsal setation and spination, length 9 mm. *Head*: small anterior marginal setae at the base of antenna one; rostrum weak; lateral cephalic lobe moderate; antennal sinus moderate; eyes absent. *First antenna* (Fig. 54): length 0.6× body, 1.9× second antenna; peduncle sparsely setulate, ratio of lengths of articles 10:7:5; flagellum much longer than peduncle, ratio of lengths 200:82, setae sparse, flagellum of 33 articles; accessory flagellum 4-articulate, reaching to the end of article 4 of the primary flagellum, without aesthetases or calceoli. *Second antenna* (Fig. 54): length 0.3× body; peduncle longer than flagellum, ratio of lengths 85:74; article 4 longer than five—33:29—articles 3–5 moderately setose; flagellum of fourteen articles, moderately setose, without aesthetases or calceoli. *Left mandible* (Fig. 55): palp of three articles, ratio of lengths 8:16:11, article 1 naked, article 2 naked medially and laterally, mediodistal face bearing an oblique row of six strong rastellate setae the longest reaching beyond M0.5 of the third article; third article broad, falcate, facially pubescent, setae 1C13D4E; incisor six toothed; lacinia mobilis five toothed; accessory blades of three rakers and three plumose setae, with three blunt bent brushy setae and fine setules onto the base of the molar; molar triturative with an anterior plumose seta and short posterior pappose seta. *Right mandible* (Fig. 55): palp articles 1 and 2 naked laterally and medially, second article with an oblique distal row of five strong rastellate setae reaching to beyond M0.5 of the third article, third article with long basofacial setules, facial pubescence, setae 14D4E; incisor with seven teeth; lacinia mobilis bifid, denticulate the posterior lobe bearing anterior and posterior teeth; accessory blades of two rakers and two plumose setae; molar triturative with short anterior plumose seta and long posterior pappose seta. *Left first maxilla* (Fig. 55): palp article 2 with seven simple slender distal robust setae; outer plate with nine apical denticulate robust setae; inner plate with two apical plumose setae, the medial slightly sub apical. *Right first maxilla* (Fig. 55): with five broad mediodistal to apical robust setae fused to the article and a single strong articulated lateral sub apical robust seta and one plumose seta; outer plate with ten apical denticulate robust setae; inner plate with two apical plumose setae, the medial seta slightly sub apical. *Second maxilla* (Fig. 55): lateral margin of outer plate without additional seta, inner margin of inner plate with two plumose setae subdistal sub marginal to the medial edge. *Maxilliped* (Fig. 55): outer plate with long medial robust setae and setae, moderately oblique; from the mid-medial margin ten strong robust setae, which increase in size distally, form a moderately oblique row across the face of the article, the ultimate robust seta mid apical, forming a continuous row with five apicolateral plumose setae; facial to the robust seta row lie four ranks of 1-1-2-2 slender setae; inner plate with five plumose medial setae, transverse row of three stout naked tooth like robust setae, three apicolateral and one ventrofacial plumose seta, and one mid apical fine seta. *First gnathopod* (Fig. 56): coxal plate with moderate apical and apicoanterior marginal setae; articles 3 and 4 bearing strong posterior scythe robust setae, rastellate on article 4; carpus short, about 0.55× propodus, slightly lobate, bearing many strong posterior rastellate robust setae; propodus long, trapezoidal, the posterior margin bearing ranks of moderate rastellate robust setae, corner of palm with one strong and two long slender lateral robust setae and one naked medial robust seta; palm slightly oblique with few short simple robust setae; dactyl with a transverse rank of four accessory setules at M0.4, nail reaching the end of the palm. *Second gnathopod* (Fig. 56): slightly larger than first gnathopod; coxal plate with two posterior setae, bearing sac like gill and broad sparsely setose oostegite; article 4 bearing long posterior robust setae; carpus elongate, as long as the propodus, bearing posterior ranks of many long simple setae; propodus elongate; posterior ranks of many long simple robust setae similar to but slightly shorter than of the carpus; palmar corner with one blunt medial robust seta and two lateral bifid robust setae, palm convex, robust setae simple, moderately long and crowded; dactyl with blunt recumbent inner tooth like robust seta, four facial spinules, nail reaching to the palmar corner. *Peraeopods* (Fig. 56): coxa 3 with few apical setae, posterior corner indistinct, posterior margin with one or two setae; coxa 4 sparsely setose apically with a row of posterior setae, moderately emarginate; both coxae bearing sac like gill and apically setose oostegite; peraeopods 3 and 4 similar, longer

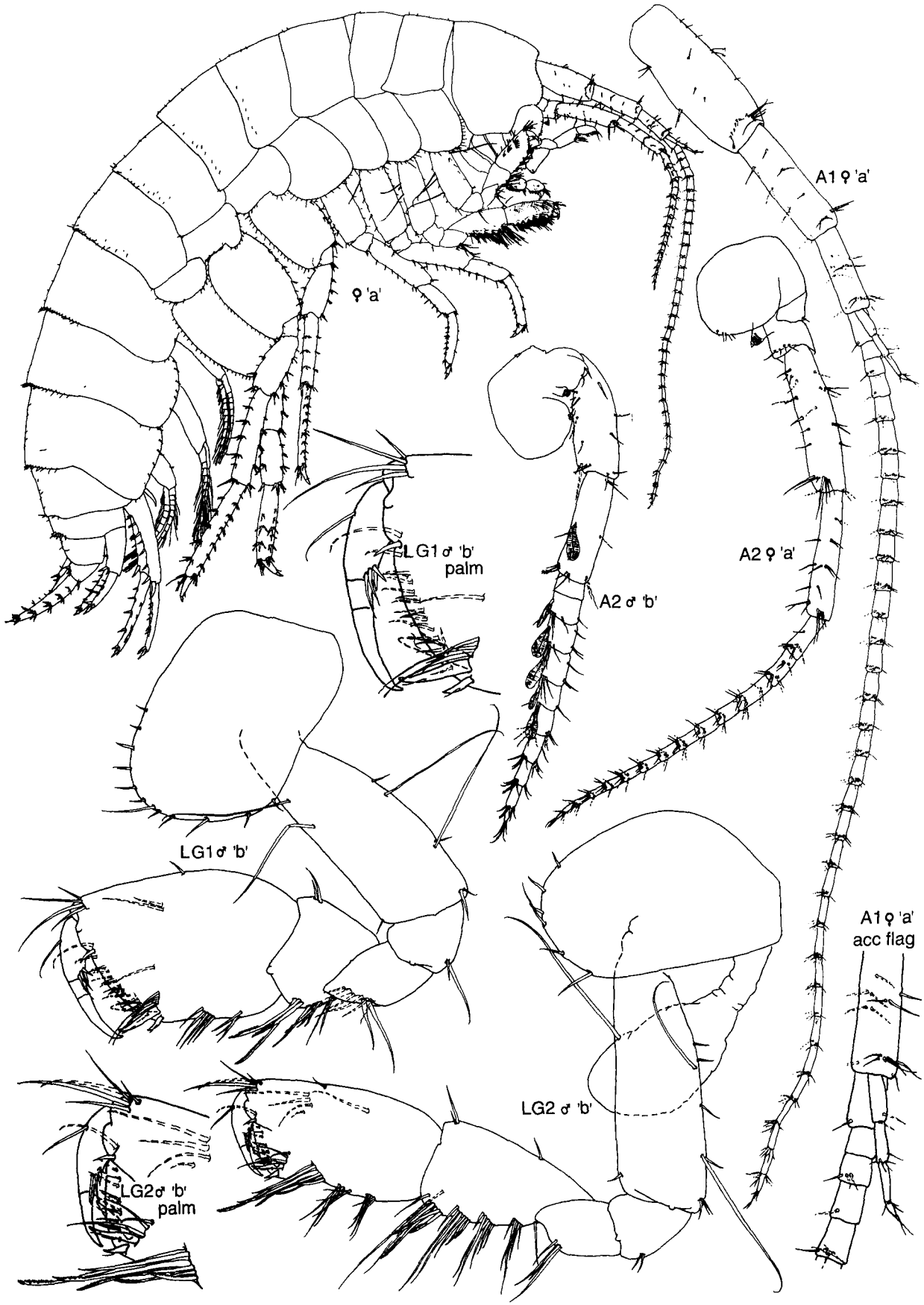

Fig. 54. *Pilbarus millsi* n.sp. holotype female "a" 9 mm whole specimen, antennae, accessory flagellum; allotype male "b" 7 mm antenna two, gnathopods 1 and 2.

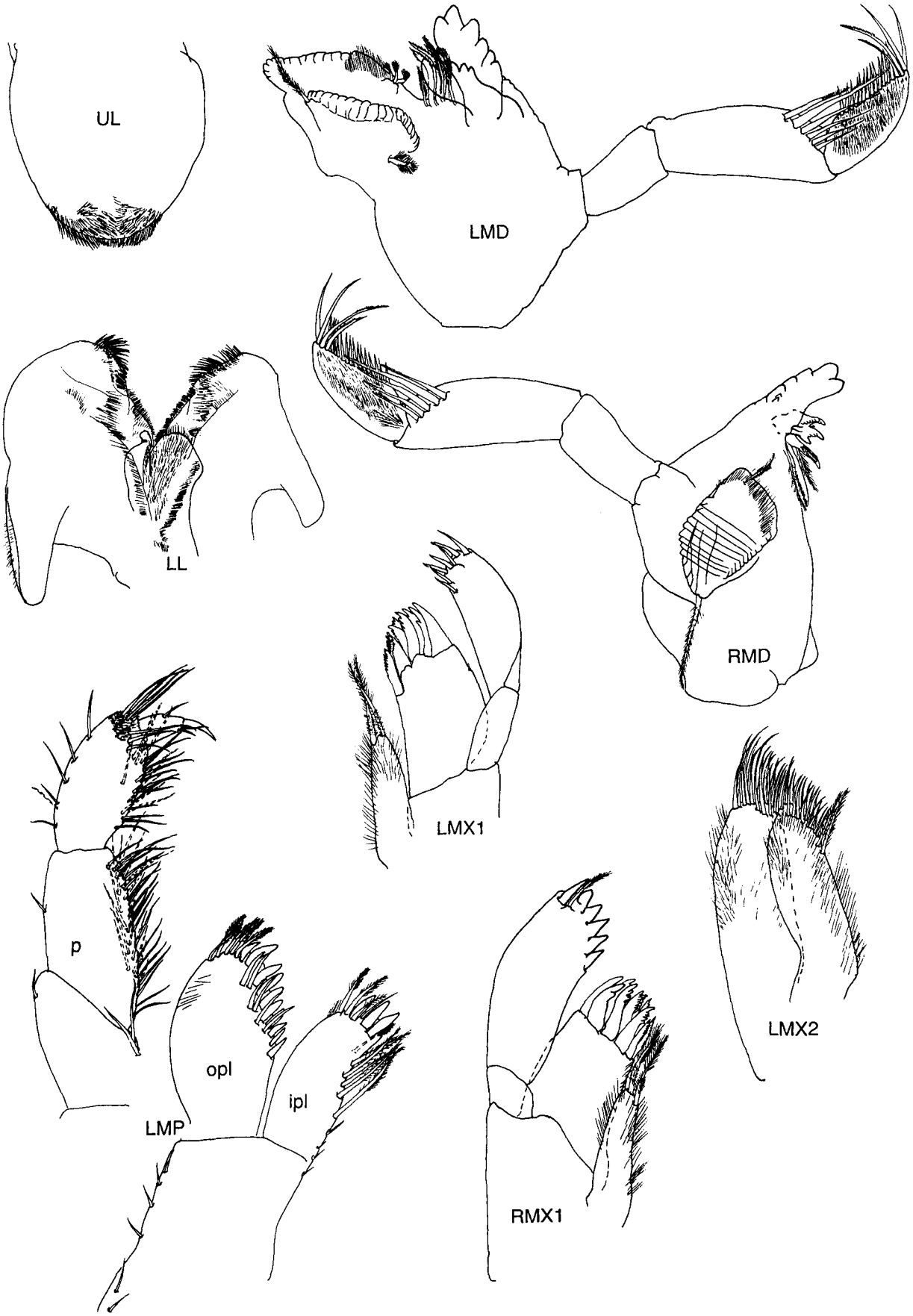

Fig. 55. *Pilbarus millsi* n.sp. holotype female "a" 9 mm; mouthparts.

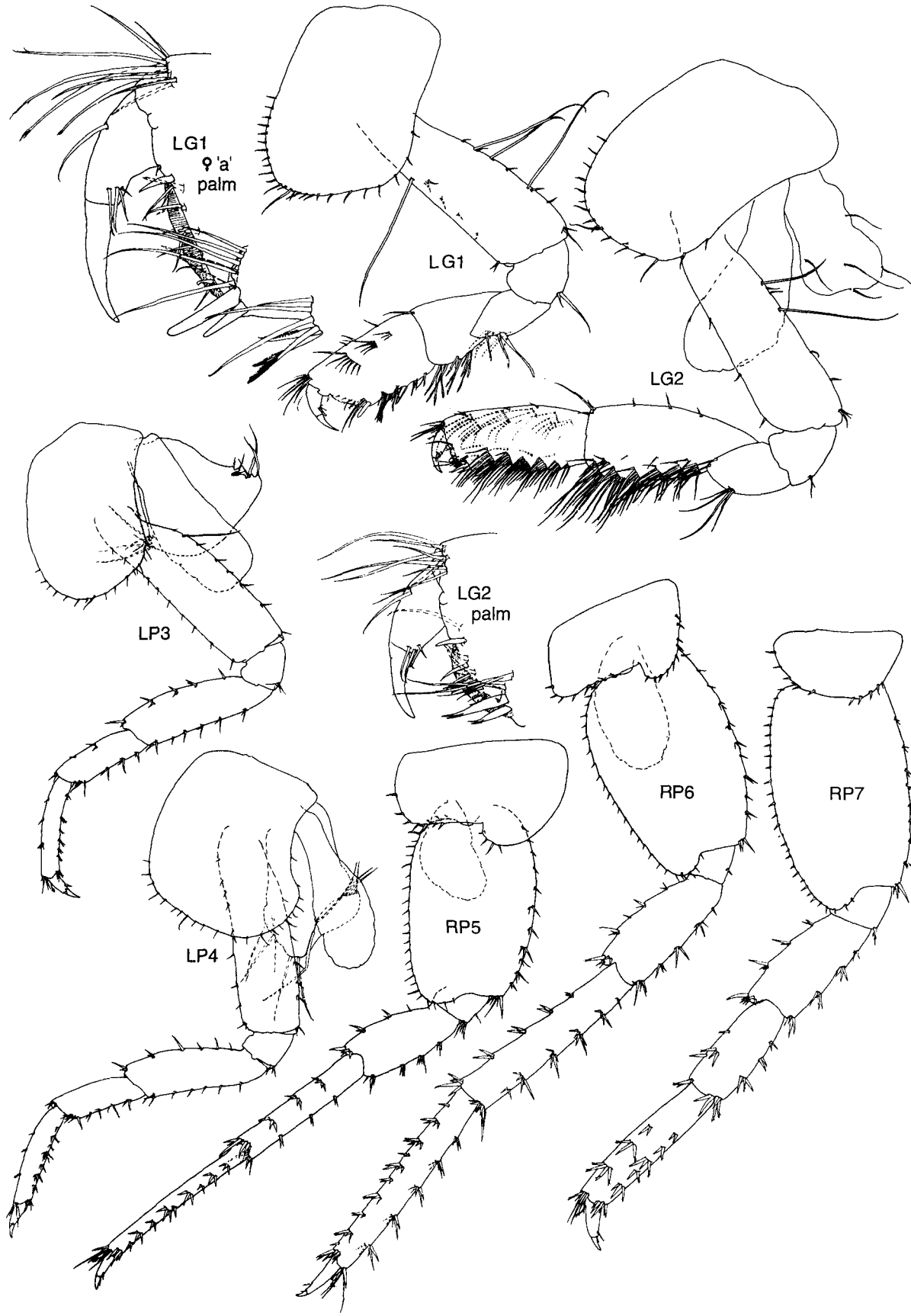

Fig. 56. *Pilbarus millsi* n.sp. holotype female "a" 9 mm; legs (all drawings except those indicated); female "c" palm of first gnathopod.

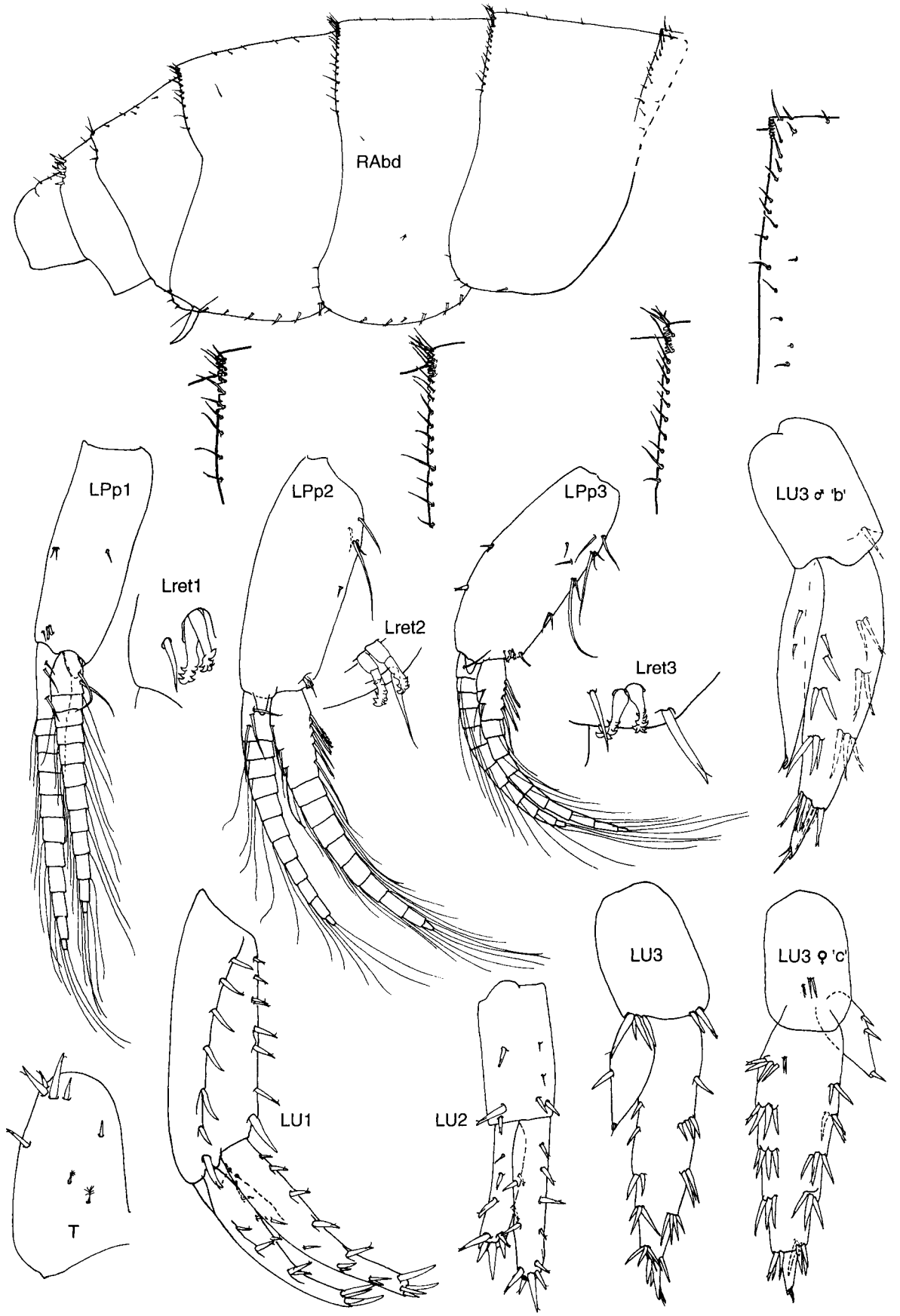

Fig. 57. *Pilbarus millsi* n.sp. holotype female "a" 9 mm; abdomen, gills, pleopods, uropods, telson (all drawings except those indicated); allotype male "b" 7 mm, third uropod; female "c" 7 mm, third uropod.

than gnathopod two, articles 4 and 5 moderately setose posteriorly, article 6 of peraeopod 4 with more posterior robust setae than peraeopod 3: peraeopods 5–7 similar, six longest, seven shortest, coxae shorter than coxa 4, posterior lobe dominant, coxae 5 and 6 bearing sac like gills, articles 2 expanded posteriorly, ovate, moderately lobate postventrally, with many short posteromarginal robust setae, other articles moderately equipped with short stout anterior and posterior robust setae; dactyls of peraeopods 3–7 each with one distofacial and one mediomarginal setule. *Epimera* (Fig. 57): without postventral teeth, posterior angles rounded, posterior setae sparse, with 1-6-6 ventrofacial robust setae. *Pleon* (Fig. 57): with sparse dorsal setae; posterior margins of pleonites 1–3 with dense, short transverse setules, and small dorsolateral truncated robust setae; pleonite 4 with sparse, weak posterior spinules; pleonite 5 with a submarginal transverse rank of five moderate and three small robust setae. *Urosomite one* (Fig. 57): with a long strong robust seta at the base of the first uropod. *Pleopods* (Fig. 57): peduncles with scarce armature, peduncle one with two mid facial spinules, two retinacula and one accessory robust seta; peduncle two with four mediobasal and one mid medial robust seta, two retinacula and one accessory robust seta; peduncle three with several strong and weak medial robust setae, two short lateral robust setae, two retinacula and two accessory robust setae; rami similar, basomedial setae of inner rami bifid; rami with 12-12, 11-10, 11-10 articles respectively. *Uropods* (Fig. 57). First uropod: peduncle length 1.2× outer ramus, 1.0× inner ramus; outer margin with dorsal row of six moderate robust setae and one distolateral robust seta; inner margin with seven dorsal and one distomedial robust seta; both rami with two rows of dorsal robust setae and four apical robust setae. Second uropod: peduncle as long as outer ramus, 0.8× inner ramus, weakly spinous on both margins, with paired distolateral and distomedial robust setae; rami with two rows of dorsal robust setae, each with four apical robust setae. Third uropod: variramous; peduncle length 0.5× inner ramus, 1.2× outer ramus; without marginal or facial arms; pair of distolateral robust setae and rank of four distomedial robust setae basal to the inner ramus; proximal article outer ramus with four transverse lateral ranks of 1-3-3-4 and one distal robust seta, and five transverse medial ranks of 1-1-2-3-4 and one distal robust seta; distal article small with three fine apical setules; inner ramus short, with one mid medial robust seta and one apical setule. *Telson* (Fig. 57): slightly shorter than urosomite three; lobes cleft 83%, laterally tumid; lateral sub apical transverse row of two large and two small robust setae, marginal dorsolateral robust seta at M0.6, small submarginal dorsomedial robust seta at M0.67 and mid dorsal penicillate setules at M0.3 and M0.4.

Description of allotype male "b". As for female "a" except in the following. *Body*: length 7 mm. *Second antenna* (Fig. 54): peduncle articles 4 and 5 with sparse arms, article 5 bearing large calceolis ventrally at M0.0.5; flagellum of ten articles with moderate setation; articles 2–6 bearing large ventral calceoli. *Mandibles*: left palp article 3 with setae 8D4E; right palp with setae 1C8D5E. *First gnathopod* (Fig. 54): articles 3 and 4 with strong simple posterior robust setae; carpus short, with moderate and long rastellate setae; propodus ovate rather than long, length 1.2× width; posterior margin with two transverse ranks of moderate setae, palmar corner rounded, with one large medial tooth like-robust seta, two lateral robust setae; palm slightly convex with moderately crowded simple robust setae; dactylus with a mid rank of four accessory spinules, nail reaching to the palmar corner. *Second gnathopod* (Fig. 54): coxal plate with sparse, moderately long apical setae, without posterior setae, bearing a large sac like gill; article 4 with several long, simple robust setae; carpus moderately long, 0.7× propodus, with four transverse ranks of mixed simple and rastellate robust setae; propodus trapezoidal, longer than wide length 2× width, posterior margin with two ranks of moderate simple robust setae and one of mixed long simple and rastellate robust setae; palmar corner broadly curved, with one medial and two lateral strong robust setae; palm convex, with moderate numbers of short simple robust setae; dactyl with four accessory setules, nail reaching to palmar corner. *Third uropod* (Fig. 57): variramous, outer ramus 1.45× inner ramus, 0.45× peduncle; peduncle without marginal or facial arms, with a single moderate distolateral robust seta adjacent the base of the outer ramus; outer ramus proximal article with lateral transverse ranks of 2-2-3 marginal robust setae and three distal robust seta, medial transverse ranks of 1-1-2-3 marginal robust seta and four distal robust setae; distal article small, naked except for two small apical setae; inner ramus with two mid facial setae and one small distal seta.

Description of female "c". As for female "a" except in the following. *Body*: length 7 mm. *Mandibles*: left palp article 3 with setae 1C12D4E; right palp setae 1C11D4E. *First gnathopod* (Fig. 56): palmar corner with one medial strong naked robust seta and five long slender and two strong naked lateral robust setae; palm moderately convex slightly oblique, with moderate numbers of simple robust setae. *Third uropod* (Fig. 57): variramous, peduncle length 0.5× outer ramus, 1.5× inner, with three small facial setae; outer ramus 2-articulate, proximal article with lateral transverse ranks of 4-4-4-3 and three distal robust setae, two small facial setae adjacent the most basal rank of robust setae, and medial transverse ranks of 2-3-3-3 and 4 distal short robust setae; distal article short with two small apical setules; inner ramus with two mediofacial short robust setae and one short distal robust seta.

Description of female "d". *Body*: length 6 mm. *Right mandible*: right mandibular palp article 3 setae 1C9D5E. Otherwise similar to female "a".

Distribution. Deep Reach Pool, Pilbara Springs, Millstream, Western Australia, 21°37'S 117°06E.

Synopsis

Thirty described species of Australian stygobiont amphipods were listed by Bradbury & Williams (1997). The present paper significantly extends this number by adding a further fourteen species and noting another species (*Wesniphargus nichollsi*) previously described, now regarded as a troglophile. Two of the new species fall within the two families which previously contained most of the diversity (Melitidae and Paramelitidae), but most are unequivocally neoniphargids and hence now bring this family into more or less equal position as a contributor to diversity of Australian stygobiont amphipods. Table I provides an updated synopsis of known forms arranged in the same way as did Bradbury & Williams (1997, table I). Figure 58 similarly documents the geographical distribution of all described forms (with some exceptions, as noted).

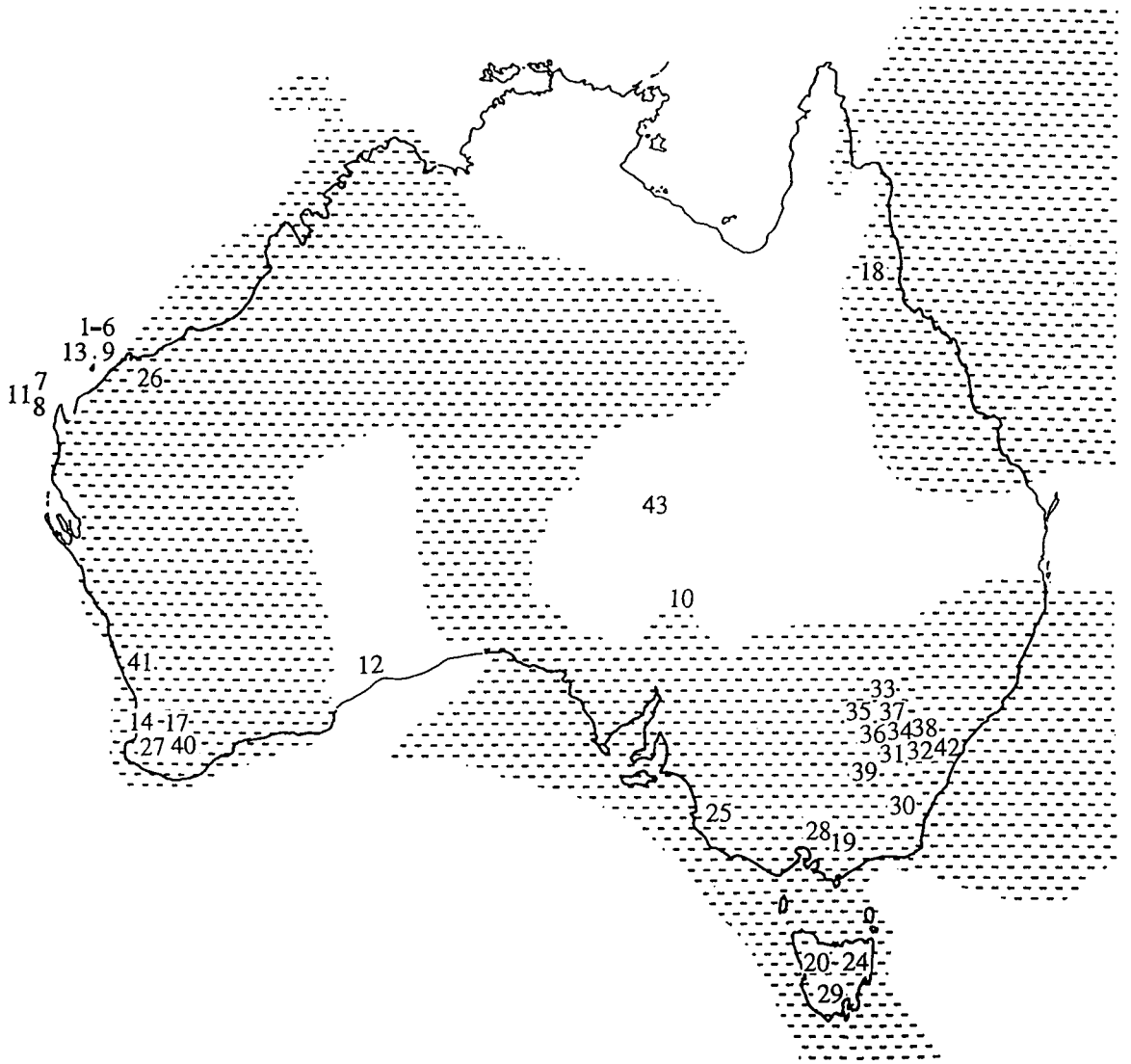

Fig. 58. Distribution of known stygobiont Australian amphipods. Stippled area indicates landmass not inundated during the Cretaceous (119–114 million years ago). Numbers indicate species shown in Table 1—*Austrochiltonia australis* (44) widespread and *Pseudomoera fontana* (45) known from widely separated locations in the southeast, not shown.

Discussion

The taxonomic and distributional information given in this paper support the general conclusions of Bradbury & Williams (1997) on the extent, nature and causes of stygobiont amphipod diversity in Australia. Thus, the description of fourteen new species confirms the significant diversity of this fauna in Australia in both hadzioid and crangonyctoid families, and the geographical distribution of these new species falls clearly within areas of Cretaceous marine transgression (melitoid species) or areas not so inundated during the Cretaceous (Paramelitid and Neoniphargid species). As further confirmation of the importance of karst in promoting stygobiont diversity, note that the new crangonyctoid species (except *Wesniphargus yanchepensis*) were collected from caves in the karst systems of New South Wales.

Much remains for investigation with regard to the stygobiont amphipods of Australia, not least in respect of their evolution and the adaptive and selective processes involved in this. Many areas of karst (for example, eastern Victoria, southeast South Australia, Nullarbor Plain, Camooweal caves in western Queensland, and many caves in Tasmania), as well as other caves (for example, the lava tubes at Undara in Queensland) have yet to be thoroughly examined, or their fauna described. Several of these sites are known to contain populations of stygobiont amphipods (Eberhard *et al.*, 1991; Eberhard & Spate, 1995), and will be the subject of future reports. Australia must now be recognised as a major centre of stygobiont amphipod diversity and we hope the present paper will both promote and support further investigations which build on this recognition.

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References

Barnard, J.L., & C.M. Barnard, 1983. Freshwater Amphipoda of the World, 1. Evolutionary Patterns. II. Handbook and Bibliography. Hayfield Associates, Mount Vernon, Virginia. Pp. 1–830.

Barnard, J.L., & W.D. Williams, 1995. The taxonomy of Amphipoda (Crustacea) from Australian fresh waters. Part 2. Records of the Australian Museum 47(2): 161–201.

Bousfield, E.L., 1973. Shallow water gammaridean amphipoda of New England. Cornell University Press, Ithaca, New York. Pp. 1–312.

Bousfield, E.L., 1977. A new look at the systematics of Gammaroidean Amphipoda of the world. Crustaceana, Supplement 4: 282–316.

Bousfield, E.L., 1982. Malacostraca, pp. 232–293. **In** S.P. Parker (ed.). Synopsis and classification of living organisms. McGraw Hill, New York.

Bradbury, J.H., & W.D. Williams, 1995. A new genus and species of crangonyctoid amphipod (Crustacea) from Western Australian fresh waters. Transactions of the Royal Society of South Australia 119(2): 67–74.

Bradbury, J.H., & W.D. Williams, 1996a. Freshwater amphipods from Barrow Island, Western Australia. Records of the Australian Museum, 48(1): 33–74.

Bradbury, J.H., & W.D. Williams, 1996b. Two new species of anchialine amphipods (Crustacea, Hadziidae, *Liagoceradocus*) from Barrow Island, Western Australia. Records of the Western Australian Museum 17(4): 395–409.

Bradbury, J.H., & W.D. Williams, 1997. Amphipod (Crustacea) diversity in underground waters of Australia: an Aladdin's Cave. Memoirs of the Museum of Victoria 56(2): 513–519.

Bradbury, M.R., J.H. Bradbury & W.D. Williams, in press. Scanning electron microscope studies of Rugosities, cuticular microstructures of taxonomic significance of the Australian amphipod family Neoniphargidae (Amphipoda). Crustaceana.

Chilton, C., 1925. A new blind freshwater amphipod (genus *Neoniphargus*) from Western Australia. Journal of the Royal Society of Western Australia 11(9): 81–85.

Christiansen, K., 1992. Biological processes in space and time: cave life in the light of modern evolutionary theory. **In**: A.I. Comacho (ed.) The Natural History of Biospeleology, pp. 377–399. Monografia del Museo Nacional de Ciencias Naturales, Madrid.

Culver, D.C., T.C. Kane & D.W. Fong, 1995. Adaptation and Natural Selection in Caves. The Evolution of *Gammarus minus*. Harvard University Press, Cambridge, Massachusetts.

Eberhard, S.M., A.M.M. Richardson & R. Swain, 1991. The Invertebrate Cave Fauna of Tasmania. Department of Zoology, University of Tasmania, Hobart. 174 pp.

Eberhard, S.M., & A. Spate, 1995. Cave Invertebrate Survey: toward an atlas of New South Wales cave fauna. Department of Urban Affairs and Planning and the Australian Heritage Commission. 112 pp.

Holsinger, J.R., 1994a. Pattern and process in the biogeography of subterranean amphipods. Hydrobiologia 287: 131–145.

Holsinger, J.R., 1994b. Amphipoda. **In**: C. Juberthie and V. Decou (eds). Encyclopaedia Biospeologica I: 147–163. Societé Biospéologie.

Karaman, G.S., 1969. XXII. Beitrag zur Kenntnis der Amphipoden. Über einige Formen des Genus *Sarathrogammarus* (Gammaridae) aus Afghanistan. Acta Musei Macedonici scientiarum Naturalium, Skopje 11(11): 195–208.

Kane, T., & D.C. Culver, 1992. Biological process in space and time: Analysis of adaptation. Pp. 377–399. **In**: A.I. Comacho (ed.). The Natural History of Biospeleology. Monografia del Museo Nacional de Ciencias Naturales, Madrid.

Knott, B., 1983. Amphipods from Nurina Cave—Nullabor Plain. Australian Speleological Federation Newsletter 101: 3–4.

Knott, B., 1985. Australian aquatic cavernicolous amphipods. Paper presented to the 15th biennial conference Australian Speleological Federation, Hobart. Pp. 1–11.

Lowry, J.K., & H.E. Stoddard, 1993. Crustacea Amphipoda: Lysianassoids from Phillipine and Indonesian waters **In** A. Crosnier (ed.). Resultata des Campagnes MUSORSTOM, Volume 10. Mémoirs Museum national d'Histoire naturelle, Paris (n.s.) 156: 55–109.

Nicholls, G.E., 1926a. *Protocrangonyx fontinalis*, a new blind freshwater amphipod from Western Australia. Journal of the Royal Society of Western Australia 12: 71–78.

Nicholls, G.E., 1926b. *Neoniphargus obrieni*, a new species of blind amphipod from Victoria. Journal of the Royal Society of Western Australia 12: 79–86.

Sayce, O.A., 1899. Art. XVII.—*Niphargus pulchellus*, a new Victorian blind amphipod. Proceedings of the Royal Society of Victoria (n.s.) 112: 152–159.

Sayce, O.A., 1901. Art. XVII.—Description of some new Victorian freshwater Amphipoda. Proceedings of the Royal Society of Victoria (n.s.) 13: 225–242.

Sayce, O.A., 1902. Art. VI.—Description of some new Victorian freshwater Amphipoda, No. 2. Proceedings of the Royal Society of Victoria (n.s.) 15: 47–58.

Smith, G.W., 1909. The freshwater crustacea of Tasmania, with remarks on their geographical distribution. Transactions of the Linnean Society of London (2, Zoology) 11: 61–92.

Stebbing, T.R.R., 1899. Amphipoda from the Copenhagen Museum and other sources. Transactions of the Linnean Society of London, (2, Zoology) 8: 395–432.

Stock, J.H., & T.M. Iliffe, 1991. Two new species of *Liagoceradocus* (hypogean Amphipoda) from South-western Pacific Islands, with Key to the World Species. Invertebrate Taxonomy 5: 807–825.

Straškraba, M., 1964. *Perthia* N.G. (Amphipoda, Gammaridae) from fresh waters of Western Australia, with remarks on the genera *Neoniphargus* and *Uroctena*. Crustaceana 7(2): 125–139.

Straškraba, M., 1966. *Hurleya kalamundae* n.g., n.sp. (Amphipoda, Gammaridae) from subterranean waters of Western Australia. International Journal of Speleology 2: 291–295.

Thomson, G.M.,1893. Notes on Tasmanian Crustacea, with descriptions of new species. Papers and Proceedings of the Royal Society of Tasmania, for 1892: 45–76.

Williams, W.D., 1986. Amphipoda on land masses derived from Gondwana. Pp. 551–559. **In**: L. Botosaneanu (ed.). Stygofauna Mundi. Brill and Backhuys, Leiden.

Williams, W.D., & J.L. Barnard, 1988. The taxonomy of crangonyctoid Amphipoda (Crustacea) from Australian fresh waters: foundation studies. Records of the Australian Museum, Supplement 10: 1–180.

Zeidler, W., 1991. A new genus and species of phreatic amphipod (Crustacea; Amphipoda) belonging to the "*chiltonia*" generic group, from Dalhousie Springs, South Australia. Transactions of the Royal Society of South Australia 115: 177–187.

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Table 1. Systematic position and geographic distribution of Australian subterranean amphipods. Modified after Bradbury & Williams (1997). NP: National Park; NSW: New South Wales; SA: South Australia; WA: Western Australia.

TAXON	DISTRIBUTION	HABIT	NO.
Melitidae			
Nedsia straskraba Bradbury & Williams, 1996a	Barrow Island, WA	troglobite	01
N. fragilis Bradbury & Williams, 1996a	Barrow Island, WA	troglobite	02
N. humphreysi Bradbury & Williams, 1996a	Barrow Island, WA	troglobite	03
N. hurlberti Bradbury & Williams, 1996a	Barrow Island, WA	troglobite	04
N. macrosculptilis Bradbury & Williams, 1996a	Barrow Island, WA	troglobite	05
N. sculptilis Bradbury & Williams, 1996a	Barrow Island, WA	troglobite	06
N. douglasi Barnard & Williams, 1995	North West Cape, WA	troglobite	07
Liagoceradocus branchialis Bradbury & Williams, 1996b		North West Cape, WA	
anchialine troglobite	08		
L. subthalassicus Bradbury & Williams, 1996b	Barrow Island, WA	anchialine troglobite	09
Brachina invasa Barnard & Williams, 1995	Flinders Ranges, SA	hyporheic interstitial	10
Norcapensis mandibulis n.sp.	North West Cape, WA	troglobite	11
Melita like.	Nullarbor Plain, WA	troglobite	12
Bogidiellidae			
Bogidomma australis Bradbury & Williams, 1996a	Barrow Island, WA	troglobite	13
Paramelitidae			
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Protocrangonyx fontinalis Nicholls, 1926a	Darling Range, WA	troglophile	15
Uroctena westralis (Chilton, 1925)	near Perth, WA	troglophile	16
Totgammarus eximius Bradbury & Williams, 1995	southwestern WA	troglophile	17
Chillagoe thea Barnard & Williams, 1995	northern Queensland	troglobite	18
Giniphargus pulchellus (Sayce, 1899)	Gippsland, Victoria	troglobite	19
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Austrogammarus smithi Williams & Barnard, 1988	Tasmania	troglophile	21
Antipodeus antipodeus (Smith, 1909)	Tasmania	troglophile	22
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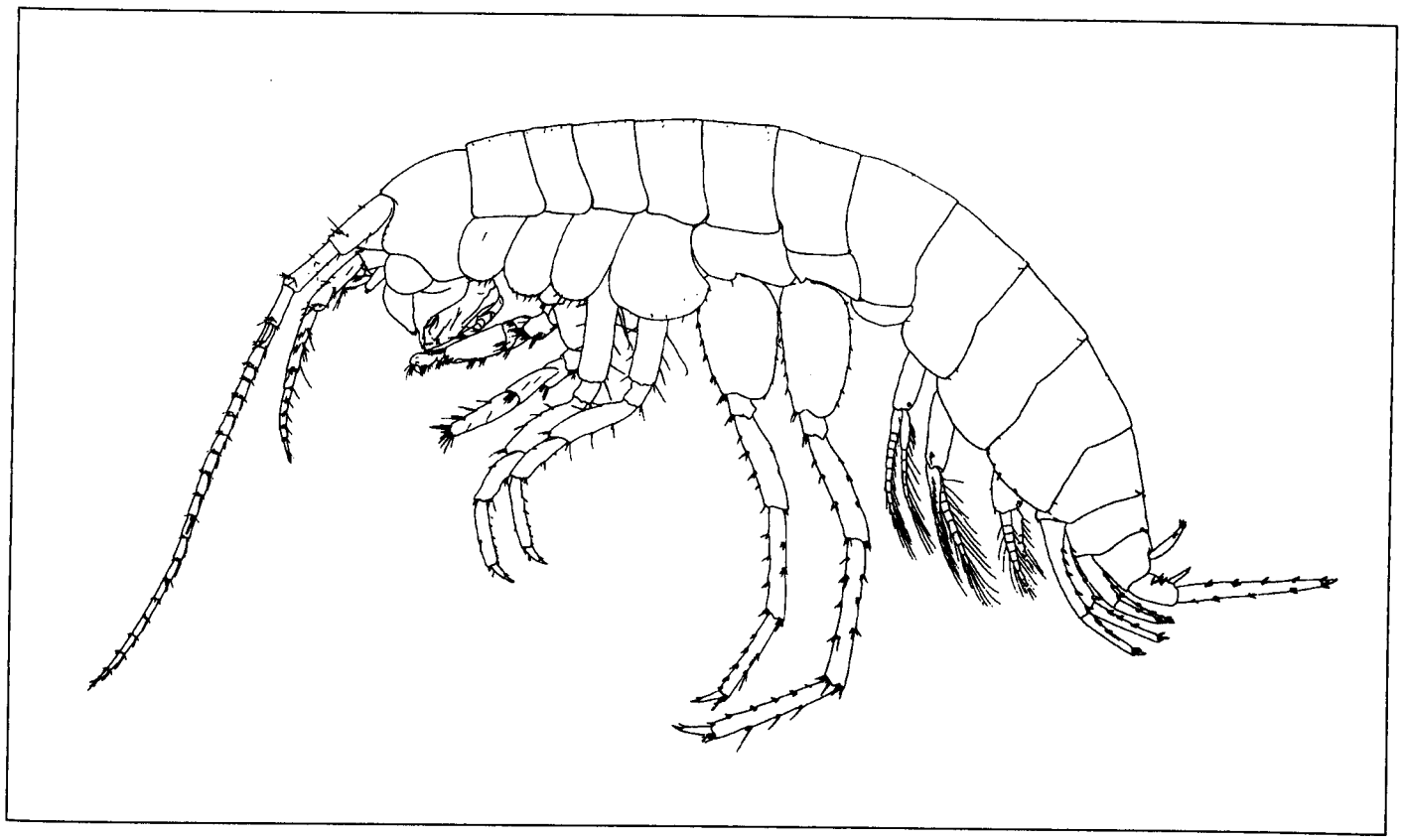
Key to and Checklist of the Inland Aquatic Amphipods of Australia

J.H. Bradbury & W.D. Williams



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Number 14

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COVER. The freshwater amphipod—*Neoniphargus secus* Bradbury & Williams, 1997—figured in "The amphipod (Crustacea) stygofauna of Australia: description of new taxa (Melitidae, Neoniphargidae, Paramelitidae), and a synopsis of known species" *Records of the Australian Museum* 49(3).

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Key to and Checklist of the Inland Aquatic Amphipods of Australia

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ABSTRACT. A key to the 74 known species of amphipods inhabiting Australian inland waters is given, as well as a glossary of terms, illustrations, checklist to the species and taxonomic references.

BRADBURY, J.H., & W.D. WILLIAMS, 1999. Key to and checklist of the inland aquatic amphipods of Australia. *Technical Reports of the Australian Museum* 14: 1–21.

The amphipods of Australian inland waters have been neglected taxonomically; they are often difficult to collect, frequently cryptic, difficult to identify and have few obvious characters. The result is that amphipods have not been used as environmental indicators by aquatic biologists involved in environmental surveys and the management of water resources, despite their role as significant components of freshwater and other inland aquatic ecosystems and their sensitivity to environmental degradation.

In recent years new foundations for the taxonomy of Australian freshwater amphipods have been published (Williams & Barnard, 1988, Barnard & Williams, 1995). These have promoted subsequent taxonomic works (Bradbury & Williams, 1995, 1996, 1997b; Bradbury *et al.*, 1998), and since 1995 the number of described Australian freshwater amphipod taxa has increased to over 70 species. Nevertheless, more species remain to be described.

Available keys are of limited use in that they are now outdated (e.g., Barnard & Barnard, 1983), address only certain parts of the fauna (e.g., Williams & Barnard, 1988), provide information at higher levels only (e.g., Horwitz *et al.*, 1995), or relate to marine taxa (e.g., Barnard, 1969). This new key, based on contemporary knowledge, enables the identification to species level of all described Australian inland aquatic amphipods. Figures provided with this key indicate characters of taxonomic importance. A glossary of terms and checklist of all species including author and date and type locality are included.

We have drawn on various sources, particularly original descriptions, as well as available keys, and have re-examined specimens where necessary. Some areas of uncertainty exist: the considerable diversity of Tasmanian species means that many new taxa have yet to be described. Among mainland populations, too, new species have been identified and await description; hypogean specimens from several areas, including Tasmania, South Australia, Queensland and Western Australia, are in the process of analysis. Specimens which do not easily key to a taxon, therefore, are likely to be new to science, unless of marine origin (often found in estuarine waters) or from terrestrial sources (the terrestrial Talitridae inhabit damp areas, often close to shores and streams, and may be found in fresh waters as accidentals). Such taxa are not covered by this key. Efforts should be made to preserve unknown specimens (in 70% ethanol), prevent damage to individuals (by careful handling and packaging), and seek taxonomic guidance. As many details as possible concerning the site (date, exact location, water quality, temperature) and identity of collector should be noted.

The sex of specimens cannot always be determined as immature animals do not often display distinguishing sexual characteristics. Late juvenile and adult females bear oostegites upon the coxae of pereopods two to five. In males, gnathopods are often enlarged, and have notched palms, there is a small penile apparatus at the posterior margin of the seventh sternite, and, particularly in the crangonyctoids and eusirids, calceoli are often present on the second antenna.

Glossary of terms

accessory flagellum. The secondary ramus of antenna 1 attached medially to peduncular article 3, often absent or vestigial. (Fig. 2).

accessory setal row. Of the mandible, consisting of blade setae and plumose setae, lying between incisor and molar. (Fig. 2).

aesthetasc. Sensory setae of antennae, flattened and non-tapering. (Fig. 2).

alae. Wing-like extensions.

article. A segment of an appendage.

basis. Second article of pereopod, in pereopods 5–7 often laterally expanded and posteroventrally lobate. (Fig. 3).

basodactylar. Character located at base of dactyl. (Fig. 3).

basofacial robust seta. Robust seta on basolateral face of appendage; often used in connection with Uropod 1. (Fig. 4).

bifid seta. Seta with the apex divided—as distinct from trigger seta. (Fig. 3).

buccal. Relating to the mouth.

calceolus, (pl. **calceoli**). A small globular or helmet-shaped, articulate sense organ usually on the male second antenna; presumably a modified aesthetasc; of rare occurrence in Gammaridea and most often seen in Eusiridae. Of diagnostic form (type "9"—Lincoln & Hurley, 1981) among crangonyctoids. (Fig. 2).

carpus. Fifth article of pereopod. (Fig. 3).

chelate. Descriptive of the palm of a gnathopod protruding as an immovable finger on which the dactyl closes. Also subchelate, parachelate, carpochelate, propodochelate, merochelate; complexly subchelate or complexly chelate are terms referring to the formation of a false chela by protrusion of teeth, cusps, or lobes from articles other than the sixth and upon which article 7 impinges to form a prehensile condition.

chela. Immovable finger of prehensile appendage.

claw, claw-like. Descriptive of a talon or simple, tapering nail. (Not descriptive of chelae as used in decapod terminology).

compressed. Flattened from side to side.

conjoint. Describing the basal amalgamation of flagellar articles on antennae. (Fig. 2).

coxa, coxal plate. [Terms used synonymously] Article 1 of a pereonal appendage, expanded into a lateral lamella. (Figs. 1, 3).

dactyl. Talon-like terminal article of pereopods (article 7) or maxillipedal palp articles 4. (Figs. 2, 3).

dendritic. Refers to a branching form, in particular of sternal gills; from *dendron* Gr. = tree. (Fig. 4).

denticulate. Finely toothed.

depressed. Flattened dorsoventrally.

dispariramous. Rami not similar; especially of uropods, one (usually the medial) ramus of modified form and reduced length.

emarginate. Descriptive of the concave posterior end of an uncleft telson or posterodorsal margin of coxa 4 (see also excavate). (Fig. 3).

entire. Descriptive of an uncleft telson.

epigean. Living above ground.

epimeron (pl. **epimera**). Lateral pleuron of pleonites 1–3; the ventrolateral plate-like extension of the body segment, often bearing setae or postventral tooth (spine) of taxonomic significance. (Figs. 1, 4).

epistome. The anterior surface of the head above the labrum; this area is often extended ventrally to appear as a part of the labrum and may be anteriorly produced as a cusp or lobe.

"eusirid". Used by some authors (e.g., Williams & Barnard, 1988) to describe gnathopods in which the propodus is inflated, palms simplified and elongate, and the flexibility increased by narrowing of the connection between propodus and carpus, the joint being cantilevered; usually both pairs of gnathopods very similar, e.g., gnathopods of perthiids. (Fig. 5). Since Eusiridae have many gnathopod forms this term is best avoided.

excavate. In particular, refers to the concave reduction of the posterodorsal corner of coxa 4 (see also emarginate). (Fig. 3). Sometimes used in reference to a notched gnathopodal palm.

falciform. Having the curved shape of a falcon's wing; especially refers to the ultimate article of a mandibular palp.

flagellum. The distal portion of either antenna; on the first antenna it commences with article 4, on the second antenna with article 6; because basal peduncular articles of antenna 2 are often difficult to resolve, the juncture may be recognised between the elongated final peduncular article and the shortened first flagellar article which is followed by similar short articles; on antenna 1, however, article 1 of the flagellum is occasionally elongate and apparently composed of non-segregated (thus conjoint) articles. (Fig. 2).

foliaceous. Leaf-like.

fossorial. Associated with the habit of burrowing, often referring to the excessively spinose or setose condition of appendages used for burrowing by Gammaridea; e.g., *Totgammarus eximius* pereopods 5–6, *Pilbarus millsi* pereopod 6.

geniculate. Permanently bent, e.g., in reference to flexed antennae.

gills: coxal. Usually paddle-like, fragile structures attached to coxae, adjacent leg. Absent from first coxa. (Fig. 3).

gills: sternal. Medial or lateral (or both) structures extending from some or all of ventral sternites 2–7—various types: simple = non branching = sausage-like e.g., *Austrogammarus*; or lumpy = bearing small lumps, but not branched e.g., *Jasptorus*; or dendritic = branched e.g., *Neoniphargus* (the presence of some, but not necessarily all, dendritic sternal gills earns the descriptor). (Fig. 4).

gnathopod dimorphism. Sexual variation in the size or form of gnathopods—male organ usually larger, thought to function in copulation as grasping organ, often seen to bear a notch ("excavate") approximately midway along the palm e.g., *Antipodeus* sp., *Neoniphargus* sp. (Fig. 3).

gnathopods. First two pairs of free thoracic appendages, differing in function and usually in appearance from following pereopods; rarely referred to as pereopods

1 and 2. Various forms recognised: mitten-like, small, rectangular, the palmar angle transverse (as in *Neoniphargus*); cantilevered (erroneously "eusirid") as in *Perthia*; ovate, in which the palmar angle is strongly oblique, as in the second gnathopod of *Nedsia*. (Figs. 1, 3).

hyaline. Clear and translucent, usually relating to lobes of the appendages.

hypogean. Living underground.

incisor. The apical portion of the mandible usually formed into a toothed chewing edge or untoothed chopping plate. (Fig. 2).

interstitial. Found in water filled spaces between substrate such as in coarse stream beds or aquifers in porous sediments.

ischium. Third article of pereopod. (Fig. 3).

joint. The juncture between two articles of an appendage.

labium. (See lower lip).

labrum. (See upper lip).

lacinia mobilis. An articulated accessory plate proximal to the mandibular incisor (can be absent or missing on either left or right mandibles, occasionally indistinguishable from a robust seta of the accessory seta-row). (Fig. 2).

lanceolate. Shaped like the blade of a lance.

lower lip (labium). A fleshy complex posterior to the mandibles, always composed of at least one pair of lobes (outer), often with a medioproximal pair of inner lobes; the lateroproximal ends of the outer lobes are often attenuated as alae and are denoted as mandibular lobes. (Fig. 2).

magniramous. Condition of the third uropod in which the inner and outer rami are approximately equally extended.

mandible. The anterior movable appendage of the buccal group; usually composed of a body bearing a distal incisor, a lacinia mobilis, robust seta row, molar, and, in most taxa, a 3-articulate (sometimes reduced) palp. (Fig. 2).

mandibular palp setae. Setae of palp articles 2 or 3 setae defined according to origin: *A,B,C,D,E,F*. (Fig. 2). (Two nomenclatural systems operate—see Fig. 5).

maxilla 1. A pair of cephalic appendages posterior to the lower lip (labium); for taxonomic purposes only three portions of each member are named: the medial (inner) lobe (plate) usually bearing marginal setae, the lateral (outer) and larger lobe (plate) bearing terminal robust setae and, attached to the outer lobe, a palp usually composed of two articles but occasionally absent. (Fig. 2).

maxilla 2. A pair of cephalic appendages posterior to maxilla 1; for taxonomic purposes recognised as a pair of lobes (plates) medial and lateral, usually strongly setose. (Fig. 2).

maxillipeds. The posterior most pair of "cephalic" appendages, representing the primitive first thoracic segment now amalgamated with the head but in amphipod taxonomy not included in the sequential numbering of thoracic appendages; for taxonomic purposes recognised as a pair of basally amalgamated appendages, each member composed of an inner (proximal) plate, an outer (distal) plate, and a palp of four articles, rarely reduced to 3 or 2 articles or absent. (Fig. 2).

meral. Pertaining to the merus (fourth article of the pereopod).

merus. Fourth article of pereopod. (Fig. 3).

molar. A process of the mandible, located on the medial margin; when completely developed it is a massive, subcylindrical body with a surface of ridges and teeth used for grinding (see triturative). (Fig. 2).

multispinous. Condition of dactylus (of pereopods); bearing 2–6+ medial robust setae.

M. Used, in conjunction with a number, to indicate the position of an object as a fraction of the distance from the base to the apex of an appendage, e.g., M = 0.5 indicates half way from base to apex.

nail. Apical portion of dactyl (not always distinct).

obsolescent. Lost, become obsolete.

palmar angle. The angle the posterior margin of the gnathopodal propodus makes with the palm; varies from transverse in rectangular propodi to strongly oblique in ovate propodi.

palmar corner. The point at which the palm meets the posterior margin of the propodus: often bearing modified setae; not clearly defined where the propodus is ovate. (Fig. 3).

palm. A posteroventral surface or margin of propodus (article 6) of a gnathopod or pereopod upon which article 7 (dactyl) closes; usually recognisable because of expansion of article 6 or by occurrence of special robust setae or other ornamentation and usually with a proximal defining limit marked by a change in marginal slope or occurrence of special robust setae. (Fig. 3).

palp. Terminal articles of a buccal appendage; in Amphipoda, only on mandibles, first maxillae, and maxillipeds as the narrow terminal articles distal to the expanded outer plates or main body. (Fig. 2).

parviramous. Condition of the third uropod in which the inner ramus is reduced to a small scale. (Fig. 4).

pediform. Shortening and thickening of antennae, especially peduncles. Seen in South African paramelitids, less common among Australian paramelitids, e.g., *Uroctena*.

peduncle. The basal articles of a fundamentally biramous appendage; in Amphipoda applied to antennae, pleopods, and uropods; antenna 1 with three peduncular articles, antenna 2 with five peduncular articles (but appendage not biramous); pleopods with one definitive peduncular article but remnants of others occurring proximally; uropods each with one peduncular article. (Figs. 2, 4).

pereonite. A segment of the pereon.

pereon. The complex of seven free thoracic segments bearing gnathopods and pereopods, not including the maxillipeds. (Fig. 1).

pereopod. A walking, grasping, standing, or feeding appendage attached to a pereonite; normally composed of seven articles, including coxa; in Amphipoda the first two pairs are usually termed gnathopods and only the last five pairs of thoracic legs called pereopods (but numbered P3–P7). Terms for articles of the appendages, i.e. coxa, basis, ischium, merus, carpus, propodus, and dactylus are frequently but not universally used in Gammaridea; instead, the articles may be simply numbered from 1 for coxa to 7 for dactyl. (Figs. 1, 3).

plate. A flattened lobe on an article of a maxilla or maxilliped.

pleonite. A segment of the pleon.

pleon. The abdomen (of six free segments in Gammaridea, rarely with some segments coalesced). See urosome. (Fig. 1).

pleopod. A biramous swimming appendage on pleonites 1–3, one pair for each pleonite. (Fig. 4).

prebuccal complex. The labrum and epistome together.

prehensile. Adapted for seizing or grasping; applicable to but rarely used for gammaridean gnathopods.

propodus. The sixth article of a thoracic appendage (especially used to denote the palmar article of a gnathopod). (Fig. 3).

pubescence. Very fine setae, often covering the face of an article. (Fig. 2).

rami. Distal articles of biramous appendages, i.e. pleopods and uropods. (Fig. 4).

parviramous: of 3rd uropod; inner ramus reduced to a small scale.

magniramous: of 3rd uropod; inner and outer r

ami approximately equally extended.

variramous: of 3rd uropod; intermediate condition.

rugose. An area of rough or lumpy appearance.

rugosity. Small setae of characteristic form on the gnathopods and maxillipedal palps of neoniphargids. (Fig. 3).

scale, scale-like. Terms applied to the accessory flagellum when forming a small lamella immovably fused to article 3 of antenna 1; and to the inner ramus of uropod 3 when strongly reduced and plate-like.

setae and **spines**. A *spine* is an outgrowth of cuticle, whereas a *seta* is pivoted at the base, with a probable distinct genetic origin. "Spine" has been employed loosely in the case of amphipods to indicate, in most cases, what are really *robust setae*, this being the correct term.

simple. Used in amphipod taxonomy to denote the absence of setae on appendages; or the occurrence of but a single article in the ramus of a uropod; or especially to the absence of a palm on a gnathopod (distinction between subchelate and simple is often weak); or to an unbranching or unlumped condition of the sternal gills.

subchelate. Article 6 of a gnathopod or pereopod having a distal palm against which article 7 closes; a prehensile condition in which the palm is not produced to form a finger; intermediate in condition between chelate and simple.

telson. A flap dorsal to the anus attached to pleonite 6, primitively bilobed but in Amphipoda usually with bases coalesced and often with lobes completely coalesced to form a single plate; i.e. cleft (bilobed), notched, entire (completely coalesced). (Fig. 4).

trigger seta. Seta bearing terminal or subterminal sensory setule. (Fig. 3).

triturative. Descriptive of the rasp-like surface of a mandibular molar, composed of teeth, ridges, and cusps.

ungulate. Horn-like in shape.

upper lip (labrum). A fleshy lobe attached to the anterior cephalic margin in front of the mandibles; occasionally the anterior surface of the labrum protrudes as a lobe or cusp; often the cephalic area to which the labrum is attached is recognisable as an "epistome" and may also be lobed; or both labrum and epistome may be indistinguishable and produced together as a single lobe.

uropod. One member of the three pairs of terminal pleonal appendages, each formed of a peduncle and two rami (inner rami of uropod 3 often differentiated, reduced or absent, rarely rami of uropods 1–2 absent or reduced). (Fig. 4).

urosome. The complex of pleonites 4, 5, 6, carrying uropods, and telson. Often numbered as urosomites 1, 2, 3. (Fig. 1). (Sometimes fused, e.g., *Paracalliope*).

urosomite. A segment of the urosome.

variramous. Condition of the third uropod in which the inner ramus is intermediate in length between reduction to a small scale (parviramous) and extended approximately equal to the outer ramus (magniramous).

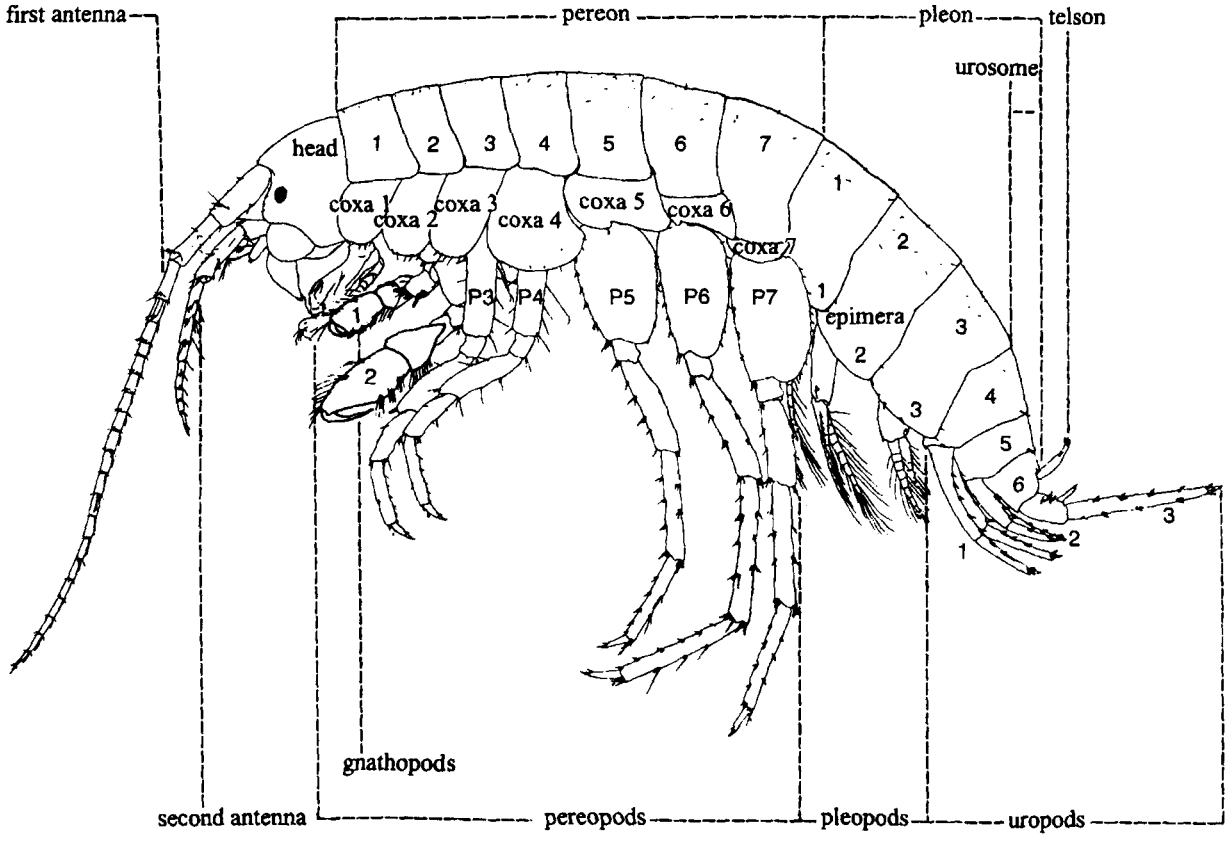

Figure 1. Generalised amphipod showing principal body-parts.

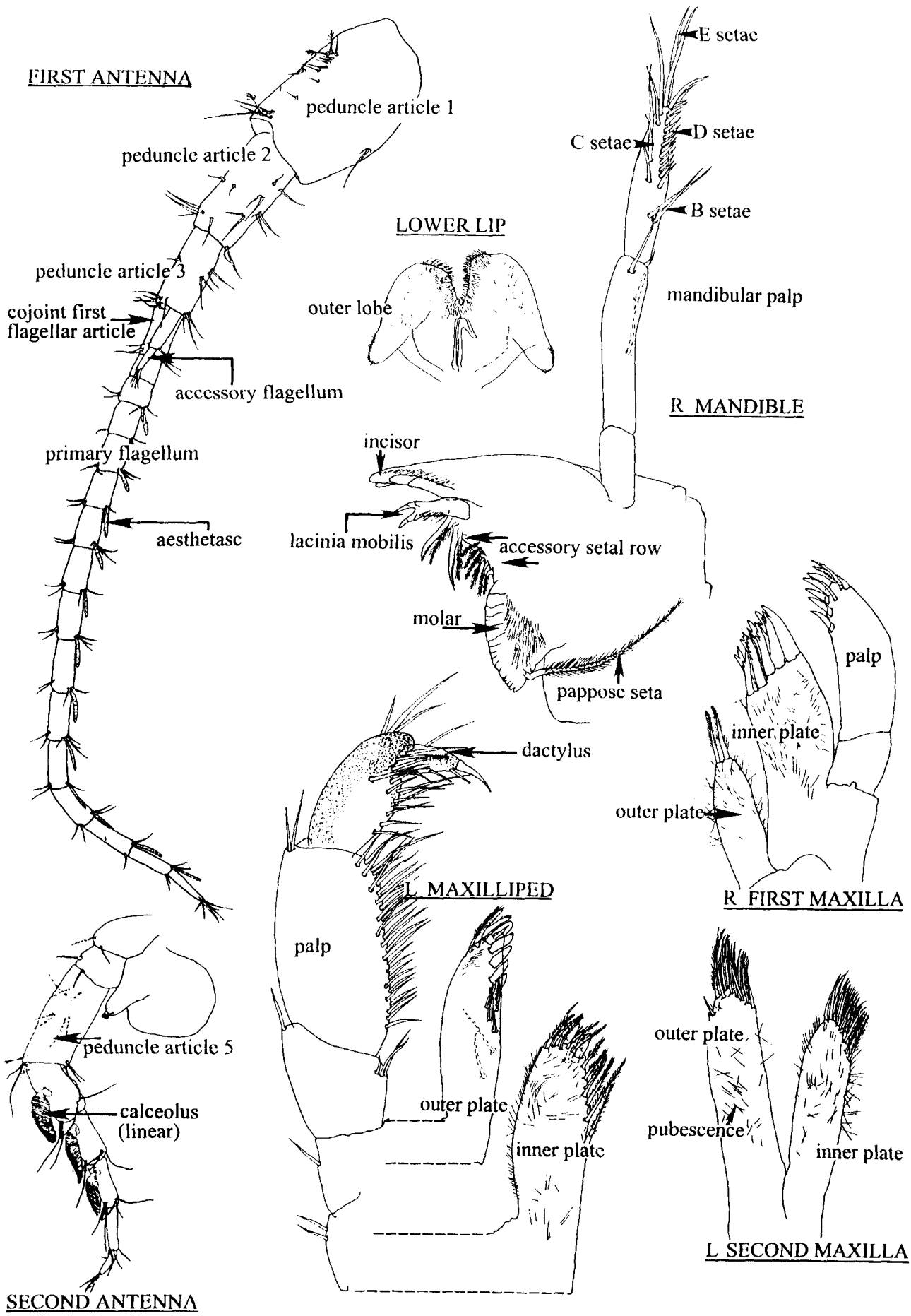

Figure 2. Parts of the head: antennae; lower lip (labium), mandible, first and second maxilla and maxilliped.

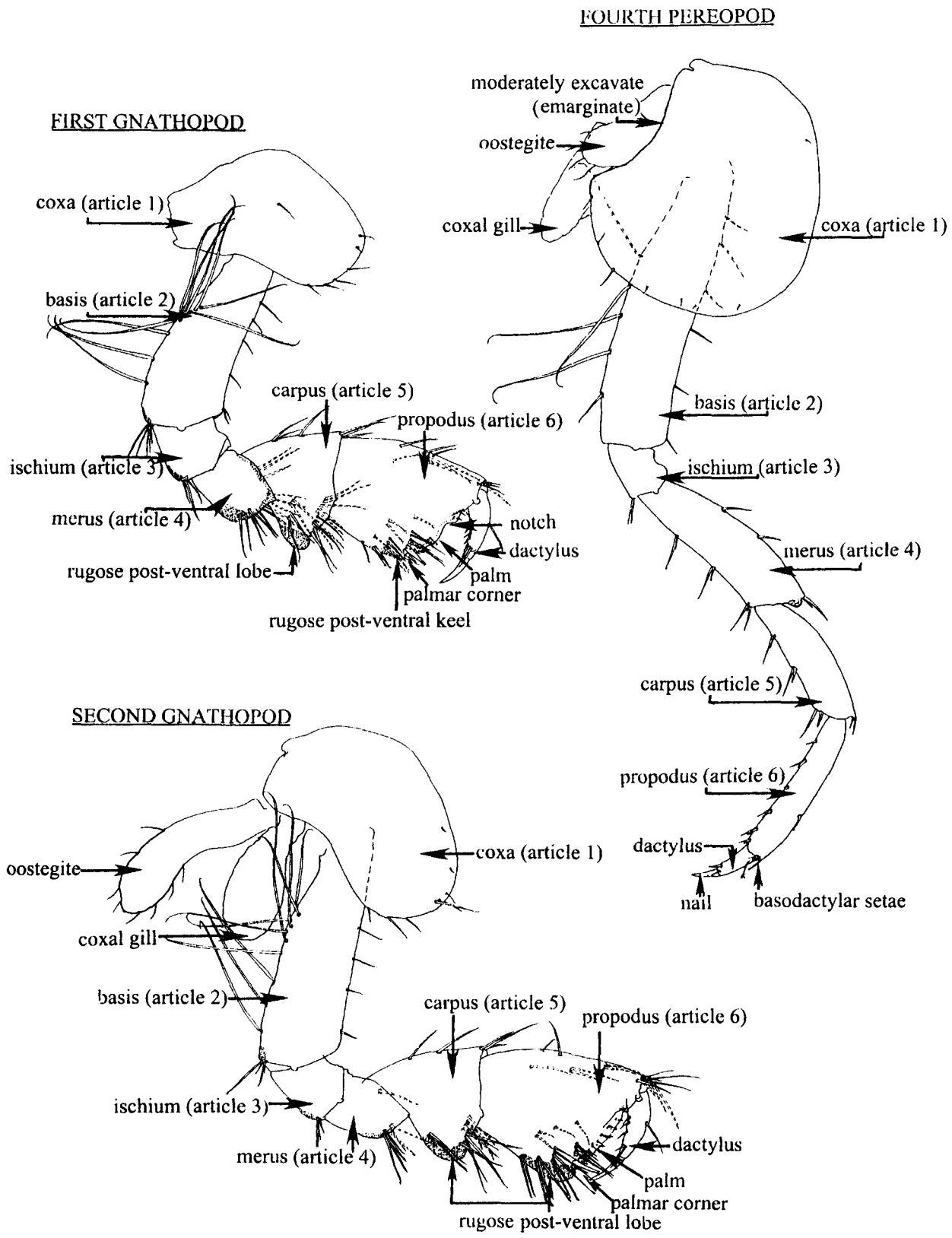

Figure 3. Pereopods: first and second gnathopod, fourth pereopod.

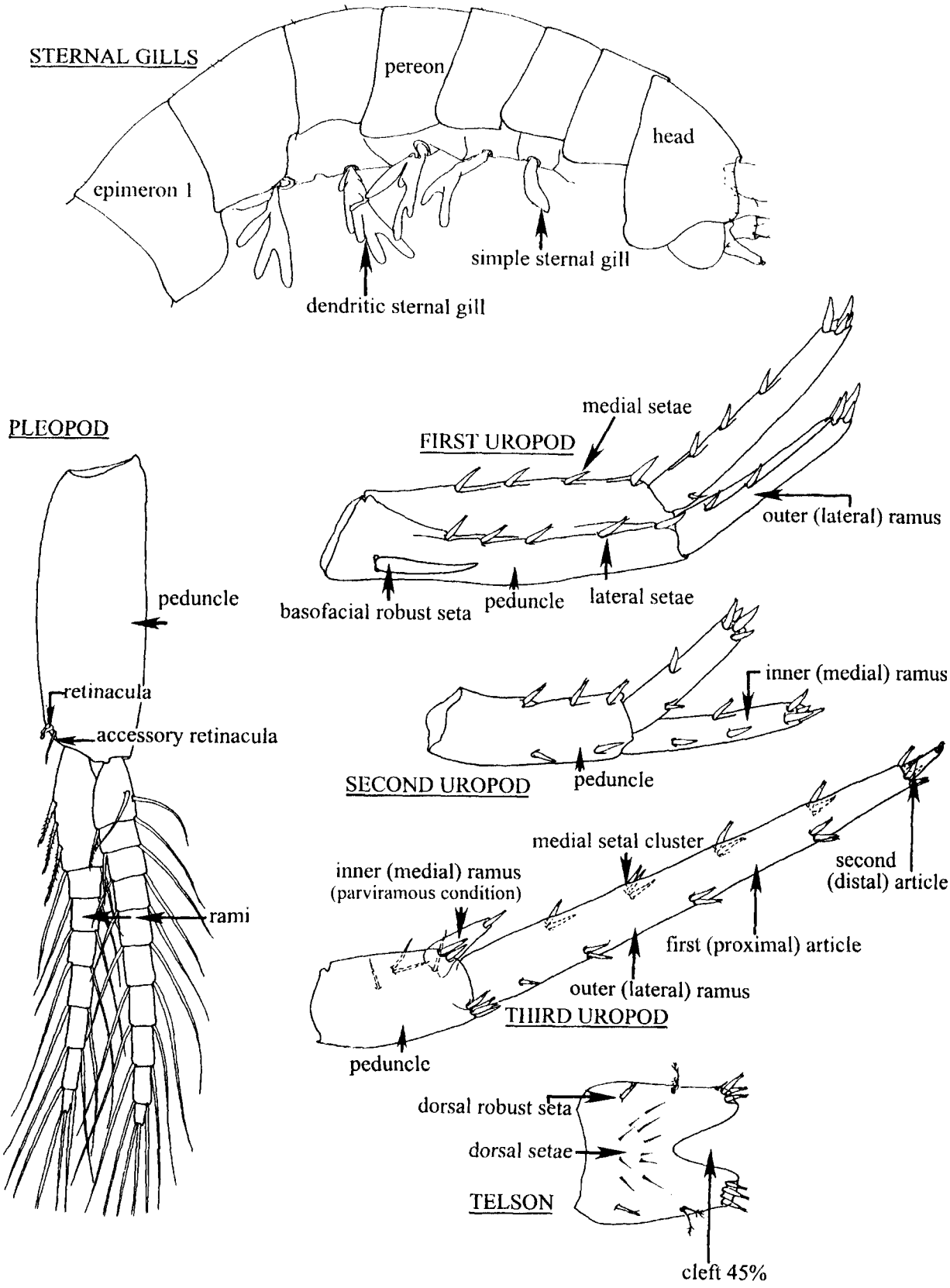

Figure 4. Sternal gills; pleopod; first, second and third uropods; telson.

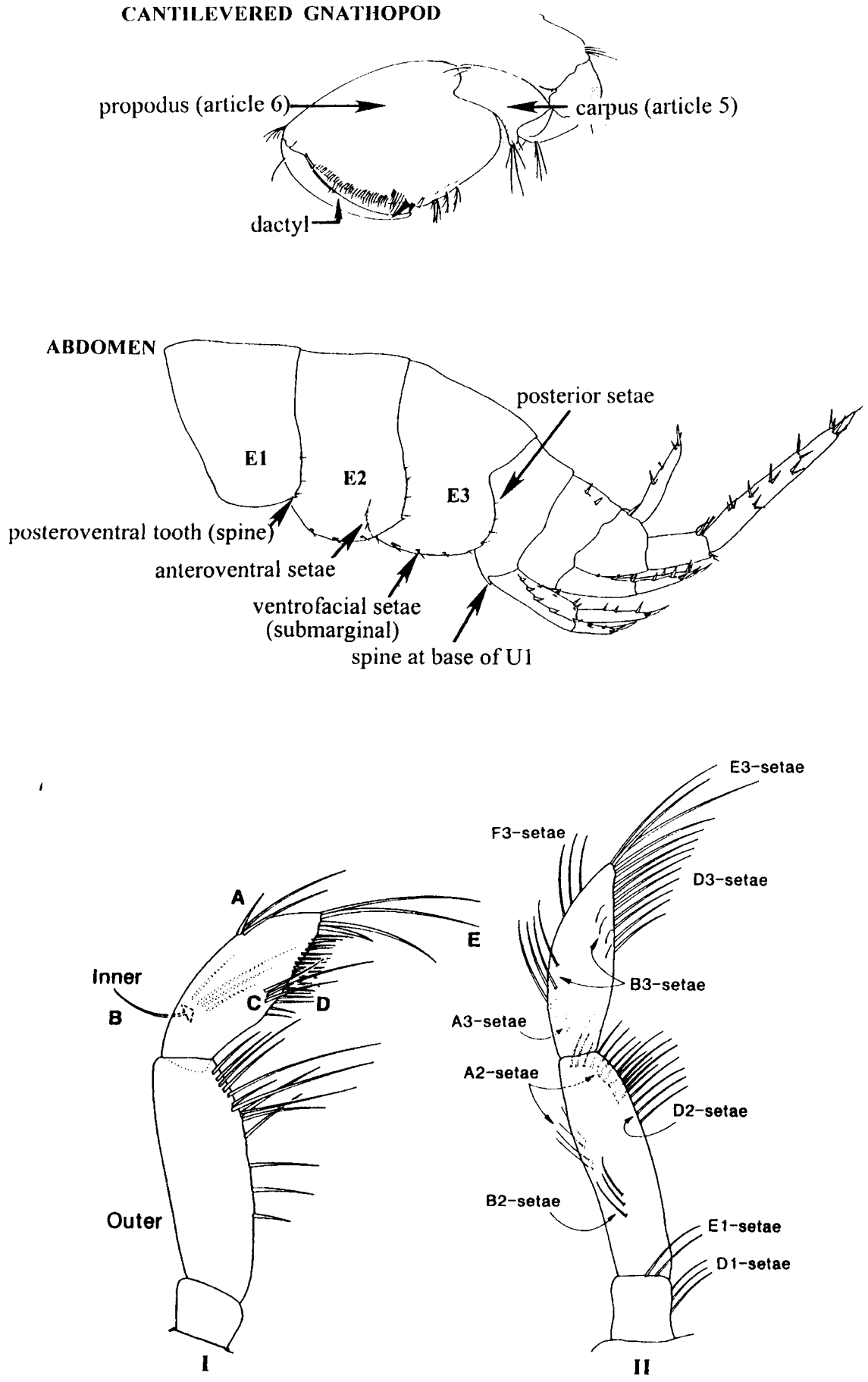

Figure 5. Cantilevered first and second gnathopods, abdomen indicating epimera, stylised mandibular palp indicating setal nomenclature of: I—Barnard & Barnard (1983), after Karaman (1969); II—Lowry & Stoddart (1993).

Key to families

1 Third uropod reduced, ramus, if present, minute; mandibles without palps 2

—— Third uropod prominent and biramous (with few exceptions), mandibles with palps 3

2 First antenna larger than second ..... (p. 10) **Ceinidae**

—— First antenna smaller than second ..... **Talitridae**

Land hoppers (Talitridae) sometimes occur as accidentals in streams or littoral regions. Not included in this key. Refer to Friend (1987).

3 Peduncle of uropod 1 bearing robust basofacial seta; antennae without calceoli; sternal gills absent ..... (p. 10) **Melitidae**

—— Peduncle of uropod 1 without robust basofacial seta; antennae with or without calceoli, sternal gills present or absent 4

4 Rami of uropod 3 equal or subequal, undifferentiated (magniramous) 5

—— Rami of uropod 3 unequal, differentiated (i.e. dispariramous), inner ramus modified, reduced, sometimes absent 7

5 Rami of uropod 3 cylindrical, gnathopod 1 distinctly larger than gnathopod 2 ..... (p. 11) **Bogidiellidae**

—— Rami of uropod 3 lanceolate, gnathopods subequal 6

6 Urosomites 2–3 fused; dactylus of pereopod 7 elongate, longer than propodus, setose ..... (p. 12) **Paracalliopiidae**

—— Urosomites 2–3 separate; dactylus of pereopod 7 neither elongate nor setose ..... (p. 12) **Eusiridae**

7 Telson entire; antenna 1 accessory flagellum absent ..... (p. 12) **Corophiidae**

—— Telson cleft or notched; antenna 1 accessory flagellum present, with 2 or more articles ..... (p. 13, **Crangonyctoidea**) 8

8 Gnathopod carpus cantilevered with propodus, sternal gills dendritic ..... (p. 13) **Perthiidae**

—— Gnathopod carpus/propodus joint ordinary; sternal gills absent, simple, lumped or dendritic 9

9 Sternal gills simple or absent, gnathopods without posterior distal rugosities ..... (p. 13) **Paramelitidae**

—— Sternal gills simple, dendritic or lumpy, gnathopods with posterior distal rugosities ..... (p. 16) **Neoniphargidae**

Family Ceinidae

The widespread genus *Austrochiltonia* is the principal representative of this family. There is some dispute on the familial position of the genus; Barnard & Barnard (1983) placed the genus in the Ceinidae, whereas Zeidler (1991) recommended the family Hyalellidae as more appropriate on the basis of the form of the mandible, third uropod and telson. Two very similar, widespread, species, *A. australis* and *A. subtenuis*, have been recognised (Sayce, 1901, 1902; Williams, 1962), but some dispute the validity of this distinction, pointing out that they are often sympatric and can interbreed (S.J. Smith & Swain, 1982). For the sake of completeness, and pending revision, both are included in this key. Another two taxa, *A. dalhousiensis* and *Phreatochiltonia anopthalma*, are described from Dalhousie Springs, South Australia (Zeidler, 1991, 1997).

Key to genera and species of Ceinidae

1 Eyes absent; coxa 4 poorly excavate posteriorly; pereopod 4 distinctly longer than pereopod 5 ..... *Phreatochiltonia anopthalma*

—— Eyes present; coxa 4 moderately to deeply excavate posteriorly; pereopod 4 shorter than pereopod 5 2

2 Third uropod without rami ..... *Austrochiltonia subtenuis*

—— Third uropod uniramous 3

3 Carpus of gnathopod 1 shorter than propodus, antennal flagellae of less than 10 articles ..... *Austrochiltonia dalhousiensis*

—— Carpus of gnathopod 1 longer than propodus, antennal flagellae more than 10 articles ..... *Aust rochiltonia australis*

Family Melitidae

Most representatives of this family are thought to be of ancient marine origin (Cretaceous) and are restricted to areas of the continent inundated by the sea during the Cretaceous. These are devoid of species of more ancient freshwater lineage (Bradbury & Williams, 1997a). Four genera have been recognised in Australia: *Brachina* (1 species); *Norcapensis* (1 species); *Nedsia* (8 species); and *Melita* (1 species, restricted to an artificial coastal freshwater lake in New South Wales, possibly of marine origin).

Key to genera and species of Melitidae

1 Lower lip bearing distinct inner lobes; third uropod outer ramus article 1 foliaceous, bearing small marginal robust setae and slender setae, second article large, foliaceous and similarly armed; telson lobes subtriangular, bearing weak slender setation 2

—— Lower lip inner lobes absent or obsolescent; third uropod outer ramus article 1 cylindrical, with marginal clusters of long, sharp robust setae, second article small, naked except for a single subapical, slender trigger seta; telson lobes ovate to subrectangular, bearing strong, stout setation 10

2 Mandibular palp of three articles ..... *Norcapensis mandibulis*

—— Mandibular palp reduced to two articles 3

3 Second maxilla with sparse marginal basomedial pubescence on inner plate only, or no pubescence on either plate 4

—— Second maxilla with moderate to dense marginal pubescence on both plates 6

4 Pleonites without dorsal robust setae ..... *Nedsia straskraba*

—— Pleonites with dorsal robust setae 5

5 Epimera 1 without distolateral robust setae; peduncle of uropod 1 with a lateral row of short facial robust setae besides the basofacial and distal robust setae; palmar corner of gnathopod 1 rounded; outer plate of maxilliped tapering from base to apex and with weak medial cusps ..... *Nedsia fragilis*

—— Epimera 1 with distolateral robust setae, peduncle of uropod 1 without facial robust setae besides basofacial and distal robust setae, palmar corner of gnathopod 1 subquadrate, outer plate of maxilliped not tapering, but rounded apically and with strong medial cusps ..... *Nedsia humphreysi*

6 Posterior margins of pleon smooth, epimera without facial robust setae other than ventral submarginal robust setae 7

—— Posterior margins of pleon sculptured into cusps, epimera with facial robust setae as well as ventral submarginal robust setae 9

7 Urosomite 1 bearing a posteroventral spine at the base of the first uropod, rami of pleopods with more than six articles, maxillipedal palp article 3 without organised comb rows of setae at base of dactyl ..... *Nedsia hurlberti*

—— Urosomite 1 without spine at base of uropod 1, rami of pleopods of less than 6 articles, maxillipedal palp article 3 bearing rows of comb setae basal to dactyl 8

8 Coxa 1 with one or more anterior robust setae, without slender anterior setae; telson without dorsal setae; length of maxillipedal outer plate 2 × width ..... *Nedsia urifimbriata*

—— Coxa 1 without anterior robust seta(e), with slender anterior setae; telson with dorsal setae; length of maxillipedal outer plate not more than 1.6 × width ..... *Nedsia douglasi*

9 Postero-lateral margins of pleonite 4 with robust setae, medial margin of outer plate of maxilliped rough, with 5 indentations ..... *Nedsia macrosculptilis*

—— Postero-lateral margins of pleonite 4 without robust setae, medial margin of outer plate of maxilliped smooth, with 4 indentations ..... *Nedsia sculptilis*

10 Mandibular palp two articulate; propodus of first gnathopod without anterior or medial palmar humps; setae of antennae, pereopods, uropods and telson not plumose ..... *Brachina invasa*

—— Mandibular palp three articulate; propodus of first gnathopod with anterior and medial palmar humps; plumose setae on antennae, pereopods, uropods and telson ..... *Melita plumulosa*

Family Bogidiellidae

Hypogean or interstitial. One species is known; *Bogidomma australis*. It is recorded from Barrow Island, Western Australia.

Family Paracalliopiidae

Represented by a single genus, *Paracalliope*; two inland aquatic species recorded from Tasmania.

Key to species of *Paracalliope*

1 Mandibular palp third article bearing 0–1 basofacial robust setae; uropod 1 outer ramus with 2 robust setae; epimeron 3 without robust setae ..... *Paracalliope larai*

—— Mandibular palp third article bearing 3 basofacial robust setae; uropod 1 outer ramus with 0–1 robust seta; epimeron 3 with 3 robust setae ..... *Paracalliope vicinus*

Family Eusiridae

Represented in Australian inland waters by two genera, *Pseudomoera* and *Paraleptamphopus*. The genus *Paraleptamphopus* is reported from Tasmania (Richardson, 1987), without specific identification; *Pseudomoera* is present as two species, both reasonably widespread in mainland southeastern Australia.

Key to genera and species of Eusiridae

1 Telson entire ..... *Paraleptamphopus*

—— Telson cleft 2

2 First maxilla inner plate medial margin oblique, bearing medial setae ..... *Pseudomoera fontana*

—— First maxilla inner plate bearing only terminal setae ..... *Pseudomoera gabrieli*

Family Corophiidae

This family is represented by one known species, *Paracorophium excavatum*, from the Brisbane River.

Superfamily Crangonyctoidea

This superfamily, represented also in the Holarctic, but dominantly Nearctic, is the most widespread and significant of Australian freshwater amphipod groups, and is thought to have dispersed from Pangea via Notogean fresh waters (Barnard & Barnard, 1983). Three Australian families are recognised, two endemic to Australia. All are cold-water species derived from ancient pre-Gondwanan stock, and are restricted to those areas of the continent not inundated by the sea during the Cretaceous, and where cool waters are found. Thus, representatives are most numerous in Tasmania and the highlands of the southeast and the cool, wet southwest, but do occur as relict species in underground streams and wet caves in warmer areas. Among the three families, Perthiidae are known only from Western Australia, whereas Neoniphargidae and Paramelitidae occur in Tasmania, Victoria, New South Wales and Western Australia, with a few specialised members elsewhere.

Family Perthiidae

There is only one known genus of the family, *Perthia*, with two species found in southwestern Western Australia.

Key to species of *Perthia*

1 Uropod 3 parviramous, inner ramus short; telson without dorsal robust setae; merus and carpus of pereopods 3–7 with long setae ..... *Perthia branchialis*

—— Uropod 3 variramous, inner ramus long; telson with dorsal robust setae; merus and carpus of pereopods 3–7 without long setae ..... *Perthia acutitelson*

Family Paramelitidae

The family Paramelitidae is represented in Australia by eleven genera, of which seven are monospecific: *Chillagoe*, from Chillagoe caves, Queensland, *Giniphargus*, from Gippsland, Victoria, *Hurleya*, *Protocrangonyx*, *Totgammarus* and *Toulrabia* from southwestern Australia, and *Pilbarus* from northwestern Australia. Of the other genera, *Austrogammarus* is widespread across southeastern Australia, *Austrocrangonyx* is found around the Barrington Tops in New South Wales, *Antipodeus* is restricted to Tasmania, and *Uroctena* to southwestern Australia.

Key to genera and species of Paramelitidae

1 Sternal gills absent 2

—— Sternal gills present and simple 8

2 Mandibular palp article 1 much longer than wide, article 2 with few setae, article 3 without A setae ..... *Pilbarus millsi*

—— Mandibular palp article 1 about as long as wide, article 2 moderately setose, article 3 bearing A setae ..... (*Antipodeus*) 3

3 Posterior setae on article 2 of pereopods 5–7 long; long setae present on articles 2–6 of pereopods 5–7; coxae 1–3 with long ventral setae ..... *Antipodeus niger*

—— Posterior setae on article 2 of pereopods 5–7 short; long setae absent on articles 2–6 of pereopods 5–7; coxae 1–3 with only short ventral setae 4

4 Ventral setae of antennae 1–2 long and dense; telson very short, apical setae absent 5

—— Ventral setae on antennae 1–2 short to long and sparse to numerous (but never long and dense); telson not very short, with apical setae 6

5 Gnathopods sexually dimorphic—male palm notched; article 6 of pereopods 3–4 with evenly spaced robust sets of setae; rami of uropods 1–2 with long marginal and apical robust setae ..... *Antipodeus wellingtoni*

—— Gnathopods not sexually dimorphic; article 6 of pereopods 3–4 with unevenly spaced robust sets of setae; rami of uropods 1–2 with short marginal and apical robust setae ..... *Antipodeus ripensis*

6 Article 2 of mandibular palp only slightly longer than article 3; gnathopods not sexually dimorphic; telson cleft 100 percent ..... *Antipodeus mortoni*

—— Article 2 of mandibular palp distinctly longer than article 3; gnathopods sexually dimorphic; telson cleft about 70 percent 7

7 Ventral setae on antennae 1–2 short and numerous; calceoli absent on male antenna 2; basodactylar robust setae and setae of pereopods 5–7 short; setae on article 2 of mandibular palp mostly short ..... *Antipodeus antipodeus*

—— Ventral setae on antennae 1–2 long and sparse; calceoli present on male antenna 2; basodactylar robust setae and setae of pereopods 5–7 long; setae on article 2 of mandibular palp mostly long ..... *Antipodeus franklini*

8 Telson entire ..... *Protocrangonyx fontinalis*

—— Telson cleft 9

9 Coxa 1 tapering distally; some dactyls of pereopods 3–7 multispinous ..... *Totgammarus eximius*

—— Coxa 1 not tapering distally; pereopods 3–7 dactyls not multispinous 10

10 Inner ramus of male uropod 3 moderately elongate—equal to or greater than 0.5 × outer ramus (vari- or magniramous) ..... (*Austrogammarus*) 11

—— Inner ramus of male uropod 3 short—less than 0.5 × outer ramus (parviramous) or absent 17

11 Coxa 4 heavily setose ventrally; uropod 3 (male hermaphrodite) with only slender setal clusters medially on outer ramus; articles 4–6 of pereopods 5–7 with many long setae ..... *Austrogammarus australis*

—— Coxa 4 poorly setose ventrally; uropod 3 with robust setae in medial slender setal clusters on outer ramus; articles 4–6 of pereopods 5–7 with few long setae 12

12 Urosomites with only 1 or none dorsal robust seta on each side 13

—— Some urosomites with 2+ robust setae on each side 15

13 Epimeron 1 lacking anteroventral setae; thick robust setae on article 6 of pereopods 3–4 with more than 1 per set; uropod 2 lacking setae; telson with dorsal robust setae ..... *Austrogammarus smithi*

—— Epimeron 1 bearing anteroventral setae; thick robust setae on article 6 of pereopods 3–4 with only 1 per set; uropod 2 bearing seta(e); telson lacking dorsal robust setae 14

14 Telson cleft about 80 percent; inner ramus of female uropod 3 elongate—0.6 × length of outer ramus, with lateral robust seta groups, apex with slender setae only ..... *Austrogammarus saycei*

—— Telson cleft 100 percent; inner ramus of female uropod 3 short—0.3 × length of outer ramus, without lateral robust seta groups, apex with robust and slender setae ..... *Austrogammarus haasei*

15 Pleonite 5 with 3 dorsal robust setae on each side; pleonite 4 with 2 dorsal robust setae on each side ..... *Austrogammarus spinatus*

—— Pleonite 5 with 4–5 dorsal robust setae on each side; pleonite 4 with 3 dorsal robust setae on each side 16

16 Coxa 4 moderately excavate; oostegites ovate; epimera with 1–6–7 ventromarginal robust setae; pleonites 4–5 with 5+–6+ dorsal robust setae; uropod 2 extending to less than 0.7 × length uropod 1 in intact specimen; telson not reaching beyond peduncle of uropod 3, with lateral marginal setae extending from M0.25 to apex ..... *Austrogammarus telsosetosus*

—— Coxa 4 strongly excavate; oostegites tending subrectangular; epimera with 3–5–5 ventromarginal robust setae; pleonites 4–5 with no more than 3 and 5 dorsal robust setae; uropod 2 extending as far as uropod 1 in intact specimen; telson reaching beyond peduncle of uropod 3, lateral marginal setae extending from M0.75 to apex ..... *Austrogammarus multispinatus*

17 Inner ramus of uropod 3 absent or minute, less than 0.1 × length of outer ramus 18

—— Inner ramus of uropod 3 present, 0.1 × or more than length of outer ramus 19

18 Gnathopods small, gnathopod 2 smaller than gnathopod 1; antenna 2 tending pediform; antenna 1 accessory flagellum 4 articles; body vermiform ..... *Giniphargus pulchellus*

—— Gnathopods large, subequal; antenna 2 normal; antenna 1 accessory flagellum 2 articles; body not vermiform ..... *Chillagoe thea*

19 Article 2 of outer ramus of uropod 3 large; 0.4 × or more length of article one ..... (*Uroctena*) 20

—— Article 2 of outer ramus of uropod 3 absent or short, less than 0.4 × length of article one 24

20 Antennae 1–2 densely setose, setae long and drooping; telson cleft 50%; gnathopods of both sexes bearing long anterior setae on carpus and propodus, article 2 of male gnathopod 2 lacking robust setae ..... *Uroctena setosa*

—— Antennae 1–2 poorly setose, setae short and stiff; telson cleft 75+ percent; gnathopods of both sexes lacking long anterior setae on carpus and propodus, article 2 of male gnathopod 2 with lateral robust setae 21

21 Article 2 of male gnathopod 2 with anterior robust setae 22

—— Article 2 of male gnathopod 2 with slender anterior setae 23

22 Article 2 of male gnathopod 2 with 4 sets (3–4 setae in each) of posterolateral robust setae ..... *Uroctena affinis*

—— Article 2 of male gnathopod 2 with 2 sets (2 setae in each) of posterolateral robust setae ..... *Uroctena whadjukia*

23 Article 2 of male gnathopod 2 with about 10–14 lateral robust setae; eyes absent ..... young of *U. affinis* and *Uroctena westralis*

—— Article 2 of male gnathopod 2 with about 6–8 lateral robust setae; eyes well developed, but white ..... young of *U. affinis* and *Uroctena yellandi*

24 Coxal gill 7 present ..... (*Austrocrangonyx*) 25

—— Coxal gill 7 absent 26

25 Hyaline hump on article 4 of gnathopod 1 large; dominant robust seta number in sets of article 6 of pereopods 3–4 = 2 ..... *Austrocrangonyx barringtonensis*

—— Hyaline hump on article 4 of gnathopod 1 small; dominant robust seta number in sets of article 6 of pereopods 3–4 = 1 ..... *Austrocrangonyx hynesi*

26 Third uropod outer ramus with small second article; mandibular palp article three lacking C setae ..... *Hurleya kalamundae*

—— Third uropod outer ramus without second article; mandibular palp article three bearing C setae ..... *Toulrabia willsi*

Family Neoniphargidae

This family consists of eight genera: *Neoniphargus*, the largest, with ten species from New South Wales, Victoria and Tasmania; *Wesniphargus* with two species from Western Australia; *Neocrypta* with six species from caves in New South Wales, and five monospecific genera: *Jasptorus solepti* and *Wombeyanus botellus* from caves in New South Wales, *Tasniphargus tyleri* and *Yulia yuli* from Tasmania, and *Uronyctus longicaudus* from South Australia.

Key to genera and species of Neoniphargidae

1 Sternal gills simple (sausage-shaped) 2

—— Sternal gills dendritic or bearing lumps 9

2 Gnathopods 1–2, ischium, merus and propodus, but not carpus, bearing rugose posterior keels ..... *Uronyctus longicaudus*

—— Gnathopods 1–2 carpus and propodus bearing rugose posterior keels 3

3 Telson cleft 50% ..... *Wombeyanus botulosus*

—— Telson cleft less than 25% ..... (*Neocrypta*) 4

4 Flagellum of second antenna of 4 articles 5

—— Flagellum of second antenna of 5–8 articles 7

5 Length of first antenna 0.4 × body length ..... *Neocrypta robinae*

—— Length of first antenna 0.5 or more × body length 6

6 Outer rami of pleopods of 2 or 3 articles ..... *Neocrypta simoni*

—— Outer rami of pleopods of 6 articles ..... *Neocrypta annae*

7 Gnathopod 2 bearing facial rugosities ..... *Neocrypta georginae*

—— Gnathopod 2 without facial rugosities 8

8 Pereopods 5–7 article two moderately expanded posteriorly, ovate, margins convex ..... *Neocrypta primaris*

—— Pereopods 5–7 article two slightly expanded posteriorly, sub rectangular, margins almost straight to concave ..... *Neocrypta moniae*

9 Sternal gills bearing lumps 10

—— Sternal gills dendritic (some, if not all) 12

10 Propodi of gnathopods expanded apically at palmar corner; third uropod outer ramus first article cylindrical, elongate, length 4 × peduncle; plumose setae absent from both rami ..... *Jasptorus solepti*

—— Propodi of gnathopods not apically expanded at palmar corner; third uropod outer ramus first article foliaceous, length 2 × peduncle, medial plumose setae present on both rami ..... (*Wesniphargus*) 11

11 Propodi of gnathopods bearing posterior rugosities; pereopod 5 moderately setate with few robust setae; carpus and propodus of pereopod 6 strongly setose; coxa four apically ovate; inner ramus of third uropod extending to M0.7 of article 1 of outer ramus ..... *Wesniphargus yanchepensis*

—— Propodi of gnathopods without posterior rugosities; pereopod 5 bearing few setae and numerous robust setae; carpus and propodus of pereopod 6 without setae; coxa four apically subquadrate; inner ramus of third uropod extending to less than M0.4 of article 1 of outer ramus ..... *Wesniphargus nichollsi*

12 Antennae 1–2 with long dense setae, basal articles of primary flagella on antennae 1–2 elongate (conjoint) ..... *Tasniphargus tyleri*

—— Antennae 1–2 with short sparse setae, basal articles of primary flagella on antenna 1–2 short 13

13 Pleopod peduncles strongly setose, outer ramus of uropod 1 with long apical spur in male ..... *Yulia yuli*

—— Pleopod peduncles not strongly setose, outer ramus of uropod 1 without long apical spur in male ..... (*Neoniphargus*) 14

14 Dactyls of pereopods 3–7 multispinose on inner margin; uropod 3 inner ramus with 2–3 apical robust setae; posterior lobes of coxae 5–7 with strong setae 15

—— Dactyls of pereopods 3–7 not multispinose on inner margin; uropod 3 inner ramus with 0–1 apical robust seta; posterior lobes of coxae 5–7 with weak setae 16

15 Third uropod inner ramus with a single, naked apical seta; epimera without posteroventral teeth; telson longer than broad, cleft 77%; outer plate of first maxilla bearing 9 denticulate robust setae; antenna 1 accessory flagellum extending beyond first article of primary flagellum ..... *Neoniphargus coolemanensis*

—— Third uropod inner ramus with 2–3 apical setae, one of which is sparsely plumose; epimera with small posteroventral teeth; telson no longer than broad, cleft 56%; outer plate of first maxilla bearing seven denticulate robust setae; antenna 1 accessory flagellum not extending beyond first article of primary flagellum ..... *Neoniphargus spenceri*

16 Gnathopods sexually dimorphic (male palms notched); coxa 4 not deeply emarginate in males; robust setae on outer ramus of proximal article uropod 3 arranged singly ..... *Neoniphargus tasmanicus*

—— Gnathopods not sexually dimorphic (male palms not notched); coxa 4 deeply emarginate in males; robust setae on outer ramus of proximal article uropod 3 arranged in multiples 17

17 Uropod 3 not extending beyond uropods 1–2; robust setae on uropods 1–2 long ..... *Neoniphargus thomsoni*

—— Uropod 3 extending beyond uropods 1–2; robust setae on uropods 1–2 short or medium sized 18

18 Calceoli present on both antennae 1–2 in males; medial margin of outer ramus of proximal article of uropod 3 with several plumose setae in male ..... *Neoniphargus fultoni*

—— Calceoli not present on antenna 1 (sometimes in antenna 2) in males; medial margin of outer ramus proximal article of uropod 3 without several plumose setae in male 19

19 Antenna 2 without calceoli in males; long setae present on posterior margins of propodi of pereopods 5–7 ..... *Neoniphargus alpinus*

—— Antenna 2 with calceoli in males; long setae lacking on posterior margins or propodi of pereopods 5–7 20

20 Uropod 3 peduncle with very long apicomedial robust seta (spur) in male, outer ramus of third uropod less than 2 × peduncle; telson cleft 70%; eyes large ..... *Neoniphargus exiguus*

—— Uropod 3 peduncle with only short apicomedial robust seta in male, outer ramus of third uropod 2–3 × peduncle; telson cleft less than 70%; eyes vestigial or absent 21

21 Eyes vestigial; outer plate of maxilla 1 bearing 7 denticulate robust setae; posterior lobes of coxae 5–7 without robust setae; outer ramus of third uropod 2 × length of peduncle; telson cleft 60%, each lobe bearing 2 lateral robust setae ..... *Neoniphargus obrieni*

—— Eyes absent; outer plate maxilla 1 bearing 5 or 9 denticulate robust setae; posterior lobes of coxae 5–7 with 1–2 robust setae; outer ramus of third uropod 3 × length of peduncle; telson cleft 50% or less, lobes without lateral setation 22

22 Outer plate of maxilla 1 bearing 9 denticulate robust setae; peduncle of uropod 1 bearing medial robust setae; telson as long as third urosomite, cleft 40%, with 3 apical robust setae on each lobe ..... *Neoniphargus secus*

—— Outer plate of maxilla 1 bearing 5 denticulate robust setae; peduncles of uropod 1 without medial robust setae; telson shorter than third urosomite, cleft 50%, with 1 apical robust seta on each lobe ..... *Neoniphargus richardi*

Check list of species

Corophiidae

Paracorophium excavatum Stebbing 1899—Brisbane River, Qld.

Ceinidae

Austrochiltonia australis (Sayce, 1901)—widespread

Austrochiltonia subtenuis (Sayce, 1902)—widespread

Austrochiltonia dalhousiensis Zeidler, 1997—Dalhousie Springs, S.A.

Phreatochiltonia anopthalma Zeidler, 1991—Dalhousie Springs, S.A.

Eusiridae

Paraleptamphopus sp. (Stebbing, 1899)—Tas.

Pseudomoera fontana (Sayce, 1902)—Woods Point, Vic.

Pseudomoera gabrieli (Sayce, 1901)—Dandenong Range and Gippsland, Vic.

Paracalliopiidae

Paracalliope larai Knott, 1975—Tas.

Paracalliope vicinus, Barnard & Drummond, 1992—Tas., King Island, southern Vic.

Melitidae

Nedsia douglasi Barnard & Williams, 1995—North West Cape, W.A.

Nedsia straskraba Bradbury & Williams, 1996—Barrow Island, W.A.

Nedsia fragilis Bradbury & Williams, 1996—Barrow Island, W.A.

Nedsia humphreysi Bradbury & Williams, 1996—Barrow Island, W.A.

Nedsia hurlberti Bradbury & Williams, 1996—Barrow Island, W.A.

Nedsia urifimbriata Bradbury & Williams, 1996—Barrow Island, W.A.

Nedsia macrosculptilis Bradbury & Williams, 1996—Barrow Island, W.A.

Nedsia sculptilis Bradbury & Williams, 1996—Barrow Island, W.A.

Norcapensis mandibulis Bradbury & Williams, 1997b—North West Cape, W.A.

Brachina invasa Barnard & Williams, 1995—Flinders Ranges, S.A.

Melita plumulosa Zeidler, 1988—coastal N.S.W.

Bogidiellidae

Bogidomma australis Bradbury & Williams, 1996—Barrow Island, W.A.

Crangonyctoidea

Paramelitidae

Austrogammarus australis (Sayce, 1901)—Dandenong Range, Vic.

Austrogammarus smithi Williams & Barnard, 1988—Magnet Creek, northwest Tas.

Austrogammarus haasei (Sayce, 1901)—Dandenong Range, Vic.

Austrogammarus saycei Williams & Barnard, 1988—Dandenong Range, Vic.

Austrogammarus spinatus Williams & Barnard, 1988—Dandenong Range, Vic.

Austrogammarus multispinatus Williams & Barnard, 1988—Dandenong Range, Vic.

Austrogammarus telsosetosus Barnard & Williams, 1995—Lake Bonney, S.A.

Austrocrangonyx barringtonensis (Chilton, 1916)—Barrington Tops, N.S.W.

Austrocrangonyx hynesi Williams & Barnard, 1988—Barrington Tops, N.S.W.

Antipodeus antipodeus (G.W. Smith, 1909)—Mole Creek, Tas.

Antipodeus wellingtoni (G.W. Smith, 1909)—Mount Wellington, Tas.

Antipodeus niger (G.W. Smith, 1909)—Hartz Mountains. Tas.

Antipodeus ripensis (G.W. Smith, 1909)—Great Lake, Tas.
Antipodeus mortoni (Thomson, 1893)—Huon River Valley, Tas.
Antipodeus franklini Williams & Barnard, 1988—Huon River Valley, Tas.
Hurleya kalamundae Straskraba, 1966—Kalamunda, W.A.
Uroctena affinis Nicholls, 1926c—near Perth, W.A.
Uroctena westralis (Chilton, 1925)—near Perth, W.A.
Uroctena setosa Nicholls, 1926c—Katanning and near Perth, W.A.
Uroctena yellandi Nicholls, 1926d—south of Armadale (near Perth), W.A.
Uroctena whadjukia Barnard & Williams, 1995—Wungong System, W.A.
Giniphargus pulchellus (Sayce, 1899)—Thorpdale, Gippsland, Vic.
Protocrangonyx fontinalis Nicholls, 1926a—Darling Range, W.A.
Toulrabia willsi Barnard & Williams, 1995—Stirling Range, W.A.
Chillagoe thea Barnard & Williams, 1995—Chillagoe Caves, Qld.
Totgammarus eximius Bradbury & Williams, 1995—southwest W.A.
Pilbarus millsi Bradbury & Williams, 1997b—Millstream, Pilbara, W.A.

Neoniphargidae

Tasniphargus tyleri Williams & Barnard, 1988—Great Lake, Tas.
Neoniphargus thomsoni Stebbing, 1899—Mount Wellington, Tas.
Neoniphargus spenceri (Sayce, 1901)—Plenty Range, Vic.
Neoniphargus fultoni Sayce, 1902—Warburton, Vic.
Neoniphargus obrieni Nicholls, 1926b—Mount Buffalo, Vic.
Neoniphargus alpinus G.W. Smith, 1909—Mount Read, Tas.
Neoniphargus exiguus G.W. Smith, 1909—near Kingston, Tas.
Neoniphargus tasmanicus G.W. Smith, 1909—Great Lake, Tas.
Neoniphargus coolemanensis Bradbury & Williams, 1997b—Murray Cave, Cooleman Plain, N.S.W.
Neoniphargus secus Bradbury & Williams, 1997b—Gurungah Cave, Wombeyan Cave system, N.S.W.
Neoniphargus richardi Bradbury & Williams, 1997b—River Cave, Wombeyan Cave system, N.S.W.
Wesniphargus nichollsi (Straskraba, 1964)—Cannington, W.A.
Wesniphargus yanchepensis Bradbury & Williams, 1997b—Yanchep Cave, W.A.
Neocrypta primaris Bradbury & Williams, 1997b—Limekiln Cave, Wellington, N.S.W.
Neocrypta robinae Bradbury & Williams, 1997b—Diprotodon Cave, Canomodine, N.S.W.
Neocrypta moniae Bradbury & Williams, 1997b—Bowan Park cave system, N.S.W.
Neocrypta georginae Bradbury & Williams, 1997b—Apple Tree Cave, Copperhania, N.S.W.
Neocrypta annae Bradbury & Williams, 1997b—Bowan Park Cave system, N.S.W.
Neocrypta simoni Bradbury & Williams, 1997b—Paradox Cave, Jenolan, N.S.W.
Wombeyanus botulosus Bradbury & Williams, 1997b—Bullio Cave, Wombeyan Cave system, N.S.W.
Jasptorus solepti Bradbury & Williams, 1997b—Wee Jasper Cave system, N.S.W.
Uronyctus longicaudus Stock & Iliffe, 1990—Mount Gambier area, S.A.
Yulia yuli (G.W. Smith, 1909)—Yules Lake, Tas.

Perthiidae

Perthia branchialis (Nicholls, 1924)—southwest W.A.
Perthia acutitelson Straskraba, 1964—southwest W.A.

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References

Barnard, J.L., 1969. The families and genera of marine gammaridean amphipoda. *Bulletin of the United States National Museum* 271: 1–535.

Barnard, J.L., & C.M. Barnard, 1983. *Freshwater Amphipoda of the World, I. Evolutionary Patterns. II. Handbook and Bibliography*. Mount Vernon Virginia: Hayfield Associates.

Barnard, J.L., & M.M. Drummond, 1992. *Paracalliope*, a genus of Australian shorelines (Crustacea: Amphipoda: Paracalliopiidae). *Memoirs of the Museum of Victoria* 53(1): 1–29.

Barnard, J.L., & W.D. Williams, 1995. The Taxonomy of Amphipoda (Crustacea) from Australian fresh waters, Part 2. *Records of the Australian Museum* 47(2): 161–201.

Bradbury, J.H., & W.D. Williams, 1995. A new genus and species of Crangonyctoid amphipod (Crustacea) from Western Australian fresh waters. *Transactions of the Royal Society of South Australia* 119(2): 67–74.

Bradbury, J.H., & W.D. Williams, 1996. Freshwater amphipods from Barrow Island, Western Australia. *Records of the Australian Museum* 48(1): 33–74.

Bradbury, J.H., & W.D. Williams, 1997a. Amphipod (Crustacea) diversity in underground waters in Australia: an Aladdin's Cave. *Memoirs of the Museum of Victoria* 56(2): 513–519.

Bradbury, J.H., & W.D. Williams, 1997b. The amphipod (Crustacea) stygofauna of Australia: description of new taxa (Melitidae, Neoniphargidae, Paramelitidae), and a synopsis of known species. *Records of the Australian Museum* 49(3): 249–341.

Bradbury, M.R., J.H. Bradbury & W.D. Williams, 1998. Scanning electron microscope studies of rugosities, cuticular microstructures of taxonomic significance of the Australian amphipod family Neoniphargidae. *Crustaceana* 71(6): 603–614.

Chilton, C., 1916. Some Amphipoda and Isopoda from Barrington Tops (4600 ft. alt.). *Journal and Proceedings of the Royal Society of New South Wales* 50: 82–98.

Chilton, C., 1925. A new blind freshwater amphipod (genus Neoniphargus) from Western Australia. *Journal of the Royal Society of Western Australia* 11(9): 81–85.

Friend, J.A., 1987. The terrestrial amphipods (Amphipoda: Talitridae) of Tasmania: systematics and zoogeography. *Records of the Australian Museum, Supplement* 7: 1–85.

Horwitz, P., B. Knott & W.D. Williams, 1995. *A Preliminary Key to the Malacostracan Families (Crustacea) Found in Australian Inland Waters*. Co-operative Research Centre for Freshwater Ecology Identification Guide No. 4. Albury: Murray Darling Freshwater Research Centre.

Karaman, G.S., 1969. XXII Beitrag zur Kenntnis der Amphipoden. Über einige Formen des Genus *Sarathrogammarus* (Gammaridae) aus Afghanistan. *Acta Musei Macedonici scientiarum Naturalium* Skopje 11(11): 195–208.

Knott, B., 1975. A new species of freshwater amphipod *Paracalliope larai*, (family Eusiridae) from Tasmania. *Papers and Proceedings of the Royal Society Tasmania* 109: 39–52.

Lincoln, R.J., & D.E. Hurley, 1981. The calceolus, a sensory structure of gammaridean amphipods (Amphipoda, Gammaridea). *Bulletin of the British Museum of Natural History* (Zool.) 40(4): 103–116.

Lowry, J.K., & H.E. Stoddart, 1993. Crustacea Amphipoda: Lysianassoids from Philippine and Indonesian waters. In *Resultata des Campagnes MUSORSTOM, Volume 10*, ed. A. Crosnier. *Mémoirs Museum national d'Histoire naturelle, Paris (n.s.)* 156: 55–109.

Nicholls, G.E., 1924. *Neoniphargus branchialis*, a new freshwater amphipod from south-western Australia. *Journal of the Royal Society of Western Australia* 10: 105–111

Nicholls, G.E., 1926a. *Protocrangonyx fontinalis*, a new blind freshwater amphipod from Western Australia. *Journal of the Royal Society of Western Australia* 12: 71–78.

Nicholls, G.E., 1926b. *Neoniphargus obrieni*, a new species of blind amphipod from Victoria. *Journal of the Royal Society of Western Australia* 12: 79–86

Nicholls, G.E., 1926c. Description of a new genus and two new species of blind freshwater amphipods from Western Australia. *Journal of the Royal Society of Western Australia* 12: 105–111.

Nicholls, G.E., 1926d. Description of a new species of *Uroctena* from south-western Australia. *Journal of the Royal Society of Western Australia* 12: 113–116.

Richardson, A.M.M., 1987. Freshwater amphipoda. In *The Freshwater Fauna of the World Heritage Area, Tasmania*, eds. W.W. Fulton and A.M.M. Richardson, pp. 23–27. Tasmania: Inland Fisheries Commission.

Sayce, O.A., 1899. Art. XVII.—*Niphargus pulchellus*, a new Victorian blind amphipod. *Proceedings of the Royal Society of Victoria* (n.s.) 12: 152–159.

Sayce, O.A., 1901. Art. XVII.—Description of some new Victorian freshwater Amphipoda. *Proceedings of the Royal Society of Victoria* (n.s.) 13: 225–242.

Sayce, O.A., 1902. Art. VI.—Description of some new Victorian freshwater Amphipoda, No. 2. *Proceedings of the Royal Society of Victoria* (n.s.) 15: 47–58.

Smith, G.W., 1909. The freshwater Crustacea of Tasmania, with remarks on their geographical distribution. *Transactions of the Linnean Society of London* (2, Zoology) 11: 61–92.

Smith, S.J., & R. Swain, 1982. Observations on the taxonomy of *Austrochiltonia* (Hurley) (Amphipoda: Ceinidae). *Bulletin of the Australian Society for Limnology* 8: 39–43.

Stebbing, T.R.R., 1899. Amphipoda from the Copenhagen Museum and other sources. *Transactions of the Linnean Society of London*, (2, Zoology) 8: 395–432.

Stock, J.H., & T.M. Iliffe, 1990. A new Australian crangonyctid amphipod with a habit convergent to the Old World genus *Niphargus*. *Stygologia* 5(3): 137–142.

Straskraba, M., 1964. *Perthia* N.G. (Amphipoda, Gammaridae) from fresh waters of western Australia, with remarks on the genera *Neoniphargus* and *Uroctena*. *Crustaceana* 7(2): 125–139.

Straskraba, M., 1966. *Hurleya kalamundae* n.g. n.sp. (Amphipoda, Gammaridae) from subterranean waters of Western Australia. *International Journal of Speleology* 2: 291–295.

Thomson, G.M., 1893. Notes on Tasmanian Crustacea, with descriptions of new species. *Papers and Proceedings of the Royal Society of Tasmania, for 1892*, pp. 45–76.

Williams, W.D., 1962. The Australian freshwater amphipods. I. The genus *Austrochiltonia* (Crustacea: Amphipoda: Hyalellidae). *Australian Journal of Marine and Freshwater Research* 13(2): 198–216.

Williams, W.D., & J.L. Barnard, 1988. The taxonomy of crangonyctoid Amphipoda (Crustacea) from Australian fresh waters: foundation studies. *Records of the Australian Museum, Supplement* 10: 1–180.

Zeidler, W., 1988. A new species of *Melita* (Crustacea: Amphipoda: Melitidae) from northern New South Wales with a note on the Genus *Abludomelita* Karaman, 1981. *Proceedings of the Linnean Society of New South Wales* 110(4): 327–338.

Zeidler, W., 1991. A new genus and species of phreatic amphipod (Crustacea; Amphipoda) belonging to the "*chiltonia*" generic group, from Dalhousie Springs, South Australia. *Transactions of the Royal Society of South Australia* 115: 177–187.

Zeidler, W., 1997. A new species of freshwater amphipod *Austrochiltonia dalhousiensis* sp.nov., (Crustacea: Amphipoda: Hyalellidae) from Dalhousie Springs, South Australia. *Transactions of the Royal Society of South Australia* 121: 29–42.

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SCANNING ELECTRON MICROSCOPE STUDIES OF RUGOSITIES, CUTICULAR MICROSTRUCTURES OF TAXONOMIC SIGNIFICANCE OF THE AUSTRALIAN AMPHIPOD FAMILY NEONIPHARGIDAE (AMPHIPODA)

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ABSTRACT

Representative taxa of Australian freshwater amphipod families were examined to determine the taxonomic significance of rugosities, microsetae on the gnathopods and maxillipedal palps. Eighteen species of twelve genera in four families were examined with both light and scanning electron microscopes. Unique palmate microsetae, rugosities, were found to be specific to the Neoniphargidae Bousfield, 1977.

RÉSUMÉ

Des taxa représentatifs des familles d'Amphipodes d'eau douce d'Australie ont été examinés pour déterminer la signification taxonomique des rugosités, microsètes sur les gnathopodes et les palpes des maxillipèdes. Dix-huit espèces appartenant à douze genres et quatre familles ont été examinées aux microscopes optique et à balayage. Des rugosités, microsètes palmées uniques ont été trouvée, spécifiques aux Neoniphargidae Bousfield, 1977.

INTRODUCTION

Gnathopodal and maxillipedal rugosities have been suggested as indicative of the freshwater Australian amphipod crangonyctoid family Neoniphargidae (cf. Williams & Barnard, 1988). These structures, which are located posteriorly on gnathopods and the apex of the third article of the maxillipedal palp of neoniphargids, were first noted by Williams & Barnard (1988) but not defined. Under the light microscope, they appear as areas of raised lumps or modified setae, and are present facially and apically on the usually prominently developed apical lobe of the third article of the maxillipedal palp, and on the gnathopods, commonly associated with lobes, humps or keels on the posterior margins of several articles, especially the merus, carpus and propodus. Rugosities have been

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included in species descriptions, and their location indicated in illustrations of neoniphargids (Williams & Barnard, 1988), but have not been described in detail for these Australian amphipods, notwithstanding their taxonomic significance.

The family Neoniphargidae Bousfield, 1977 within the superfamily Crangonyctoidea Bousfield, 1977, as defined by Williams & Barnard (1988), contains four Australian genera: *Neoniphargus* Stebbing, 1899, *Tasniphargus* Williams & Barnard, 1988, *Wesniphargus* Williams & Barnard, 1988, and *Yulia* Williams & Barnard, 1988. It is characterized inter alia by the presence of rugosities on the maxillipedal palp article three and gnathopods, oostegites of broad to medium width, and sternal gills dendritic or bearing small lumps (Williams & Barnard 1988). Rugosities (undefined) are not, however, exclusively neoniphargid among Australian crangonyctoids, as Williams & Barnard (1988) record their presence on the maxillipedal palp and gnathopods of *Protocrangonyx fontinalis* Nicholls, 1926 (Paramelitidae Bousfield, 1977), from Western Australia.

Recently described neoniphargid species from several caves in New South Wales (Bradbury & Williams, 1997) bear rugosities, but do not have three other family characters, namely, sternal gills that are simple (not complex or lumped), a telson that is slightly to moderately cleft (not deeply cleft), and oostegites that are narrow (not broad). Seven such species have been ascribed to two new neoniphargid genera (*Neocrypta* and *Wombeyanus* Bradbury & Williams, 1997). A combination of characters, including the presence of rugosities, was considered sufficient to place them as neoniphargids (Bradbury & Williams, 1997).

Rugosities would be unique neoniphargid markers if they differed from those reported from *Protocrangonyx fontinalis* and from other cuticular structures found in similar positions among other Australian amphipods. However, resolution that is sufficient to clarify the form of rugosities cannot be achieved with the light microscope. To resolve this matter, scanning electron microscope study of rugosities on the post ventral regions of the gnathopods and apex of maxillipedal palps of four families of Australian amphipods was made. This paper reports on the results.

The morphology of several other amphipod microcuticular structures has been examined with the aid of the scanning electron microscope, including the cuticle itself (Meyer-Rochow, 1981; Halcrow & Bousfield, 1987; Read & Williams, 1991), cuticular pores (Halcrow, 1985; Halcrow & Powell, 1992), the organ of Bellonci (Steele, 1984, 1986), mandibles (Watling, 1993), calceoli (Lincoln & Hurley, 1981; Lincoln, 1985; Stapleton & Williams, 1988; Godfrey et al., 1988), setae (Oshel et al., 1988; Oshel & Steele, 1988; Olyslager & Williams, 1993; Platvoet, 1985; Steele, 1991), and the callynophore (Lowry, 1986).

Description and classification of peracarid crustacean cuticular processes have recently been reviewed by Jacques (1989), Watling (1989), and Wagner (1994). The cuticular structures examined in detail in this study are small, articulated, without setules, annuli, or teeth. They thus fall within Watling's (1989) Type IV, but are not among forms described by Jacques (1989) in his study based upon decapod cuticule, nor among structures observed by either Watling (1989), or Wagner (1994), although would be included within Wagner's (1994) category of Type II microsetae. Among studies of the morphology of amphipod setae, the work of Oshel & Steele (1988) in which they describe and distinguish four classes, each of several sub-classes, is useful. However, their use of the term "microtrich" to describe setae of length less than 25 μm appears incorrect, "microtrich" having already been established as descriptive of an expanded part of a cell (Wagner, 1994). In this report we refer to rugosities as microsetae.

MATERIALS AND METHODS

Eighteen species of twelve genera of three Australian crangonyctoid families (Neoniphargidae Bousfield, 1977, Paramelitidae Bousfield, 1977, and Perthiidae Williams & Barnard, 1988), as well as the talitroid family Ceinidae Barnard, 1972, were examined for the presence of rugosities by both light and scanning electron microscopy (table I). The first and second gnathopods of one side and both maxillipedal palps were dissected from preserved (70% ethanol) specimens from Victoria, New South Wales, Tasmania, and Western Australia (table I) identified to genus or species. Specimens were prepared for examination under the light microscope (Wild M20) as wet mounts in 70% alcohol under cover slips. Subsequently, they were prepared for the scanning electron microscope using a method modified from Felgenhauer (1987): fixation for 12-14 hrs in 4% paraformaldehyde/1.25% glutaraldehyde in phosphate buffered saline (PBS) + 4% sucrose, at pH 7.2; washed twice for 30 min in PBS + 4% glucose; post-fixed in 1% OsO_4 for 2 hrs under refrigeration; dehydrated through successive alcohol (ethanol) baths (70, 90, 95, 100%) for two hours and two changes in each; followed by 1 hour in 100% ethanol; 20 min in equal parts 100% alcohol and 100% acetone; 20 min in 100% acetone. Specimens were then dried to critical point by replacement of acetone with CO_2 and evaporation of the CO_2; mounted on a microscope stub with a "sticky-tab"; sputter coated with gold-palladium; and examined at 10 kV with a Philips XL30 scanning electron microscope. Specimens were examined at approximately 300 to 10 000× magnification. Photographic results were recorded on diskette.

TABLE I
Material examined of Australian Amphipoda

Neoniphargidae

Neocrypta primaris Bradbury & Williams, 1997. Lime Kiln Cave, New South Wales.
Neoniphargus sp. nov. 'a'. Dinner Plain, Mt. Hotham, Victoria.
Neoniphargus thomsoni Stebbing, 1899. Mt. Wellington, Tasmania.
Neoniphargus sp. nov. 'b'. Quamby Brook, Tasmania.
Tasniphargus tyleri Williams & Barnard, 1988. Woods Lake, Tasmania.
Wesniphargus nichollsi (Straškraba, 1964). Boyanup, Western Australia.
Wesniphargus sp. nov. 'a'. York River at Nalg, Tasmania.
Wesniphargus sp. nov. 'b'. Tooms Lake, Tasmania.
Wesniphargus sp. nov. 'c'. Green Pond Rivulet, Tasmania.
Wesniphargus sp. nov. 'd'. Cock Creek Plain, Tasmania.
Yulia yuli (G.W.Smith, 1909). Youls Tarn, Ben Lomond, Tasmania.

Ceinidae

Austrochiltonia australis (Sayce, 1901). Meadows, South Australia.

Paramelitidae

Antipodeus niger (G. W. Smith, 1909). Mt. Wellington, Tasmania.
Austrocrangonyx sp. nov. Barrington Tops, New South Wales.
Austrogammarus spinatus Williams & Barnard, 1988. Bayswater, Victoria.
Protocrangonyx fontinalis Nicholls, 1926. Darlington, Western Australia.
Uroctena westralis (Chilton, 1925). Darlington, Western Australia.

Perthiidae

Perthia acutitelson Straškraba, 1964. Yeagarup Lake, Western Australia.

RESULTS

Examination under the light microscope confirmed the consistent presence of rugosities among neoniphargids on the posterior lobes or keels on some or all of articles two to six of the gnathopods, and on apical extensions of the third article of the maxillipedal palps. Rugosities were not visible under the light microscope among any species other than of the family Neoniphargidae, including *Protocrangonyx fontinalis*

Scanning Electron Microscope (SEM) examination revealed details of cuticular structures only at magnifications greater than 400×.

Cuticular polygonal surface patterning is seen in several species on the gnathopods (fig. 1a) and, more exceptionally, maxillipedal palps (fig. 1b, c). Polygonal patterning is mostly five- or six-sided, and discernible through overlying microsetae, whether simple or complex, small (fig. 1d, e) or elongate (figs. 1f, 2a). Not all articles were so patterned, and apolygonal cuticle also occurred both on gnathopods (fig. 2b, c) and maxillipedal palps (fig. 2d).

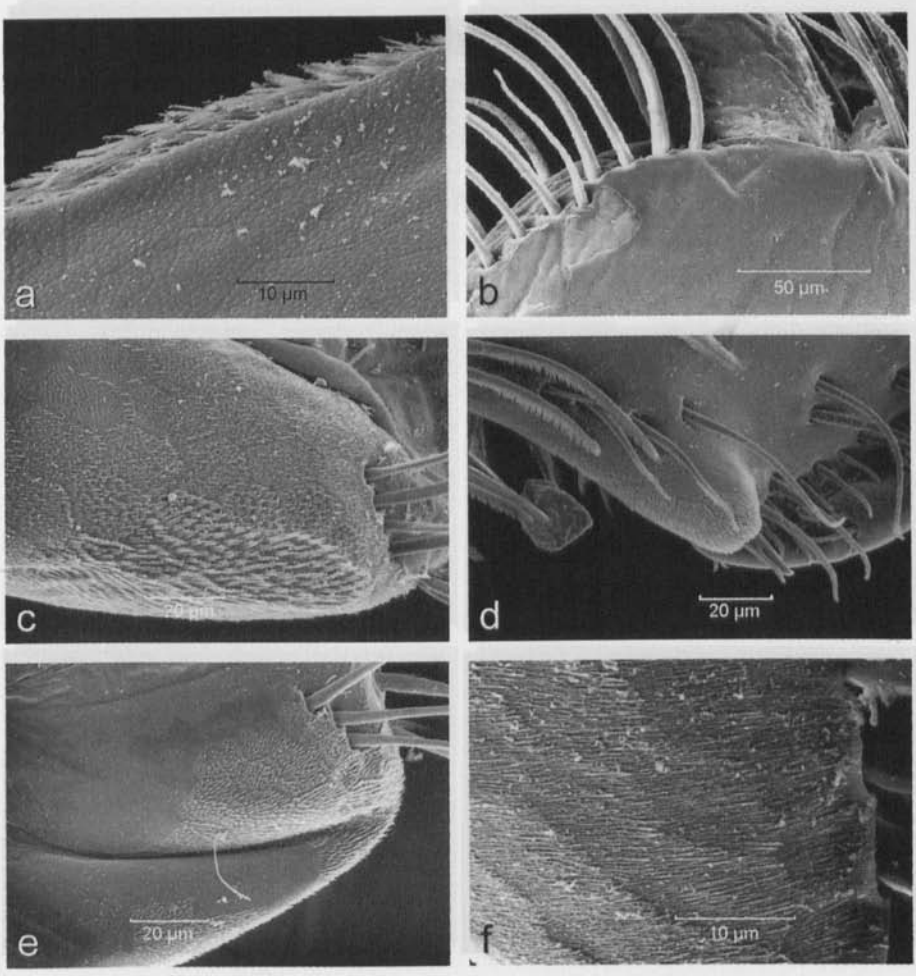

Fig. 1. SE-micrographs of rugosities. a, *Neocrypta primaris*, ventral margin, gnathopod one; b, *Perthia acutitelson*, maxillipedal palp article three apex and base of dactyl; c, *Wesniphargus* sp. nov. 'a', disto-lateral face and ventral margin of merus, gnathopod two; d, *Austrochiltonia australis*, palmar corner and disto-ventral margin, gnathopod one propodus; e, *Wesniphargus* sp. nov. 'b', lateral face and disto-ventral margin, gnathopod two merus; f, *Austrogammarus spinatus*, posterior face and margin, gnathopod one ischium.

Several types of setal structures were found on most species. Lanceolate structures arranged singly (fig. 2e), or in groups (fig. 2f), often arising from a broad common base (fig. 3a), occur facially on gnathopodal articles (fig. 3b, c) and maxillipedal palps (fig. 3d) of neoniphargids and others, as well as post-ventrally on articles of the gnathopods of non-neoniphargids (fig. 3e).

Setae of the rugose areas of neoniphargids visible under the light microscope, when seen under the scanning electron microscope, are basally stalked, hand-like microsetae with two, three, or more fingers, usually expanding toward the

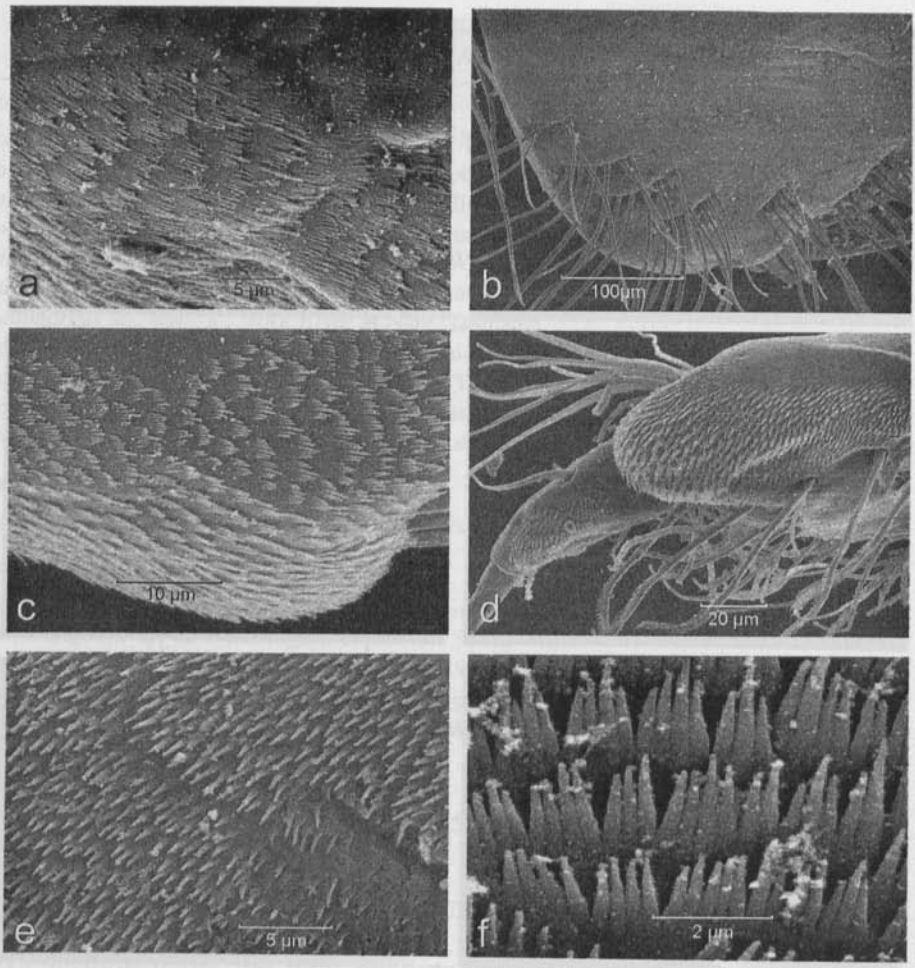

Fig. 2. SE-micrographs of rugosities. a, *Perthia acutitelson*, disto-ventral corner, gnathopod one basis; b, *Neoniphargus* sp. nov. 'a', disto-ventral apex (palmar corner), gnathopod one propodus; c, *Wesniphargus* sp. nov. 'b', disto-ventral corner, gnathopod one basis; d, *Wesniphargus* sp. nov. 'b', maxillipedal palp article three apex and dactyl; e, *Wesniphargus* sp. nov. 'b', disto-lateral face, gnathopod two basis; f, *Antipodeus niger*, ventro-lateral face, gnathopod one propodus.

peripheries, the lateral digits curving outward apically (figs. 3f, 4a, b). Microsetae of the rugose areas varied in length from 2.5 μm (fig. 1c) to 20 μm (fig. 4b), those at the outer periphery usually much longer than those facial (fig. 4c). Such setae on the gnathopods and maxillipedal palps of all neoniphargids examined, varying only in size and proportion, but not in form, and were absent from all other taxa examined. They are, however, similar to setae described by Oshel & Steele (1988) from article 5 of the second gnathopod of *Lysianassa alba* Holmes, 1903, designated type 4e: 'palmate, with a broadly flattened end and three or

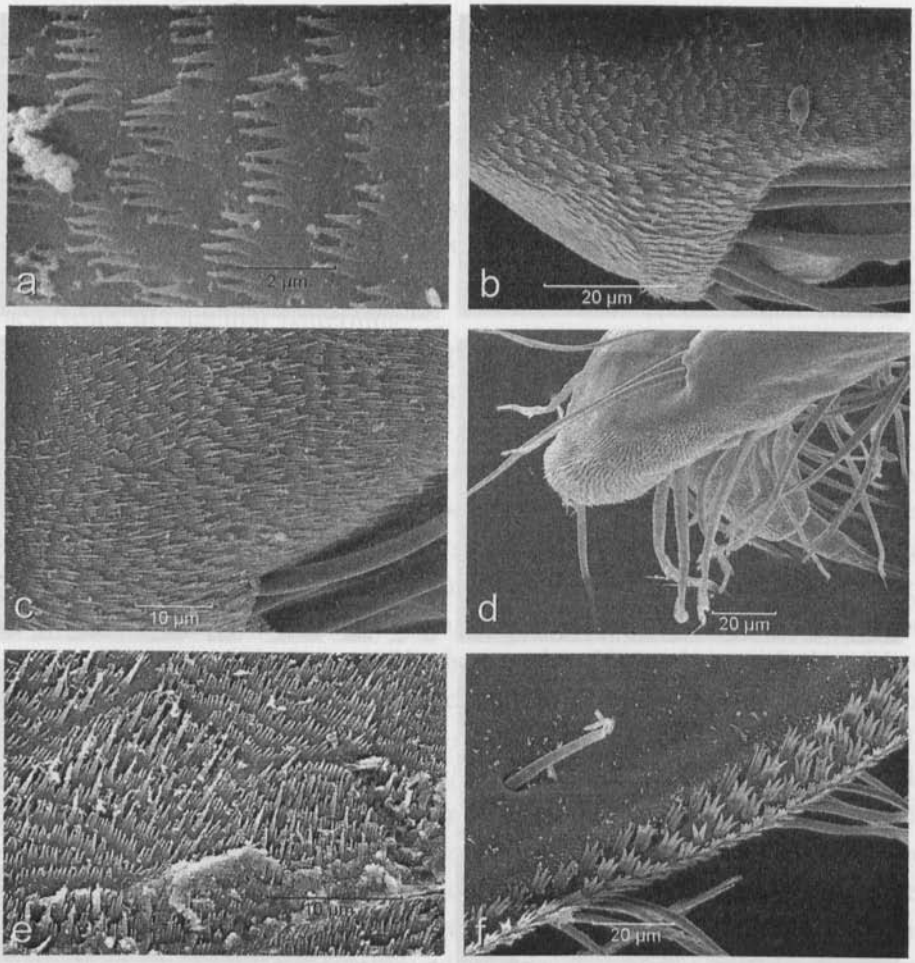

Fig. 3. SE-micrographs of rugosities. a, *Neoniphargus thomsoni*, lateral face, posterior lobe, gnathopod one carpus; b, *Wesniphargus* sp. nov. 'b', lateral view, disto-ventral margin, gnathopod two basis; c, *Wesniphargus* sp. nov. 'c', lateral view, disto-ventral margin, gnathopod one ischium; d, *Yulia yuli*, maxillipedal palp article three apex and dactyl; e, *Antipodeus niger*, ventro-lateral face, gnathopod one basis; f, *Yulia yuli*, ventro-distal margin, gnathopod one propodus.

more finger-like projections; may or may not be stalked', and by Kaufmann (1994) from the carpus and propodus of the second gnathopod of the lysianassoid *Orchomene limodes* Meador & Present, 1985.

Microsetae with superficial similarity to the palmate structures of neoniphargids occur on a small area of the post-distal region of the second article of gnathopod 2 of the perthiid species *Perthia acutitelson* Straškraba, 1964 (fig. 4d). These structures, however, appear to be broad-based, compound linear microsetae with short lateral and long central elements, and without the disto-lateral bent

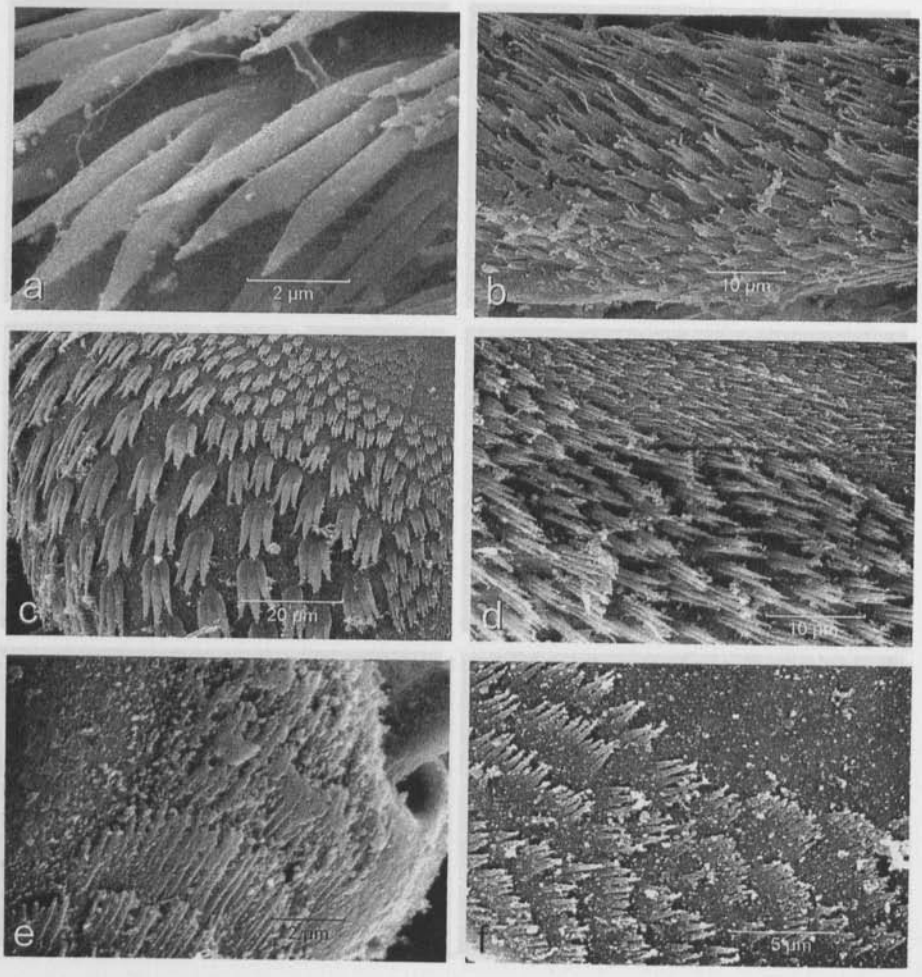

Fig. 4. SE-micrographs of rugosities. a, *Neoniphargus thomsoni*, post-ventral margin setae, gnathopod one carpal lobe; b, *Tasniphargus tyleri*, medial face, ventral margin, maxillipedal palp third article; c, *Neoniphargus* sp. nov. 'a', lateral face, posterior lobe, gnathopod one merus; d, *Perthia acutitelson*, lateral face, disto-ventral margin, gnathopod one basis; e, *Protocrangonyx fontinalis*, ventro-distal corner, gnathopod one ischium; f, *Protocrangonyx fontinalis*, ventro-lateral margin, gnathopod one basis.

apex or stalked bases as in the rugosities of neoniphargids, and are similar to linear microtrichs of the coxal plate of *Podocerus* sp. (*Podocerus* Leach, 1814) described by Halcrow & Bousfield (1987).

Rugose areas of gnathopods and maxillipeds of *Protocrangonyx fontinalis* described by Williams & Barnard (1988) were found to be crowded regions of compound lanceolate microsetae (sensu Halcrow & Bousfield, 1987) (fig. 4e, f).

DISCUSSION

Cuticular polygonal patterning was noted in representatives of all families, at times through long or dense overlying setae. Halcrow & Bousfield (1987) found them abundant among gammarid amphipods, but were unable to suggest any functional significance, although they noted trends in similarity of pore and polygon patterns in agreement with earlier work (Bousfield, 1978, 1982, 1983). In this study, it was not our intention, nor possible, to discern higher order characteristics in cuticular patterning.

Studies of cuticular micro-structures of amphipods are reported by several authors, notably Halcrow & Bousfield (1987), Oshel & Steele (1988) Oshel et al. (1988), Platvoet (1985), Watling (1989), and Read & Williams (1991). Watling (1989) established fundamental definitions of cuticular outgrowths, and classified setae into four principle groups, these being adapted and modified by Wagner (1994). Oshel & Steele (1988) grouped small (length less than 25 μm) amphipod setae ("microtrichs") into 4 classes and 13 types on the basis of morphology whilst acknowledging their groups were not exhaustive since many amphipod taxa had not been studied. Fish (1972), in a study of isopod setae distinguished two microtrich types on the basis of form and size: triangular structures of approximately 2 μm length arranged in crescent rows, and 10 μm long single microtrichs set into sockets in the cuticle. Platvoet (1985), in a study of the side line organs (which were termed Type II microtrichs sensu Oshel & Steele, 1985) of *Gammarus* Fabricius, 1775 and *Echinogammarus* Stebbing, 1899, considered those organs of phylogenetic significance, observing differences of structure, composition, and location between the genera. Wagner (1994) in reviewing the Thermosbaenacea Monod,1927 employed microsetal types in taxonomic discriminations within that group.

Lanceolate microsetae occurring facially and post-ventrally on the gnathopodal articles and maxillipedal palp of Australian non-neoniphargids, and facially on the gnathopods and maxillipedal palps of neoniphargids are similar to the lanceolate microtrichs reported by Halcrow & Bousfield (1987, figs. 20, 24-26, 30), in a spectrum of amphipod species. The elongate paired (or more) microsetae of *Perthia acutitelson* Straškraba, 1964 appear to be derived forms of compound linear microsetae like those described as compound microtrichs by Halcrow & Bousfield (1987, fig. 30) from a coxal plate of *Podocerus* sp., or dense lanceolate microsetae similar to those on the head of *Meteodiceros fuegiensis* Schellenberg, 1931 (cf. Halcrow & Bousfield, 1987, fig. 25). They are unlike the rugosities of neoniphargids.

Rugosities, recorded from the gnathopods and maxillipedal palp of *Protocrangonyx fontinalis* Nicholls (see Williams & Barnard, 1988), were not visible under

the light microscope in specimens examined by us, but may be visible in larger specimens. In any case, those areas which appeared rough to Williams & Barnard (1988) do bear microsetae visible under the scanning electron microscope of our specimens. However, the setae present were not neoniphargid-type rugosities, but rather ranks of compound linear microsetae, similar to, although longer than, hammate setae (rows) recorded as associated with 'Type A pegs' (Read & Williams, 1991) widely distributed on the cuticle of *Gammarus pseudolimnaeus* Bousfield, 1977.

Palmate microsetae were present on the gnathopods and mandibular palps of neoniphargids examined; all taxa bore microsetae of a similar morphology in rugose areas, structures not found in any of the other species examined. However, similar structures have been described by Oshel & Steele (1988, fig. 16) from the second gnathopod of *Lysianassa alba*, and by Kaufmann (1994, fig. 9B) from the second gnathopod of the lysianassoid *Orchomene limodes*. An association between neoniphargids and lysianassids (marine species with a single freshwater genus, *Onisimus* Boeck, 1871 in shallow water of the Caspian Sea), seems unlikely. The similar structures have presumably evolved separately.

Microscopic examination of neoniphargid rugosities, albeit at very great magnification, gives no indication of the function of these organs, although their location suggests a simple tactile purpose. Kaufmann (1994) considered that the similar structures found in *Orchomene limodes* were non-innervated spines; i.e., non-articulated cuticular processes, with perhaps a cleaning function during grooming, or gustatory function during feeding. This may be true of *O. limodes*, but that species bore the structures on the second gnathopod alone, which was seen to have a distinctly different function from the first gnathopod during both grooming and feeding. The neoniphargids, however, bear them not only on the carpus and propodus of the second gnathopod, but also, according to species, on other articles of both gnathopods, as well as on the maxillipedal palps. It seems likely that the organs have at least a gustatory function. Oshel & Steele (1988) considered similar structures of the second gnathopod of *Lysianassa alba* to be 'setae' (type 4e); i.e., structures produced not as an epidermal outgrowth, but by 'the actions of specialised cells', and thus of phylogenetic significance. Because of their length and overlapping, the exact nature of attachment of these microsetae in neoniphargids cannot be clearly seen from the scanning electron microscope pictures, although their distinctly stalked origin is clear.

As a family characteristic, however, neoniphargid rugosities are consistent and visible under the light microscope at moderate magnification, and therefore important taxonomic criteria for Australian crangonyctoids. Where some family characters have been shown as absent, as in the case of simple rather than budded

or fully dendritic sternal gills, the presence of rugosities indicates affinity with the Neoniphargidae.

The consistency of this character across the family, and its general absence in other families, supports the placement of the new genera *Wombeyanus* and *Neocrypta* within the Neoniphargidae. It also suggests that, despite earlier ideas of the possibly polyphyletic structure of this family (Williams & Barnard, 1988), it may indeed be of single phylogenetic origin.

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REFERENCES

BOUSFIELD, E. L., 1978. A revised classification and phylogeny of amphipod crustaceans. Trans. Royal Soc. Canada, **4**: 343-390.

— —, 1982. Amphipoda. Gammaridea. In: S. B. PARKER (ed.), Synopsis and classification of living organisms: 254-285. (McGraw-Hill, New York).

— —, 1983. An updated phylogenetic classification and palaeohistory of the Amphipoda. In: F. R. SCHRAM (ed.), Crustacean phylogeny. Crustacean Issues, **1**: 257-278.

BRADBURY, J. H. & W. D. WILLIAMS, 1997. The amphipod (Crustacea) stygofauna of Australia: description of new taxa (Melitidae, Neoniphargidae, Paramelitidae), and a synopsis of known species. Rec. Australian Mus., **49** (3): 249-341.

FELGENHAUER, B. E., 1987. Techniques for preparing crustaceans for scanning electron microscopy. Journ. Crustacean Biol., **7** (1): 71-76.

FISH, S., 1972. The setae of *Eurydice pulchra* (Crustacea, Isopoda). Journ. zool., London, **166**: 163-167.

GODFREY, R. B., J. R. HOLSINGER & K. A. CARSON, 1988. A comparison of the morphology of calceoli in the freshwater amphipods *Crangonyx richmondensis* s. lat. (Crangonyctidae) and *Gammarus minus* (Gammaridae). Crustaceana, (suppl.) **13**: 115-121.

HALCROW, K., 1985. The fine structure of the pore canals of the talitrid amphipod *Hyale nilssoni*. Journ. Crustacean Biol., **5**: 606-615.

HALCROW, K. & E. L. BOUSFIELD, 1987. Scanning electron microscopy of surface microstructures of some gammaridan amphipod crustaceans. Journ. Crustacean Biol., **7** (2): 274-287.

HALCROW, K. & C. V. L. POWELL, 1992. Ultrastructure diversity in the pore canal systems of amphipod crustaceans. Tiss. Cell, **24** (3): 417-436.

JACQUES, F., 1989. The setal system of crustaceans: types of setae, groupings, and functional morphology. In: B. E. FELGENHAUER, L. WATLING & A. B. THISTLE (eds.), Functional morphology of feeding and grooming in Crustacea. Crustacean Issues, **6**: 1-13.

KAUFMANN, R. S., 1994. Structure and function of chemoreceptors in scavenging lysianassoid amphipods. Journ. Crustacean Biol., **14** (1): 54-71.

LINCOLN, R. J., 1985. Morphology of a calceolus, an antennal receptor of gammaridan Amphipoda (Crustacea). Journ. nat. Hist., London, **19**: 921-927.

LINCOLN, R. J. & D. E. HURLEY, 1981. The calceolus, a sensory structure of gammaridean amphipods (Amphipoda: Gammaridea). Bull. British Mus. (nat. Hist.), (Zool.) **40** (4): 103-116.

LOWRY, J. K., 1986. The callynophore, a eucaridan/peracaridan sensory organ prevalent among the Amphipoda (Crustacea). Zool. Scripta, **15** (4): 333-349.

MEYER-ROCHOW, V. B., 1981. Note on the cuticular morphology in the terrestrial amphipod *Orchestia* sp. (Crustacea). Zool. Anzeiger, **207** (1-2): 74-77.

OLYSLAGER, N. J. & D. D. WILLIAMS, 1993. Function of the type II microtrich sensilla on the lotic amphipod, *Gammarus pseudolimnaeus* Bousfield. Hydrobiologia, **259**: 17-31.

OSHEL, P. E. & D. H. STEELE, 1988. Comparative morphology of amphipod setae, and a proposed classification of setal types. Crustaceana, (suppl.) **13**: 90-99.

OSHEL, P. E., V. J. STEELE & D. H. STEELE, 1988. Comparative SEM morphology of amphipod microtrich sensilla. Crustaceana, (suppl.) **13**: 100-106.

PLATVOET, D., 1985. Side-line organ in gammarids (Crustacea, Amphipoda). Beaufortia, **35** (7): 129-133.

READ, A. T. & D. D. WILLIAMS, 1991. The distribution, external morphology, and presumptive function of the surface microstructures of *Gammarus pseudolimnaeus* (Crustacea: Amphipoda), with emphasis on the calceolus. Canadian Journ. Zool., **69**: 853-865.

STAPLETON, J. L. & W. D. WILLIAMS, 1988. The morphology of the calceolus of an Australian crangonyctoid freshwater amphipod. Crustaceana, **52** (2): 157-162.

STEELE, V. J., 1984. Morphology and ultrastructure of the organ of Bellonci in the marine amphipod *Gammarus setosus*. Journ. Morph., **181** (1): 97-131.

— —, 1986. Ultrastructure of paired coniform 9+0 sensory cilia: a new type in the organ of Bellonci of the marine amphipod *Gammarus setosus*. Cell and Tiss. Res., **245** (1): 117-125.

— —, 1991. The distribution and frequency of type II microtrichs in some gammaridean amphipods. Hydrobiologia, **223**: 35-42.

WAGNER, H. P., 1994. A monographic review of the Thermosbaenacea (Crustacea: Peracarida). A study on their morphology, taxonomy, phylogeny and biogeography. Zoologische Verhandelingen, Leiden, **291**: 1-338.

WATLING, L., 1989. A classification system for crustacean setae based on the homology concept. In: B. E. FELGENHAUER, L. WATLING & A. B. THISTLE (eds.), Functional morphology of feeding and grooming in Crustacea. Crustacean Issues, **6**: 15-26.

— —, 1993. Functional morphology of the amphipod mandible. Journ. nat. Hist., London, **27** (4): 837-849.

WILLIAMS, W. D. & J. L. BARNARD, 1988. The taxonomy of crangonyctoid Amphipoda (Crustacea) from Australian fresh waters: foundation studies. Rec. Australian Mus., (suppl.) **10**: 180.

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