THE SYSTEMATICS AND PHYLOGENY OF THE GENUS
DIOLCOGASTER ASHMEAD (HYMENOPTERA: BRACONIDAE:
MICROGASTRINAE) WITH A REVISION OF AUSTRALASIAN SPECIES

Lateral view of female Diolcogaster sons (Wilkinson). Scale = 400 μm.

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The braconid wasp subfamily Microgastrinae comprises about 1300 described species world-wide, some of which are important parasitoids of pest Lepidoptera. The genus Dioicogaster Ashmead is one of 52 genera recognised in the subfamily. Previously it has been treated under the generic names, Microgaster Latreille and Protomicrophtis Ashmead but more recently it has been identified as a separate member of the Cotesia-complex of genera. Although relatively easy to identify, Dioicogaster has been postulated to be polyphyletic. Further the Australasian fauna is substantial, although only six species were previously recognised. These two aspects of Dioicogaster, its phylogenetic status within the Cotesia-complex and the Australasian fauna, are the focus of this study.

A brief literature review describes the history of taxonomic and phylogenetic studies on the Microgastrinae and, in particular, the genus Dioicogaster. Although the monophyly of the Microgastrinae is clearly demonstrated, the relationships within the subfamily are not well-resolved and recent studies present conflicting hypotheses. Further, the monophyly of Dioicogaster has been seriously questioned recently and it is possible that the genus is paraphyletic or, more likely, polyphyletic with respect to other Cotesia-complex genera.

A detailed treatment of the external morphology of the genus is presented and explains characters and terminology used in the taxonomic revision and phylogenetic analysis. A section on methodology then follows and describes the techniques used for collection and identification of material, the use of scanning electron microscopy (SEM), environmental scanning electron microscopy (ESEM) and field emission scanning electron microscopy (FESEM). The selection and treatment of phylogenetically important characters and the selection of in-group and out-group taxa is discussed along with the methodology adopted for phylogenetic analyses, and the workings of the parsimony program PAUP (version 3.1.1).

The in-group taxa selected include 26 species of Australasian Dioicogaster, representative species from non-Australasian species-groups, the type species of the genus, Dioicogaster brevicaudus (Provancher), as well as an additional 28 taxa from 20 other microgastrine genera comprising representatives of both cotesine and non-cotesine genera. Epsilogaster panama Whitfield and Mason (Mendeselliniae), Cardiochiles fuscipennis
Szépligeti, *Cardiociales eremophilasturtiae* Dangerfield and Austin (Cardiochilinae), and a hypothetical ancestor were used as out-groups. A data matrix was compiled using MacClade (version 3.02) for these 68 taxa and 43 characters. Eight of these characters were treated quantitatively, and preliminary analyses were undertaken with them included and excluded to assess whether they had a higher level of homoplasy compared with qualitative characters. Analyzes were conducted using out-group taxa individually and in all possible combinations. The most parsimonious solution for the data set (i.e. that with the shortest tree(s) and highest consistency index), was obtained when the hypothetical ancestor was used as the out-group and the data treated as unordered. In all other analyses (e.g. using other out-group taxa and ordered data), either the tree length was longer and/or the consistency index was lower.

Based on the phylogenetic analyses conducted, the *Cotesia*-complex was not resolved as a monophyletic group, although most of the included genera were so resolved, i.e. *Baluka* De Saeger, *Deuterixys* Mason, *Fornicia* Brullé, *Microplitis* Foerster, and *Wilkinsonellus* Mason. Further, *Dielcogaster* was clearly shown to be polyphyletic as indicated by the fact that the *basimacula*+merata+fasciopennis* species-groups, the *connexus*-group and the *euterpus*-group of *Dielcogaster* were resolved as sister-groups to other microgastrine genera. The monophyly of several species groups of *Dielcogaster* was however confirmed, i.e. the *basimacula*-group, *euterpus*-group, *hadromatus*-group and the *spretus*-group. The phylogenetic analyses also indicated that the *abdominalis* - and *scotica*-groups form a monophyletic group, while the *connexus*-group appears to be polyphyletic. However, clear from the analyses undertaken is that the data show an extremely high level of homoplasy as indicated by the fact that only six of 43 characters unequivocally support a single clade consisting of *Fornicia* species. Further, this level of homoplasy means that the overall pattern of relationships is unstable in that minor changes to either PAUP parameters and/or character coding produced trees of different topology, although the groups discussed above were virtually always resolved.

Even though *Dielcogaster* is now shown to be polyphyletic, this level of phylogenetic instability make it effectively impossible to reclassify the genus and divide it into smaller systematically stable genera. For this reason *Dielcogaster* is maintained as a separate working genus until the generic boundaries within the Microgastrinae are better resolved.
Diolcogaster is revised for the Australasian region and recorded for the first time from New Zealand. Based on the above analyses, six species-groups are proposed for the Australasian fauna, a further three species-groups are recognised as extantinal, while the relationships of 10 species were not resolved and, accordingly, they represent monotypic species-groups. A total of 26 species are now known from Australasia of which six were previously described. D. eclectes (Nixon) is record for the first time from the region and 19 species are described as new: Diolcogaster adiastolo, D. alkingara, D. ashmeadi, D. dangerfieldi, D. dichromus, D. hadromnatus, D. harris, D. iqballi, D. lucindae, D. masonii, D. merata, D. muzaffar, D. ramannii, D. new-guineaensis, D. nixoni, D. notopectus, D. robertsi, D. walkerai, and D. youafi. A new genus, Neodiolcogaster, is erected for the new species D. whitfieldi, while Choeras tegularis (Szepligeti) is also transferred to this new genus. For both genera, an illustrated key to Australasian species based on females is presented, and where possible notes on their biology and host relationships are also given.

The results of this study are discussed in regard to the inadequacy of morphological data to determine phylogenetic relationships within the Microgastrinae, and their potential as biological control agents. Although this study has by no means exhausted the likelihood of finding characters useful for phylogenetic analysis, it is also clear from this and previous work that morphological characters will probably not fully resolve relationships within this subfamily because of the extremely high level of homoplasy. In this respect the role of other data sets, such as those generated by molecular systematics, is discussed as a means of solving generic-level relationships with the subfamily. Finally, the role of Diolcogaster species in biological control is discussed along with their host relationships, and general importance in regulating host populations.