THE BIOLOGY AND ECOLOGY OF RAMPION MIGNONETTE *Reseda phyteuma* L.

by

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THE BIOLOGY AND ECOLOGY OF RAMPION MIGNONETTE
Reseda phyteuma L.

The potential of this plant to become a weed, particularly in the vineyards of Australia, initiated this study.

Rampion mignonette established in a newly planted vineyard at Clare, South Australia, photographed on 15 May 1997.

"To win the secrets of a weeds plain heart"

James Russell Lowell (Sonnet XXV).

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ABSTRACT

The aim of this study was to collect information in order to increase knowledge of the biology and ecology of rampion mignonette so as to provide a basis for integrated control and management.

The potential of this plant to become a weed in Australia prompted this study. The Animal and Pest Plant Commission realised the threat to the Australian wine industry and possibly also broadacre farming and stated the need for information on the biology and ecology of the weed.

Rampion mignonette (*Reseda phyteuma* L.), is a new weed to South Australia being first found in vineyards at Clare, lat. 33°50′ S., long 138°37′ E., in 1986. It is an annual to short-lived perennial agricultural weed from the Mediterranean region which grows to 30 cm height and flowers from May to January in Australia.

Literature covering the family Resedaceae and rampion mignonette up to 1997 is reviewed. Maps showing its world distribution and distribution in Australia have been drawn. Drawings of rampion mignonette showing the plant habit, main stem components, seedlings and details of the flower, capsule and seeds have been prepared.

A survey of 500 ha of vines to the east of Clare found that rampion mignonette showed little migration to blocks initially free of the weed and this suggests that currently employed methods of containment are effective. Population reduction can be achieved by careful management including both chemical and cultural techniques. Migration and increases in abundance are likely to be slow, under commonly practised vineyard management in southern Australia.

A single isolated plant 75 cm in diameter produced 831 capsules which were estimated to contain 17,500 seeds.

An experiment to determine the effect of seeding depth on seedling emergence found that rampion mignonette seedlings are able to emerge quite readily from depths of up to 30 mm and that a sample of rampion mignonette seed was found to be 25% germinable and contained 12% hard seed.

An experiment to ascertain the potential of rampion mignonette to compete with wheat, faba beans, subterranean clover and grass pasture indicated that rampion mignonette is a weed which colonises bare ground and will not establish under growing winter annuals and so is therefore unlikely to have potential to become a major weed of broadacre crops and pastures in the South Australian dryland farming system.

Rampion mignonette has the potential to compete with grapevines and reduce grape yields.

Preliminary investigations into the effects of herbicides found that Glyphosate, Glufosinate Ammonium, Oxyfluorfen, Oryzalin, Napropamide and Oxadiazon were all effective in controlling rampion mignonette.

General conclusions to the research indicate that rampion mignonette is unlikely to cause major losses to broadacre agriculture but is likely to increase costs and cause losses of production in viticulture.

STATEMENT

This thesis contains no material which has been submitted previously in full or part to any University for any degree or diploma and to the best of my knowledge and belief, it contains no material previously published or written by any other person except when due reference is made in the text. I consent to the thesis being made available for loan and photocopying. The copyright of this thesis belongs to the author.

Robin St John-Sweeting

16 June, 1998

The author's publications relating to rampion mignonette are listed in Appendix 1.

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CHAPTER 1

1 GENERAL INTRODUCTION

Rampion mignonette (*Reseda phyteuma* L.), is a new weed to South Australia being first found in vineyards at Clare, lat. $33^{\circ}50'$ S., long $138^{\circ}37'$ E., in 1986. The plant may have been introduced into a vineyard of the Clare Valley by an imported grape harvesting machine known to have been in the area in the early 1980's. It is an annual to short-lived perennial agricultural weed from the Mediterranean. In its native range in southern Europe, northern Africa and the Middle East, rampion mignonette is found in naturally disturbed rock sites, usually on limestone, and is common in vineyards (Anzalone *et al.* 1982) (Cooke 1991). It has the potential to spread and increase agricultural production costs in southern Australia and is well adapted to the climate of southern Australia and New Zealand (Carter 1993). Pearce (1986) records four species of *Reseda* that exist in South Australia., *R. luteola* L., *R. alba* L., *R. lutea* L., and *R. odorata* L. Cutleaf mignonette, (*Reseda lutea* L.) is a major crop weed in southern Australia (Heap *et al.* 1987). Morphologically rampion mignonette has a prostrate habit and the ability to produce large quantities of seed.

In 1991 a rampion mignonette specimen was located in the National Herbarium of Victoria, it had been collected by J. Shovelton on 20 May 1985 at Nagambie, Victoria; lat. $36^{\circ}47'$ S., long $145^{\circ}10'$ E. The plant was growing in an irrigated pasture on the property of Mr K. Newnham. The soil type was a sandy clay loam. Mr Newnham believed that seed of the plant was introduced with seed of imported American lucerne 4-5 years earlier. The lucerne stand failed, and was followed by three successive wheat crops. In 1984 the paddock was sown with an irrigation pasture mixture which established poorly. During the summer rampion mignonette was noticed in isolated patches across the paddock. Stock would not eat it and Mr Newnham removed all the plants (Cade 1985) (Clarke 1991). Montgomery (1991) contacted Ken Newnham on 21 November 1991 who said that he had not seen the weed since 1987.

In 1990 rampion mignonette was estimated to have colonised 38 ha of vineyards at Clare in South Australia (Cooke 1991). In 1991 the Animal and Plant Control Commission implemented a co-ordinated control programme with an aim to contain rampion mignonette to existing areas within Clare. Observations of the weed's vigour, lack of documented international scientific information and wine industry concern prompted this study to commence in 1991. Carter (1992) predicted that it may soon spread to other vine growing districts with the movement of workers, vehicles and machinery. From this background and because of the known behaviour of cutleaf mignonette (*Reseda lutea* L.) as a weed and potential losses produced by rampion mignonette it seemed important to initiate a research programme covering the agronomic and ecological aspects of the weed.

Ecologists tend to look at weeds as colonising plants with a special ability to take advantage of human disturbance of the environment (Holzner and Numata 1982). Rampion mignonette is a plant that has been shown in this study to thrive on bare ground particularly in vineyards where there is a considerable amount of human disturbance. The population dynamics of rampion mignonette is of concern particularly with its calculated ability to produce 45,000 seeds per m^2, and ability to emerge from as deep as 45 mm. The interference or competitive aspect of rampion mignonette in relation to the reduction of grape yields caused by competition for moisture and nutrients is also of concern.

The aim of this study was to collect information to increase knowledge of rampion mignonette so as to provide a basis for integrated control and management. This information was accumulated by conducting a review of the literature, a survey of 500 ha of vines at Clare to ascertain rampion mignonette's current distribution and level of infestation, experiments to evaluate the competitive effect of crops and pastures on rampion mignonette and field and laboratory studies to ascertain biological and ecological aspects of the weed.

CHAPTER 2

2 LITERATURE REVIEW

2.1 INTRODUCTION

This literature review will cover the family Resedaceae and review relevant publications relating to rampion mignonette. It will also introduce the South Australian agricultural environment as a background perspective to its growth requirements.

2.1.1 LITERATURE

Since rampion mignonette is a new weed to Australia, (being first identified in the 1980's) there is very little local literature relating to it. Specific literature relating to rampion mignonette is scarce even in those countries where it occurs naturally (Martí 1994). This review covers the available literature up to 1997.

2.1.2 THE SOUTH AUSTRALIAN AGRICULTURAL ENVIRONMENT

The South Australian climate is similar to that of countries around the Mediterranean sea, parts of Chile and Argentina in South America, South Africa, parts of south western Asia and the western United States of America. Winters are mild and humid and summers are hot and dry. The topography is of relatively flat plains with undulating hills and some hilly ranges. Major viticultural areas are the Barossa Valley, Clare Valley, Southern Vales, Riverland and the South East (Figure 2.1).

The soils in South Australia are predominantly alkaline. They are acutely deficient in nitrogen and phosphorus (e.g. 0.05% N and 50 p.p.m. P) (Carter and Day 1970). Salinity in the main is not a problem although there are some isolated patches of saline soils. The soils around Clare are duplex crusty red brown earths with surface gravels and clayey red brown earths and are in the main more fertile than the Barossa Valley.

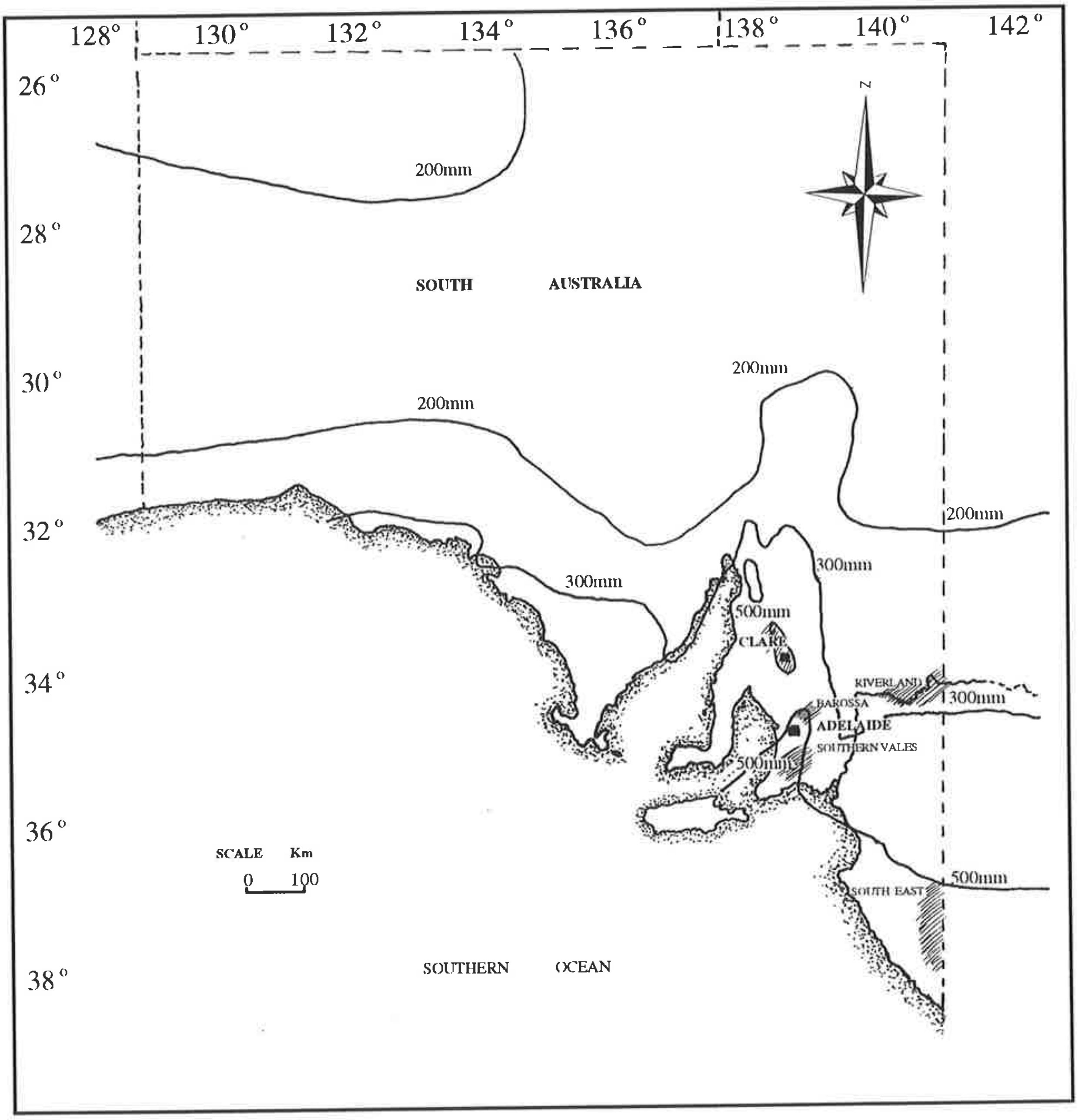

Figure 2.1 Map of South Australia showing rainfall isohyets, the state's capital (Adelaide) and Clare where the first outbreak of rampion mignonette was found. Existing major grape growing regions are shaded.

European settlement of South Australia commenced in 1836 with the establishment of Adelaide and clearing of large expanses of the state's natural vegetation. Since South Australia extends from near the Tropic of Capricorn to Latitude 38° S. there is a great variation in climate.

The three main zones are:

1. The dry inland pastoral rangeland zone with a rainfall of less than 250 mm where low intensity grazing occurs based on a delicate balance of utilisation and conservation of the native vegetation. The native vegetation in the driest zone consists of grasses, shrubs and low trees such as *Stipa* spp, *Danthonia* spp, *Themeda australis*, *Atriplex* spp and *Kochia* spp.
2. The cereal sheep zone with a rainfall from 250 to 500 mm where cereal crops are grown in rotation with pasture and crop legumes with the pastures being grazed by sheep. In the 1980's and 1990's there has been an increase in the level of continuous cropping with approximately 50:50 rotations of cereals and pulses with an associated reduction of pastures on some properties.
3. The high rainfall zone with a rainfall greater than 500 mm supports high intensity grazing with less cropping other than viticulture.

Rampion mignonette at present is only known in Clare where the altitude is 400 m above sea level. This area is prone to more spring frosts than the Barossa Valley. There is no climatic reason to believe that rampion mignonette will not be able to thrive in the other major grape growing regions of South Australia; the Barossa, Riverland, Southern Vales or South East.

2.2 RESEDACEAE

2.2.1 THE FAMILY RESEDACEAE

The family Resedaceae is divided into six genera, *Caylusea, Ochradenus, Oligomeris, Randonia, Reseda* and *Sesamoides*. Of the six genera *Reseda* is the largest, with 55 of the 69 species occurring within the family (Abdallah & De Wit 1978). The species are distributed throughout the Mediterranean region and Europe, the savannah and arid regions of Africa and India and in the Canaries and Cape Verde Islands. Only a few species comprising the genus *Reseda* have any significance as weeds in Europe. Sweet mignonette (*R. odorata* L.) which is strongly scented is widely cultivated as a garden plant (Hanf 1984). The indigenous distribution of Resedaceae is difficult to delineate due to its colonisation in other parts of the world as a weed although its distribution is mainly related to soil types and in particular, *R. lutea* is confined to calcareous and chalky soils as described by Abdallah and De Wit (1978) and confirmed by Heap *et al.* (1987) in South Australia (Bailey and Wicks 1994).

As translated by Cooke (1996), Muller (1857) stated the following:

> "The main home of the Resedaceae is the Mediterranean basin with the Red Sea Persian Gulf regions. The range of limits of the family are 57° N in Scotland and 15° S in Africa apart from a few in California and the Cape of Good Hope. In all my research I never saw one herbarium specimen of *Reseda* that had been attacked by insects as so often happens to Cruciferae specimens. All species of Resedaceae contain a yellow pigment, extractable by water. Called luteoline by Chevreul. It is most abundant in *R. luteola*, therefore this sp. has been cultivated as a dye plant."

2.2.1.1 *Reseda* in Australia

Five naturalised species of *Reseda* exist in Australia; *Reseda alba* L., *Reseda lutea* L., Reseda *luteola* L., Reseda *odorata* L. and Reseda *phyteuma* L. (Heap 1993). Figures 2.2 to 2.6 include brief notes on the habit and distribution of each species naturalised in Australia.

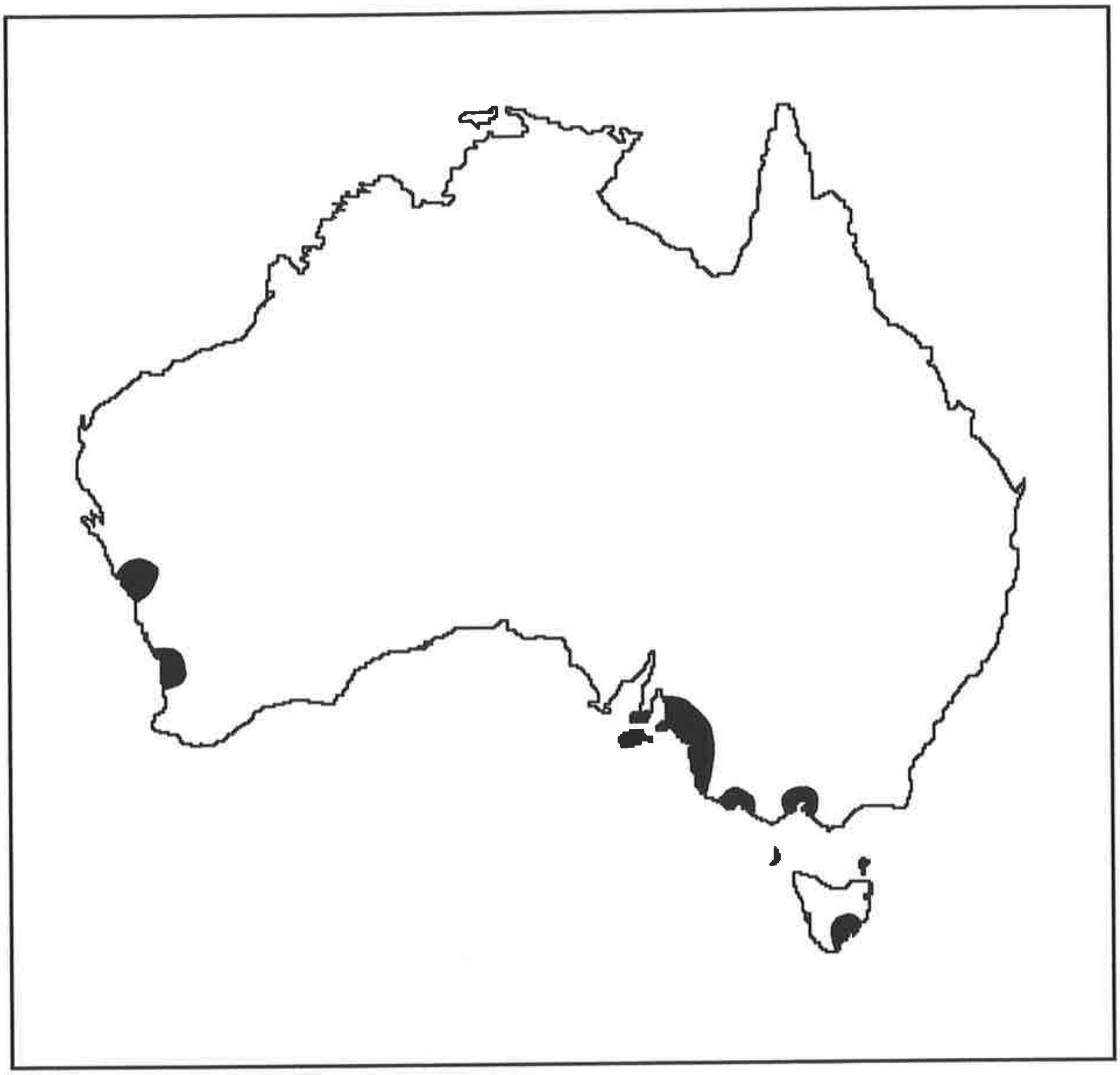

Figure 2.2 Distribution of white mignonette (*Reseda alba*) in Australia. (Pearce 1982).

NOTE: an annual or rarely perennial herb growing to 70 cm height and flowering from August to February in Australia, native to the Mediterranean and naturalised world wide in temperate and sub tropical areas (Pearce 1982).

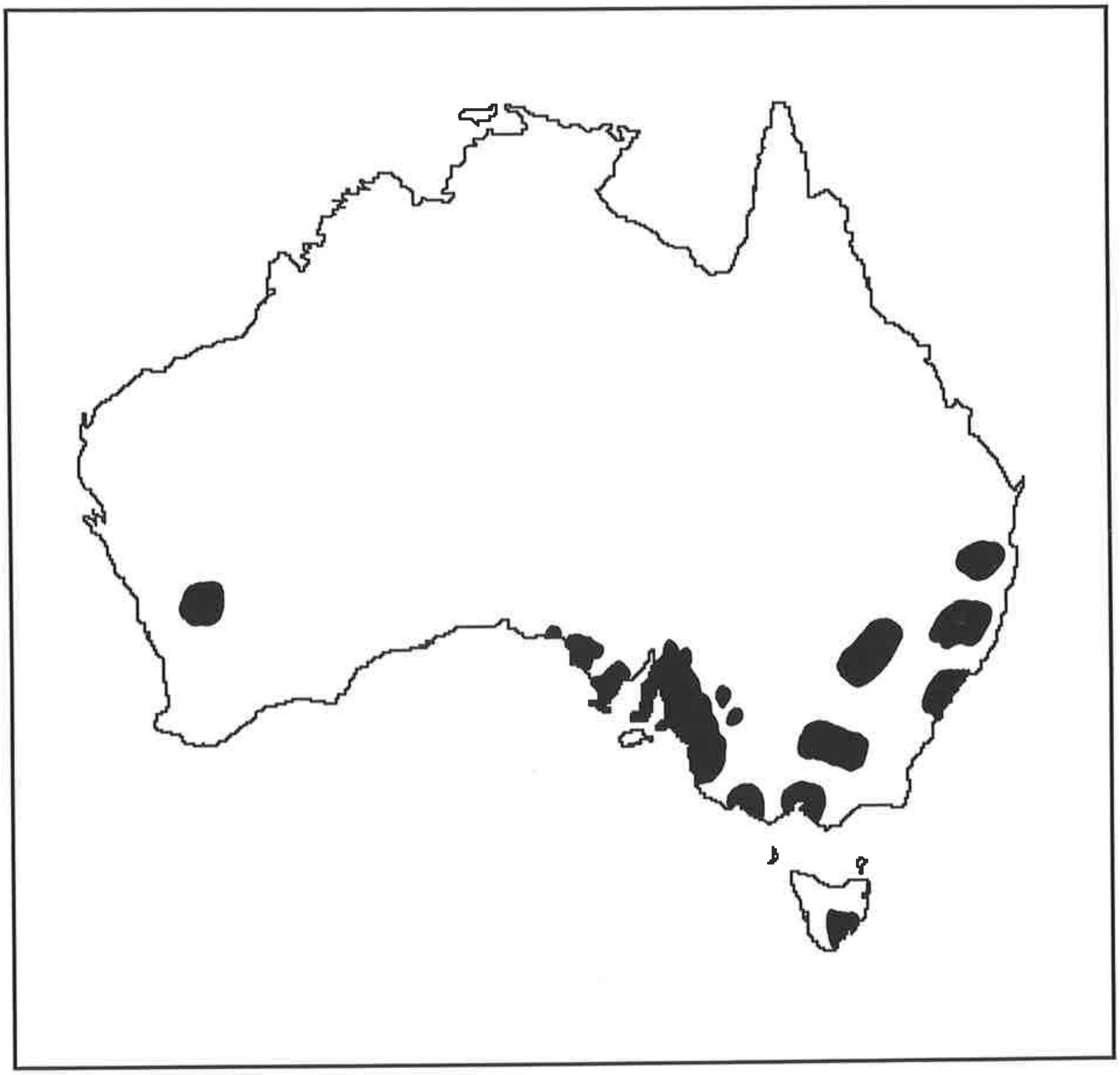

Figure 2.3 Distribution of cutleaf mignonette (*Reseda lutea*) in Australia. (Pearce 1982 and Heap *et al* 1987).

NOTE: perennial sprawling to erect herb growing to 80 cm height and flowering from September to February in Australia, native to the Mediterranean and Asia Minor (Turkmenistan) (Pearce 1982).

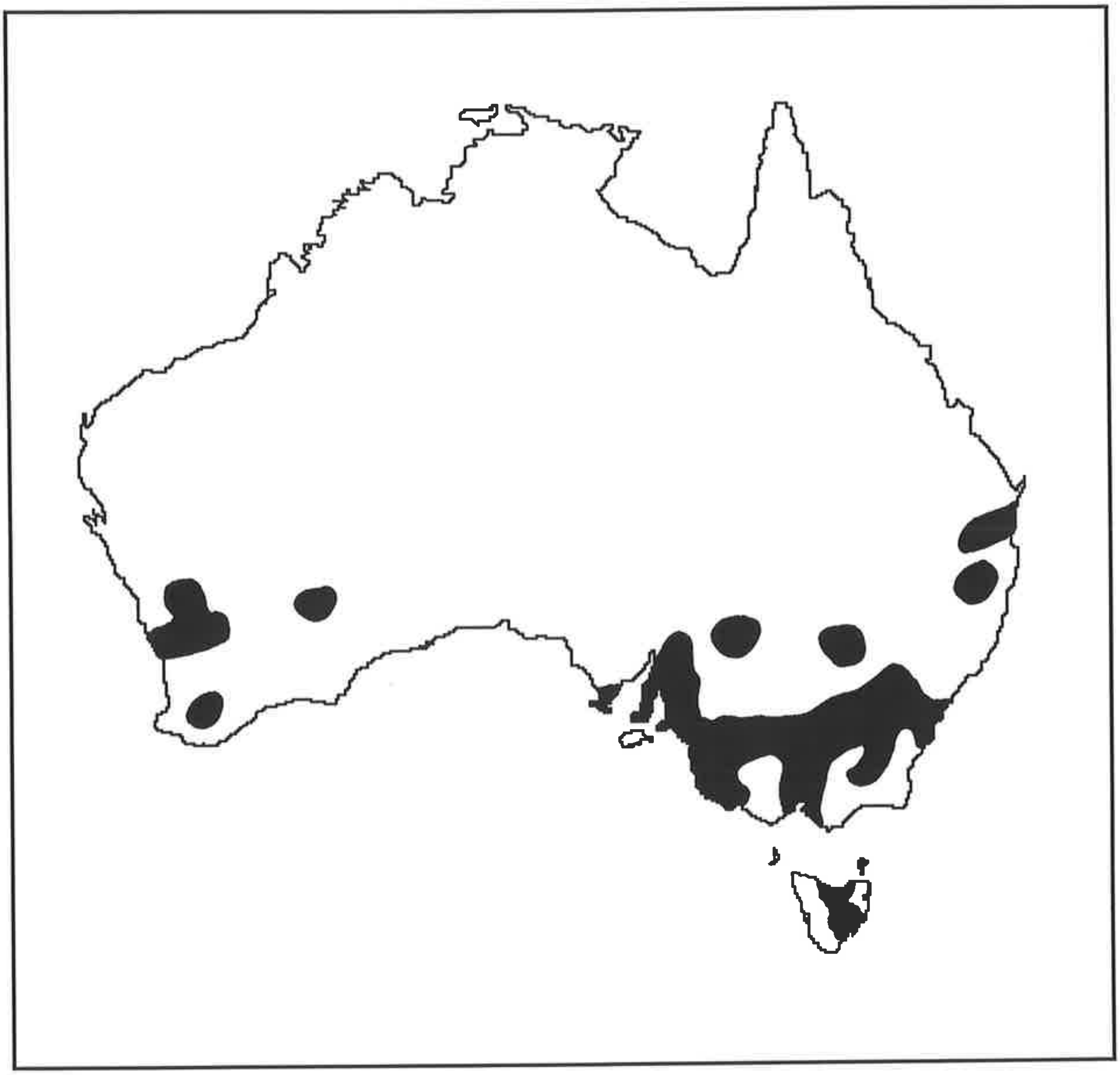

Figure 2.4 Distribution of wild or dyers mignonette (*Reseda luteola*) in Australia. (Pearce 1982).

NOTE: a glabrous erect perennial herb growing to 1.5 m height usually flowering all year in Australia, native to the Mediterranean, Asia Minor and Afghanistan. Has been cultivated as a dye plant (Pearce 1982).

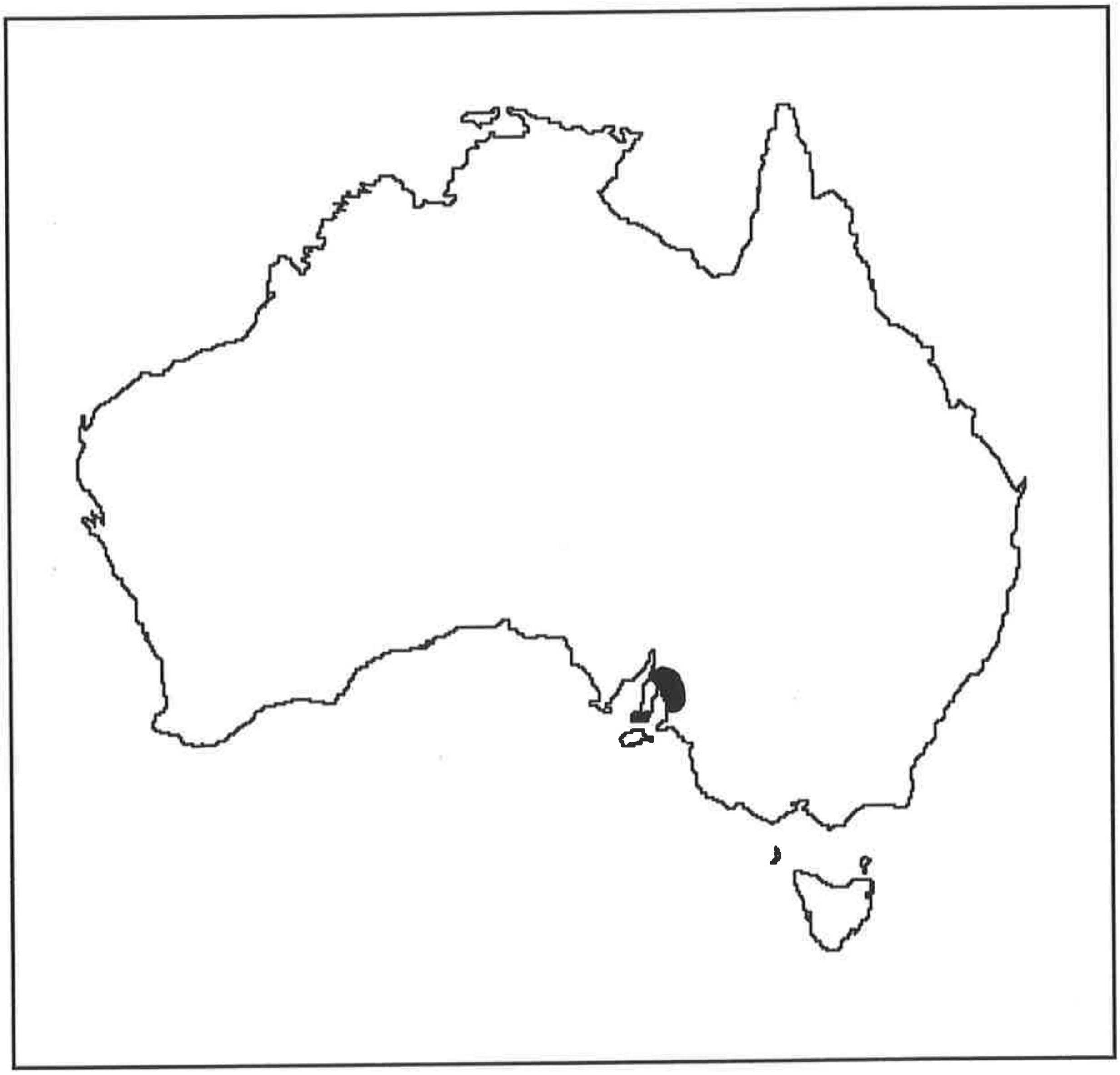

Figure 2.5 Distribution of sweet mignonette (*Reseda odorata*) in Australia. (Pearce 1982).

NOTE: annual or sub perennial erect or sprawling herb growing to 80 cm height flowering in May and August to January in Australia, native to the south eastern Mediterranean being widely cultivated as a scented garden plant (Pearce 1982).

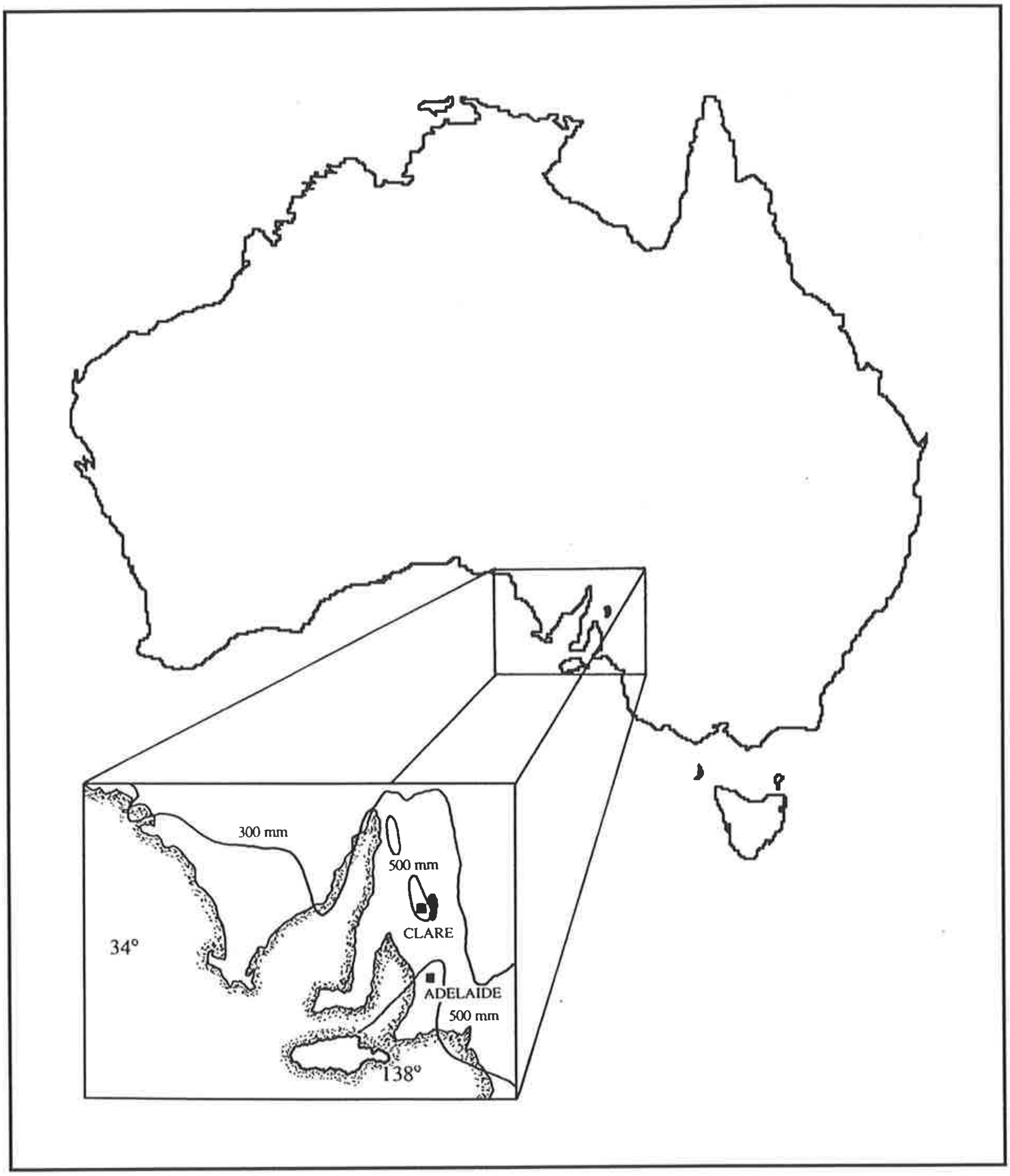

Figure 2.6 Distribution of rampion mignonette (*Reseda phyteuma*). Known occurrence 1991 to 1997 in Australia.

NOTE: annual or short lived perennial growing to 30 cm height flowering from May to January in Australia, native to southern Europe, northern Africa and the middle east.

2.2.2 RAMPION MIGNONETTE *Reseda phyteuma* L.

2.2.2.1 Name :

Botanical name: *Reseda phyteuma* L.

Standard common name: Rampion mignonette

All the specimens naturalised in Australia belong to the subspecies *phyteuma* and within that subspecies to the var. *phyteuma* (Cooke 1991). *R. tournefortii* is a synonym of *R. phyteuma* L. 1862 *R. phyteuma* ssp *collina* used. 1863 *R. aragonensis* used and reported as a biennial flowering in all seasons. *Reseda* may be derived from the Latin 'sedare' to calm or recede as it is known to calm diseases and all inflammations (Abdallah and De Wit 1978). The term mignonette is derived from the French 'mignon' which refers to the small delicately formed flowers (Heap *et al.* 1987). A specimen in the Linnean Herbarium (629.21) is accompanied by '8 phyteuma' in Linnaeus's handwriting and is designated as the type, although there is no certain evidence that it served as a basis when publishing the name *Reseda phyteuma* L. (1753). There are two specimens marked HU (629.22 and 629.23) originating from Hortus Upsaliensis.

Carter (1989) documents the use of the common name rampion mignonette as follows:

> "Why rampion mignonette? The plant has no English common name however the Herbarium Australeinse, Division of Plant Industry CSIRO Canberra recommended the common name as it conforms to the French and German usage of rampion. Rampion is the English common name for plants which are of the genus *Campanula* that were previously considered *Phyteuma*. The adoption of a common name at this early stage is to avoid the "Lincoln weed syndrome" i.e. teetulpa weed; chilpunuda grass; sand rocket; wall rocket are all used common names for *Diplotaxis tenuifolia*."

The dispatch of the first unknown specimen from the Clare valley to Kew Gardens, London in 1986 had the benefit of positive identification thus resulting in only a short period in which the plant was incorrectly named as *Reseda odorata*. Such action avoided nomenclature confusion as was the case with salvation jane (*Echium plantagineum* L.) in the 1970's which was also identified as *E. violaceum* and *E. vulgare* (Piggin 1976). Hanf (1984) reports the synonyms *Reseda aragonensis* Loscos and Pardo. and *Reseda litigiosa* Sennen and Pau.

Cooke (1997), in an unpublished note, entitled "Is naturalised *Reseda phyteuma* derived from *Reseda odorata* ?" outlines the following:

> "*Reseda odorata* (sweet mignonette) is sometimes grown as a cottage garden flower for its scent and is grown on a large scale in Europe for the perfume industry.
>
> The hypothesis that *R. odorata* is an anthropogenic derivative of *R. phyteuma* was proposed as early as the 18th century by Haartman. Abdallah & DeWit (op. cit. 290) suggest that early agriculturists tolerated the non-aggressive weed *R. phyteuma* in their gardens and gradually selected it for prettier flowers and stronger fragrance.
>
> *Reseda odorata* was a late introduction to northern European gardens. Its absence from the encyclopaedic herbal of Culpeper (1653) is evidence that it was still unknown in mid-17th century England. It was introduced to that country around 1750 (Miller, 1754) and within a decade was so popular that Miller (1759) reported that unscrupulous seedsmen were supplying *R. phyteuma* as a substitute. However he also makes the interesting observation that some gardeners believed their plants had degenerated into a scentless form.
>
> In fact, *R. odorata* in cultivation will revert to a form with the weak androsterone-like scent of *R. phyteuma* unless the strong scent character is maintained by deliberate selection. In Australia, where it had been introduced by 1837 at the latest (Stephens, 1839), it has been perpetuated by self seeding in gardens. Seed catalogues of

> the 1930's mention named cultivars such as 'Machet', 'Golden Machet', 'Machet improved', 'Red giant', 'White pearl', 'Goliath' and 'Incomparable', with single or double flowers ranging from white through yellow to deep red (Brunning, 1934). But these were open-pollinated lines and commercial seed growers did not select to maintain the scent quality. As a result, Australian garden strains had become "scentless" by the late 20th century when scented cultivars were re-introduced from New Zealand (Nottle, 1992)."

This leads us to believe that the naturalised rampion mignonette at Clare may well have been a garden escape and closely related to sweet mignonette.

It has been noted from field trips to Clare (1991 to 1997) that flowering rampion mignonette plants have a pleasant sweet smell. The sweet smell is most obvious in spring and summer.

2.2.2.2 Botanical description :

Drawings from Abdullah and De Wit (1978) are attached in Appendix 2. These drawings show both subspecies ssp. *phyteuma* and ssp. *collina*, and of note is the less spherical shape of the ssp. *phyteuma* capsule.

Cooke (1991) described rampion mignonette (*Reseda* phy*teuma*) as follows:

> "*Reseda phyteuma* L., Sp. P1. 449 (1753); Yeo, F1. Europaea 1:348 (1964). var *phyteuma* Annual or short-lived perennial to 30 cm high with a slender taproot. Stems branching from the base, decumbent to ascending, leafy with prominent scabrid ridges. Leaves narrowly oblanceolate or the lower ones trifid-cruciform with oblanceolate lobes, 3-10 cm long reducing up the stem, scabrid on the back of the midvein, otherwise glabrous; base cuneate; margins strongly undulate; apices obtuse. Flowers numerous in a raceme, each with an ovate bract c. 2 mm long. Pedicels 4-6 mm long at flowering, accrescent to 5-10 mm and decurved in fruit. Sepals 6, narrow-obovate, unequal, 3-5 mm long, persistent and accrescent to 5-10 mm in fruit, scabridulous on the back of the midvein. Petals 6, 3-5 mm long, white; limb of superior petal with a narrow attachment to the appendage, symmetrically divided into 9-18 linear lobes; lateral petals similarly but less regularly divided; anterior petal shorter, the limb entire or few-lobed. Stamens 16-20, deciduous; anthers c.1mm long, yellow. Ovary stipitate, glabrous with 3 scabridulous ribs. Capsule nodding, obovoid-cylindric, trigonous, 12-14 mm long, 6-9 mm wide. Seeds 6-8 reinform, c. 2 mm long, rugose, grey to greenish brown. This is the first Australian record of *R. phyteuma*, which appears to be confined to five vineyards between Atherley and Hill River at Clare (NL region). The vineyards are not contiguous, but four have a common owner and the fifth is close by, suggesting a recent

introduction. This population was formerly assigned (Cooke, 1987) to *R. odorata* (sweet mignonette), a widespread but uncommon garden escape which differs in having spathulate petal-lobes and subglobose capsules. Seedlings emerge at any time of the year when water is available; flowering is recorded from May to October. In its native range in southern Europe, northern Africa and the middle east, *R. phyteuma* is a ruderal of naturally disturbed rocky sites, usually on limestone. It has become an uncommon weed in vineyards, and also in sunflower, wheat, chickpea and faba bean crops in a region of Spain with a climate comparable to the agricultural zone of South Australia (Hidalgo *et al.* 1990).

The common name "rampion mignonette" has been selected for this plant as the English equivalent of the botanical name.

Specimens examined: 2 km E of Clare, 5 .ix. 1990, D Cooke 579 (AD; ADA 4328; CANB; MEL); Stanleys' vineyard, Clare, 5 .ix. 1990, D Cooke 581 (AD; ADA 4329); 2 km W of Clare, 29. vi. 1989, J. Heap 21 (AD; ADA 4315; ADA 4316); Clare, 19. x. 1988, A Mayfield (AD 98905082); Clare, 4. v. 1987, T. Yeatman (ADA 9412).

OVERSEAS: Saint-Marcel, Italy, 11. vii. 1969, A Charpin (AD 97030127); between Pinczow and Skowronne, Poland, A Jasiewicz, 2 .ix. 1955 (AD 97049555); near Bardinetto, Italy, 28. viii. 1964, C. van Steenis 20544 (AD 98588764)."

2.2.2.3 Karyology :

Chromosome number of *R. phyteuma* 2n=12 (Valdes 1987).

2.2.2.4 Morphology and variation :

Carter (1989) documented the following general description:

> "To the casual observer it appears to be one of the other mignonette plants. On closer examination the leaves are spathulate possibly with some lobes onside, but not like *R. lutea* cutleaf mignonette. Leaves are more like *R. odorata* sweet mignonette and *R. luteola* dyers weed. The leaves are 5-15 mm wide, and 50-100 mm long. The petals are white to yellow. It is much shorter than dyer's weed, growing 10 - 50 cm high."

R. phyteuma is usually an annual ascending herb but occasionally may occur as a biennial or perennial and develop a subligneous taproot. In the first year the root is whitish with a pallid violet-grey hue. The stems are as a rule ascending, but may also be erect. The leaves may become large and herbaceous on fertile soils or remain much smaller on poor soils (Abdallah and De Wit 1978).

2.2.2.5 Taxonomy and identification :

Identification of the taxa often requires close examination of the flowers and fruit. This is evidenced by the original identification of *R. phyteuma* at Clare as *R. odorata*. Abdallah and De Wit (1978) have adequately documented the taxonomy of the Resedaceae.

2.2.2.6 Economic importance and significance as a weed :

R.phyteuma is said to be eaten as a vegetable (having a taste similar to cabbage) in Greece (Abdallah and De Wit 1978). Garcia - Torres (1994) states that *Reseda phyteuma* is a weed of little importance in southern Spain. Wilson (1989) found no record of it being an aggressive weed, but the European weed literature in this library is probably not complete.

Detrimental effects : Rampion mignonette is a weed of bare ground and disturbed areas particularly in vineyards. Most *Reseda* species occur as weeds but are never aggressive or noxious (Abdallah 1967). However Heap *et al.* (1987) pointed out that this was not so in South Australia, where *Reseda lutea* is an exceptionally persistent, competitive and proclaimed noxious species which is well adapted to cropping areas.

Cucumber mosaic virus : Rampion mignonette acts as a disease host and is reported as being infected with cucumber mosaic virus in a vegetable field with a Mediterranean climate in the Avignon area. The virus can overwinter in rampion mignonette (Quiot *et al.* 1979). At present rampion mignonette is not a common weed in cucumber crops in Australia but if it were to become one it may pose a threat as a disease host.

Land values : Grape yield losses of 1 t/ha have been reported when rampion mignonette is present (Smith 1997). It is likely the presence of rampion mignonette will lower the market value of properties.

Beneficial effects : Its use for grazing and hay production is unknown. It may have value as a ground cover to reduce erosion of road cuttings and other bare exposed ground.

Legislation : Groves (1991) reports that in countries settled comparatively recently by Europeans, such as Australia, parliamentary legislation is used to prevent the entry of plant propagules. He also reports from Navaratnam and Catley 1986 that in Australia, the Federal *Quarantine Act* 1908 has been successful in keeping some undesirable plants out of this country. The legislation has not kept out 'new' weed species of known taxonomic identity that were not listed by proclamation in the Act. Legislation has had little success in controlling invasion by new weeds. Further aspects of legislation are covered in the general discussion. The rampion mignonette policy in South Australia of the Animal and Plant Control Commission (1991) was drafted by R.Carter. This policy comes under the Animal and Plant

Control (Agricultural Protection and Other Purposes) Act, 1986. At the time the potential of rampion mignonette as a weed of agriculture was unclear and a program was developed to contain existing infestations. The aim of the commission's co-ordinated control programme was to contain rampion mignonette to existing areas, in the Clare area of South Australia. The objectives of the program were:

- To eradicate any areas outside the hundred of Clare.
- To eradicate any areas less than 0.5 ha or on roadsides within the Hd of Clare.
- To control areas within private property to minimise risk of dispersal of seeds.
- To survey the extent of the infestations.
- To determine the potential to cause loses to agriculture, viticulture and other industries in South Australia.

Declaration : To implement the policy rampion mignonette was included in class 1c(iv) of the second schedule.

- It was declared a notifiable weed throughout South Australia.
- It was declared a plant that must be destroyed throughout South Australia.

Restrictions applied to the sale, entry and movement on roads to restrict dispersal of seed. For the Hundred of Clare landowners were required to control the plant as much as was reasonably achievable.

2.2.2.7 Geographic distribution :

Origin and world distribution : A native of southern Europe and northern Africa (Abdallah and De Wit 1978). Originally from the Mediterranean regions (Yeo 1964), it prefers warm environments and is more common in southern Europe (Hanf 1984). Highest levels of the Resedaceae occur between 30° and 40°N latitudes or northern Morocco and southern Spain (Bailey and Wicks 1994). Valdés *et al.* (1987) record rampion mignonette distribution as central and southern Europe, northern Africa and south west Asia and reports that in vineyards in Jerez (Spain) it is known and flowers from March to July. Ribeiro (1990) states that Rampion mignonette is a weed of little importance in Portugal. It is mainly confined to walls, rocky places and margins of rural roads. Rampion mignonette occurs all over central and southern Europe (east to Hungary), and in the western Mediterranean region of northern Africa (Abdallah and De Wit 1978). Pujadas (1994) states that *Reseda phyteuma* is very common in the southern Iberian Peninsula and is frequently found in rough terrain. Garcia - Torres (1994) acknowledges the occurrence of rampion mignonette in southern Spain. Abdallah and De Wit (1978) reported that in 1686 rampion mignonette was known to be an ingredient in love philtres in early Greece and Asia minor; in 1857 it was reported as 'Loves plant of Montpellier' and described it as one of the species that grow on the 'Pyrenaean hills and about Montpellier'. Groves (1994) on 11 March 1994 located some flowering material of rampion mignonette in a space near laboratory buildings in field plots not far from Montpellier.

Australian distribution of rampion mignonette naturalised in Australia :

Other than the temporary outbreak at Nagambie, Victoria in the mid 1980's the only other known occurrence of rampion mignonette in Australia is the outbreak at Clare in South Australia. The Clare infestation was visited by Mr. John Heap on 29 June 1989 and the following observations made:

> "The infestation is in a vineyard and in an adjacent crop and pasture approximately 2 km east of Clare on the Burra road. The vineyard is one of four owned by Jim Barry Wines. The area consists of several hectares of vines on a slope divided by a series of contour banks. The intervine area is cultivated and some rows are sown to beans or triticale. Adjacent to the vineyard is a crop and a pasture grazed by sheep. The soil is a shallow red loam over rock. The pH is unknown."

The distribution at Clare has been documented in Chapter 4 of this thesis under a survey of plant distribution at Clare, South Australia.

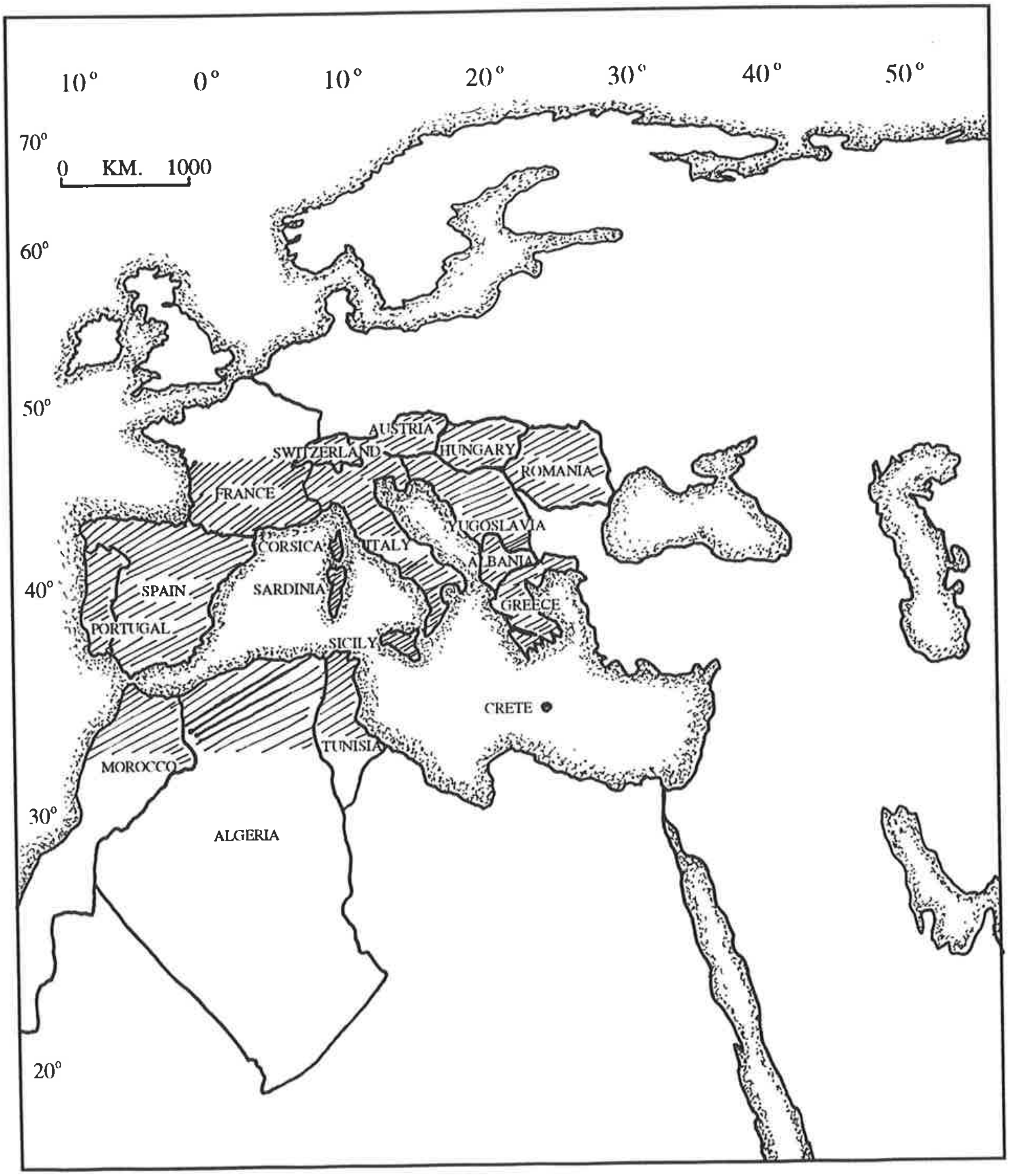

Figure 2.7 **Distribution of rampion mignonette (*Reseda phyteuma*) in the Mediterranean region including southern Europe and northern Africa (Abdallah & De Wit 1978, Franzini 1982, Susplugas *et al.* 1989, Valdés *et al.* 1987, Ribeiro 1990, Garcia-Torres 1994, Pujadas 1994, Groves 1994 and Hanf 1984).**

2.2.2.8 Habitat :

Climate : In general, climate is the main limiting factor to the potential distribution of a plant species. Rampion mignonette has an extensive distribution between 48° N and 32° N latitude. Carter (1993) used a computer model CLIMEX to match 29 sites of the native range of rampion mignonette in north Africa and south-west Europe, with climates of Australia and New Zealand (Figure 2.8) to predict potential growth areas. It was found that the climate of the Western Australian wheat belt and south-eastern Australia is similar to that of the native range of rampion mignonette. The predictive range also included the major vineyard areas of Australia. In addition it was found that in New Zealand the climate of Napier in the North Island and parts of the South Island match its native range. It grows in the Córdoba region in southern Spain where the climate is characterised by mild wet winters and hot dry summers. Monthly average temperatures range from 9° C in January to 27° C in July and August. There is a frost risk period of 3-4 months and rainfall in the region ranges from 463 mm in Al modóvar del Rio to 697 mm in the city of Córdoba. Rain occurs mainly in February to March and November to December. There is a long dry season in most of the area (Hidalgo 1990).

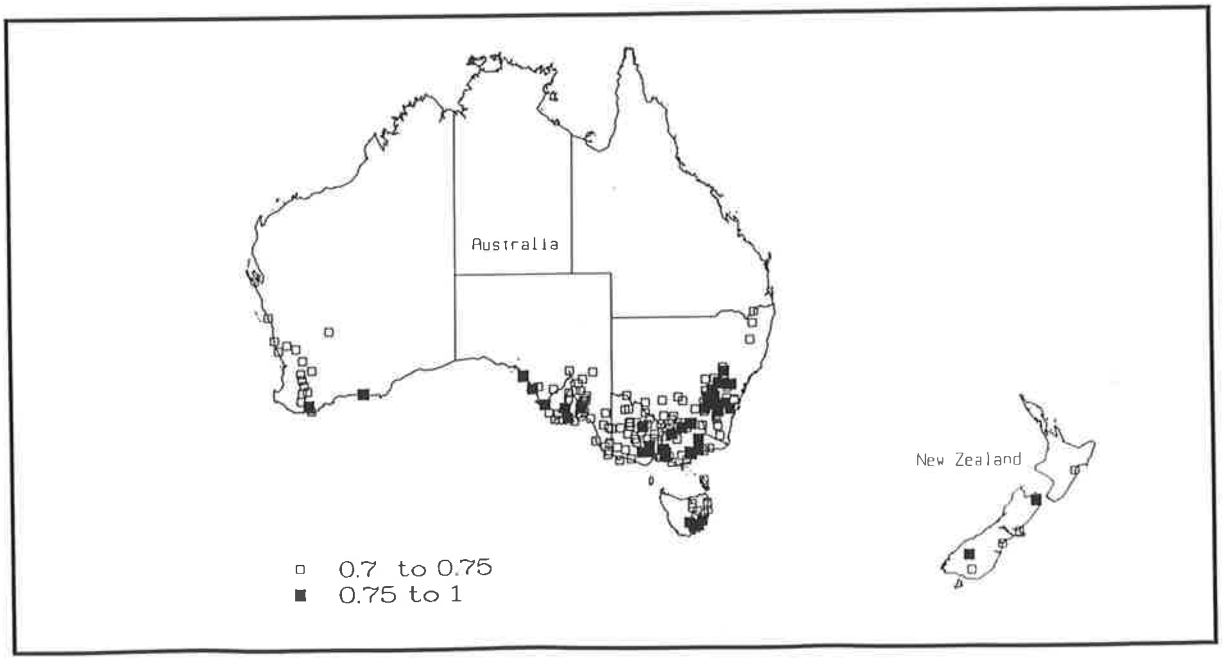

Figure 2.8 The potential range of rampion mignonette (*Reseda phyteuma*) in Australia and New Zealand. Match indices > 0.7 are a good match (Carter 1993).

Soils : Abdallah and DeWit (1978) report:

> "A wide range of mother-rock and soils serve for growing localities but there seems to be a preference for calcareous soils e.g. near Montpellier, Malaga, the Jura mountains, Hungary (on dolomite) etc. Other growing - localities were e.g. volcanic soils in S. Spain, gravels in Algeria (Biskra), sandy fields near Geneva, siliceous slopes in the E. Pyrenees, schists near Barcelona. Mostly it grows on well - drained, dry and often stony or sandy grounds, much heated by the sun (Zaragoza) Malaga, Algarve (Portugal), Geneva."

Hanf (1984) states it is found on dry stony soils and Hidalgo *et al.* (1990) indicates that it grows on loamy-sandy to clayey soils with a carbonate content of between 0 to 30% and a pH usually >7.0.

Communities in which the species occurs : Garcia - Torres (1994) states that rampion mignonette mainly grows in olive groves in the south of Spain and not in annual crops. Hanf (1984) states that it is found mainly in vegetable crops, more rarely in cereals and on wasteland. As a rule it occurs at or near sea-level but may ascend to the lower or medium altitudes on mountains, (350 - 1450 m) (Abdallah and De Wit 1978). Carter (1990) found that rampion mignonette is a weed in Portugal where it is confined to walls , rocky places and margins of rural roads near villages. Rampion mignonette is a weed in dryland but not irrigated farmland in Spain (Hidalgo *et al.* 1990). Carter (1992) reported that it is known in vegetable fields (Quiot *et al.* 1979) and in maize and vines (Franzini 1982). In the Córdoba region of Spain rampion mignonette is regarded as a summer weed germinating in spring and growing through the summer. It mainly infests summer growing sunflowers (Hidalgo *et al.* 1990).

2.2.2.9 Plant growth and development :

Perennation :

Colonisation : Invasiveness relates to the rate of spread of naturalised plant populations. It is difficult and takes a long time to directly measure this rate, but some general principles have been established which reflect the likely invasiveness of a plant species. Virtue (1996) discusses invasiveness under the topics of ecological and biological attributes, previous history as a weed elsewhere, current distributions, time since naturalisation, size of native range and absence of natural enemies. For crop weeds, economic impact can be estimated by weed density-yield loss response curves. He further indicates that knowledge of the potential distribution of a major new weed enables landholders to be alerted to the risk of invasion, and justifies enforcement of measures to prevent the introduction of weed disseminules into such areas. Software based on climate (CLIMEX 7 and BIOCLIM) to predict potential distribution are well developed.

Phenology :

Germination and emergence :

Lovett and Knight (1996) report from Norris's work (1992) that allelopathy is interference between plants, mediated by chemicals released from at least one of the species concerned. The compounds concerned may be alkaloids, terpenes and steroids, flavanoids, toxic gases, organic acids and aldehydes, aromatic acids, simple saturated lactones and tannins. No known allelopathic inhibition is known in rampion mignonette.

Mycorrhiza : There are no reports in the literature of the presence or absence of mycorrhiza on rampion mignonette.

2.2.2.10 Response to human manipulation :

Grazing effect : Cade (1985) reported from observations made at the Nagambie outbreak in Victoria that stock would not eat rampion mignonette. However it is known that species of the Resedaceae are palatable; Maghaddam (1977) reports that cutleaf mignonette (*Reseda lutea*) is a plant well adapted to the arid and semi arid rangelands of Iran, that it provides early spring green growth, is palatable to sheep and goats and compares favourably with alfalfa in nutritive content. Detail on its nutritive value and toxicity are unknown. No cases of animal poisoning have been reported. It is known that seeds will survive transmission through the guts of farm animals (Atkeson *et al.* 1934) (Burton 1948) (Heap and Honan 1993) (Heap 1993) (Harmon and Keim 1953) and the horse, where it was shown that viable seeds were deposited up to 10 days after ingestion (St. John-Sweeting and Morris 1990). The consumption of rampion mignonette by horses or sheep highlights the need for animal quarantine legislation to limit its spread.

2.2.2.11 Control measures :

Carter (1991) produced a proposal for assistance from the Australian Quarantine Inspection Service (AQIS) to eradicate the only Australian infestation in vineyards at Clare, South Australia. The proposal outlined how the South Australian Animal and Plant Control Commission intended to attempt to eradicate rampion mignonette with an initial three year program funded with AUD $148,000 from AQIS rather than the existing commissions containment program. Carter pointed out that the full potential of rampion mignonette as a weed of dryland crops and vines may not be known for 10 - 20 years and by then it may not be practical to eradicate it.

Biological control measures :

Biological control usually refers to weed management by insects or microorganisms (Lovett and Knights 1996). Where a weed is a problem in its native environment the chances of finding a biological agent is reduced although there is the possibility that an effective control agent may be present (Anonymous 1982). Groves (1991) reports from Julien (1982) that at present biological control programs have a success rate of between 25% and 40% and rarely is the level of success predictable. As with other single methods of control, the result may be that one weed replaces another.

Insects and diseases : Hoffman (1954) lists the root weevil *Baris morio* as an insect enemy of *Reseda phyteuma* in its European range of France, Spain, Algeria and Morocco. Bailey and Wicks (1994) conducted a spring survey, (9 April to 3 June, 1994) for natural enemies of cutleaf mignonette, *Reseda lutea,* and other species of *Reseda* in Morocco, Spain, Portugal and southern England. Of the natural enemies identified they found root weevils are likely to be most useful control agents of *Reseda lutea,* as dead or weakened rhizomes reduce the plant's capacity for vegetative regeneration. Other enemies found were seed feeding weevils, leaf mining insects and leaf and stem fungi. In their preliminary report of a survey in Portugal, Morocco, Spain and southern England covering the prospects for biological control of cutleaf mignonette (*Reseda lutea*), they recommended that areas surveyed be re-surveyed to determine over time the extent of damage to known existing populations of *Reseda* caused by natural enemies and that the survey area be extended into southern France. Heap (1993) observed a number of insect enemies of *Reseda lutea* in South Australia; these include polyphagous leaf eaters, cabbage butterfly (*Pieris rapae*), woolly bear caterpillar (*Spilosoma glatignyi*) and a leaf mining fly (*Diptera agromyzidae*). Bailey and Wicks (1994) have observed *Heliothis* sp. feeding on *Reseda lutea* capsules and stated that no pathogens have been recorded on *R. lutea* in South Australia, although a fungus provisionally identified as *Albugo candida* was reported from lower Yorke Peninsula (Heap 1993). Many of the natural enemies observed do not appear to be specific to the Resedaceae although some have been recorded on the Cruciferae, a related family; none of these natural enemies appears to control the weed in Australia.

2.2.2.12 History

Identification of the first South Australian specimen : In 1986 a plant from the Clare Valley infestation was sent to Kew Gardens London by John Heap for identification. The plant was confirmed as *Reseda phyteuma* in a letter (Appendix 3) dated 1 September 1989 from K.L. Wilson of the Royal Botanic Gardens, Kew, London to H.R. Toelken of the South Australian State Herbarium.

Specimen Kew Gardens: Specimen Heap 21 was viewed at the Royal Botanic Gardens Kew Herbarium in February 1994 the note adjoining the plant from South Australia read:

> "*Reseda phyteuma L.* ssp *phyteuma.* Determined by K.L. Wilson 1. IX. 1989. Ex State Herbarium of South Australia Adelaide (AD). *Reseda phyteuma L.* South Australia. Region 8: Northern Lofty. 2 km W of Clare, in vineyard (Jim Barry Wines) (Clare is at 33°50′ S, 138°37′ E) Dense infestation, several hectares. Cultivated, disturbed and pasture land in and adjacent to vines. Present since circa 1985. Area sometimes visited by international tourists. Sprawling; erect flower stems. Rosette leaves entire, divided in most flower stems. Flowers circa 6mm diam., petal: cream to yellow - Capsules green, to 15mm long.
>
> John W. Heap 21 29.vi. 1989."(Appendix 4)
>
> It should be noted that 2 km W of Clare should have read 2 km E of Clare.

Initiation of this study: As outlined in the general introduction, the potential of this plant to become a weed in Australia prompted this study. The Animal and Pest Plant Commission realised the threat to the Australian wine industry and possibly also broadacre farming and stated the need for information on the biology and ecology of the weed.

CHAPTER 3

3 MORPHOLOGY AND REPRODUCTION

3.1 BOTANICAL DRAWINGS OF RAMPION MIGNONETTE *Reseda phyteuma* L.

Drawings were made to aid with identification and as a reference of morphological characteristics. Correct plant identification is critical to allow access to literature and effective weed management.

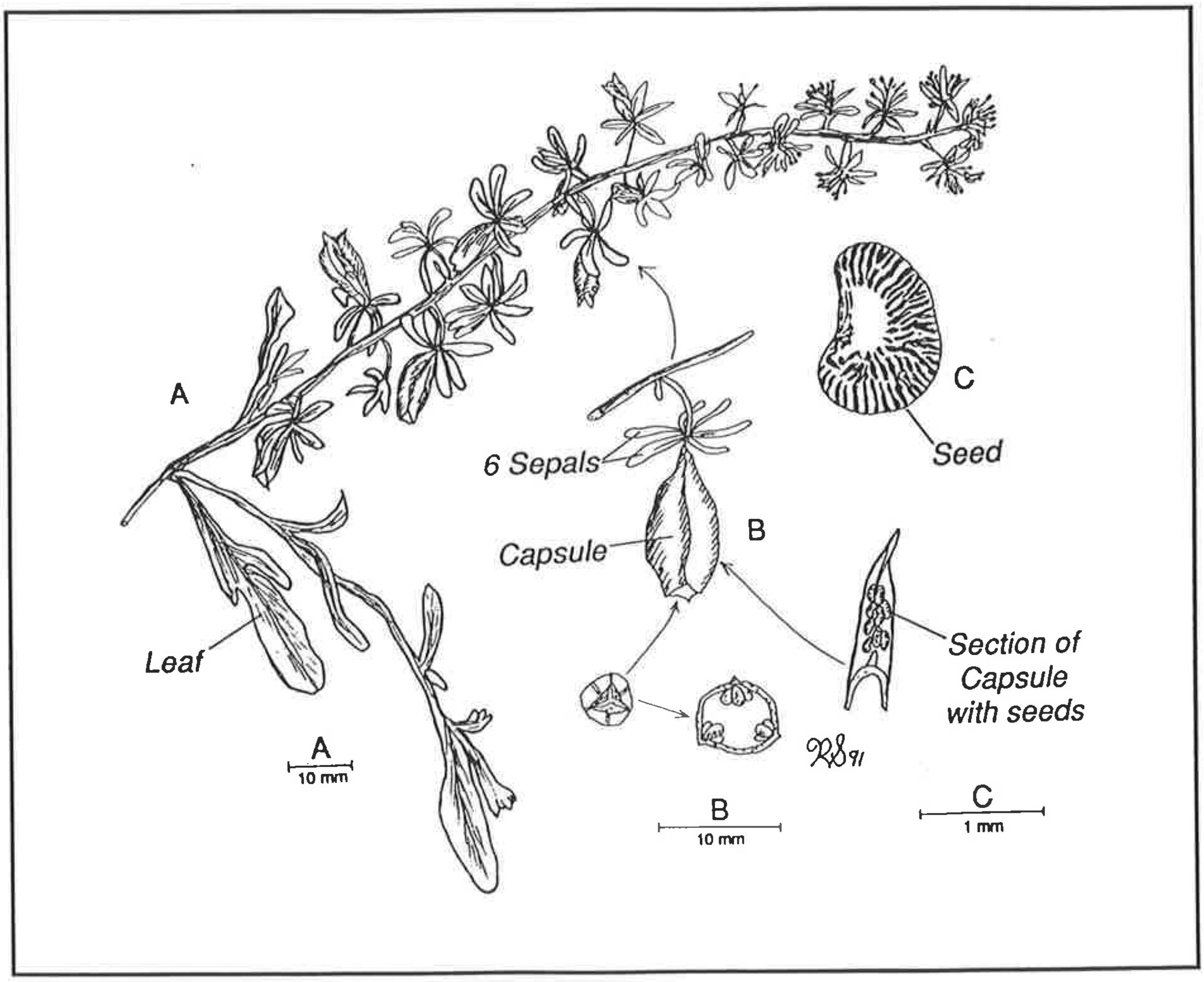

Figure 3.1 ***Reseda phyteuma*** **L. A. Portion of plant showing a leaf, young inflorescence at the tip and the location of developing fruits. B. Capsule with outstanding 6 sepals. Note the section of capsule with seeds. C. Reniform seed.**

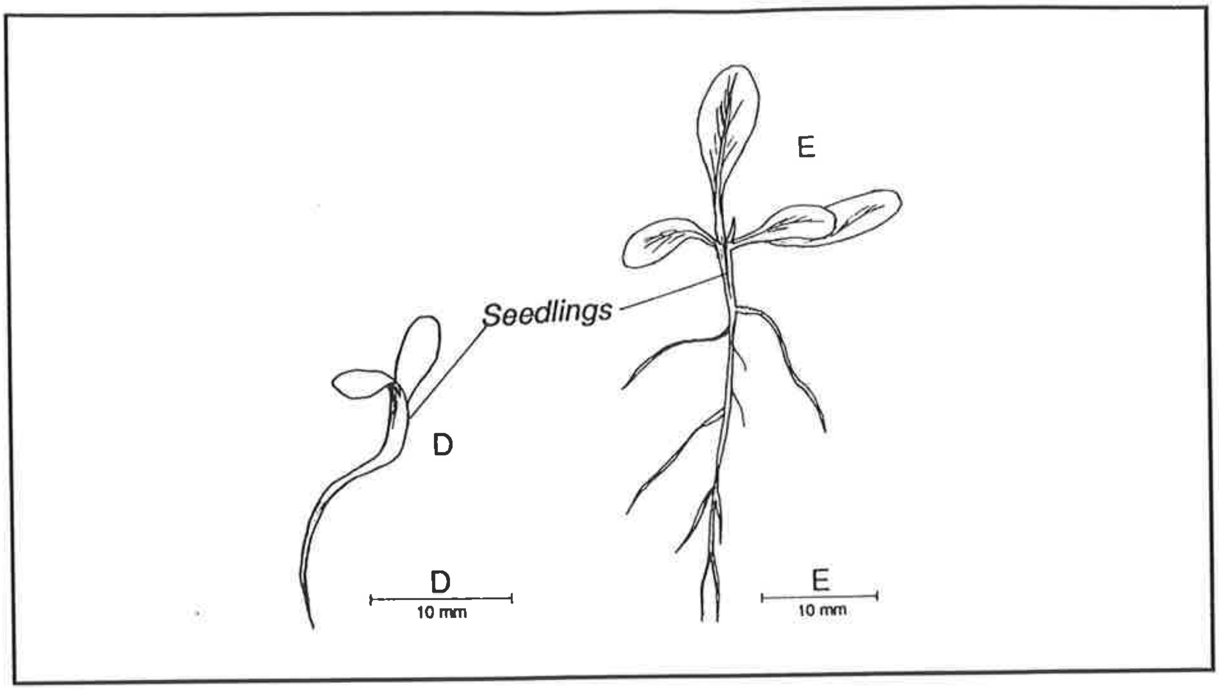

Figure 3.2 ***Reseda phyteuma*** **L. D. Seedling just after emergence 14 days after water imbibition at 15°C. E. Seedling 28 days after water imbibition at 15 to 18°C.**

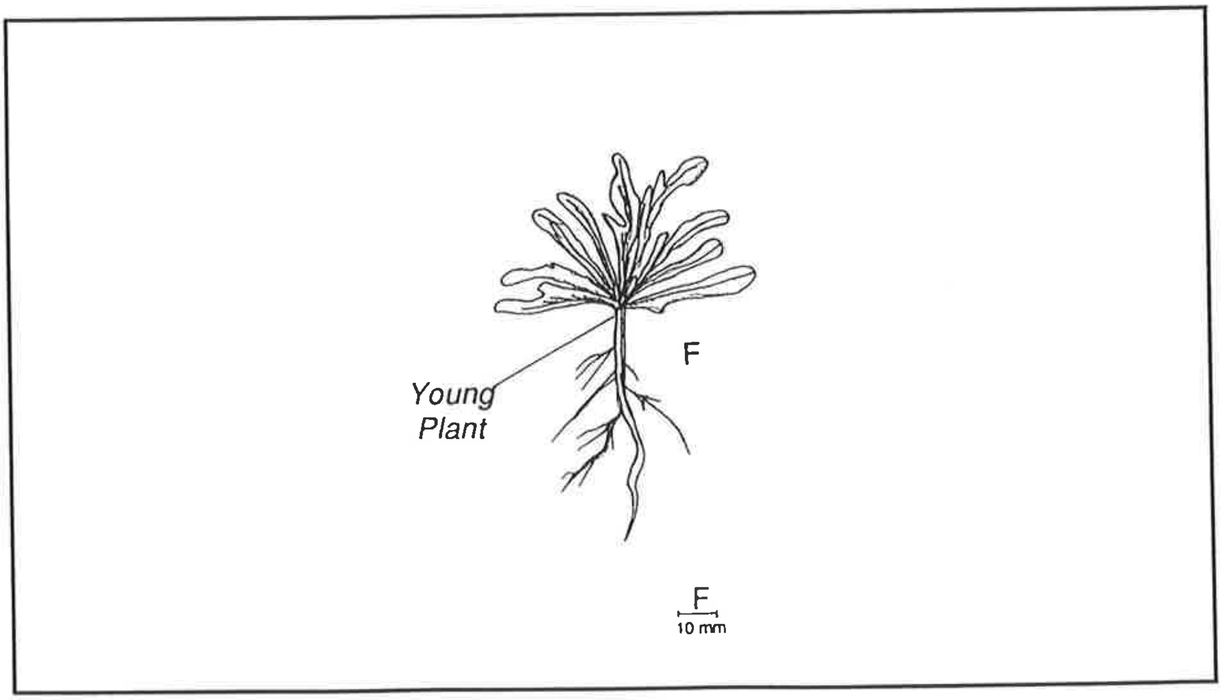

Figure 3.3 ***Reseda phyteuma*** **L. F.Young plant 42 days after water imbibition at 15 to 18°C.**

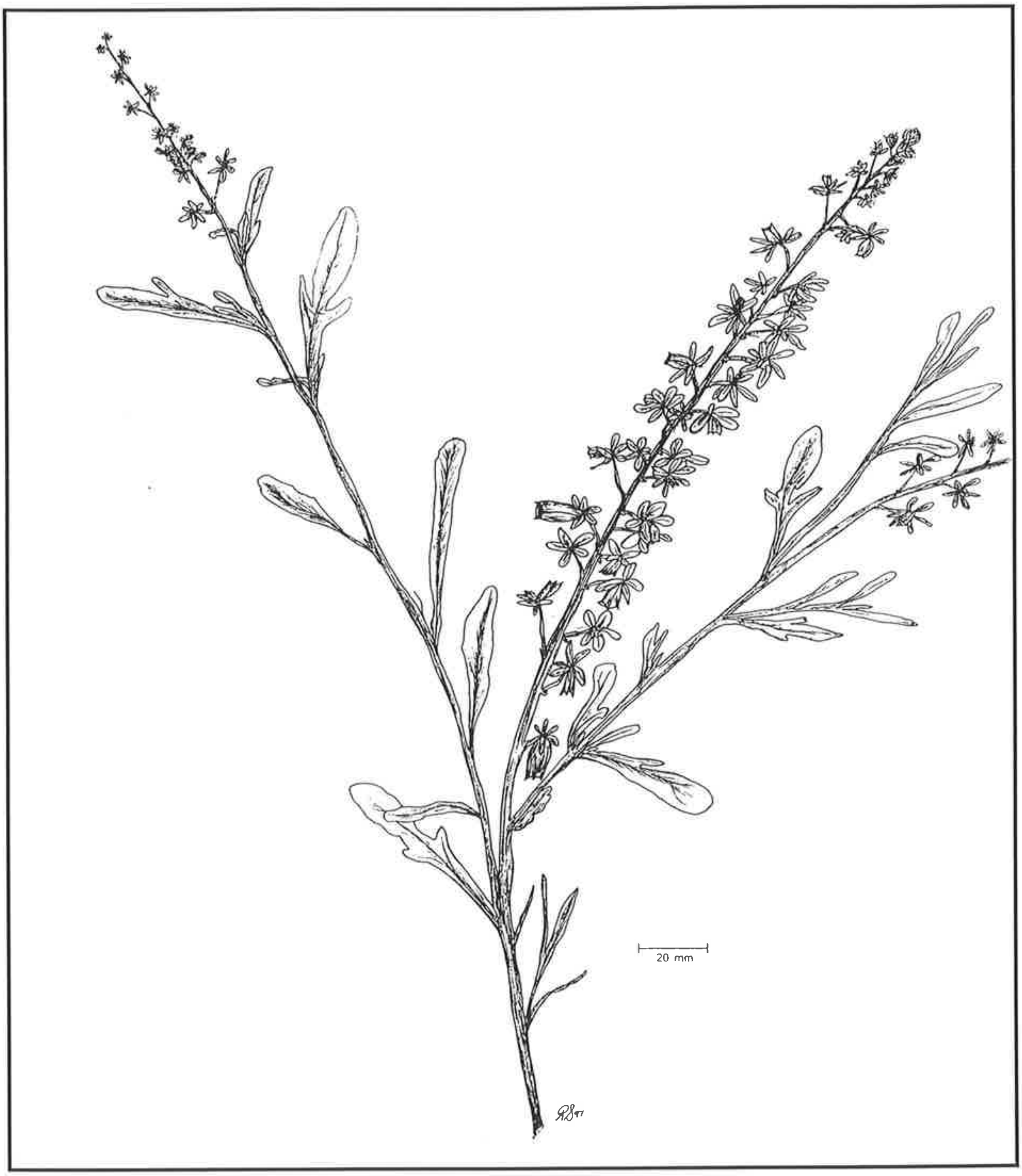

Figure 3.4 ***Reseda phyteuma*** **L. Main stem portion taken from the plants crown with two laterals showing the leafiness of the laterals and flowers and fruits on the main stem.**

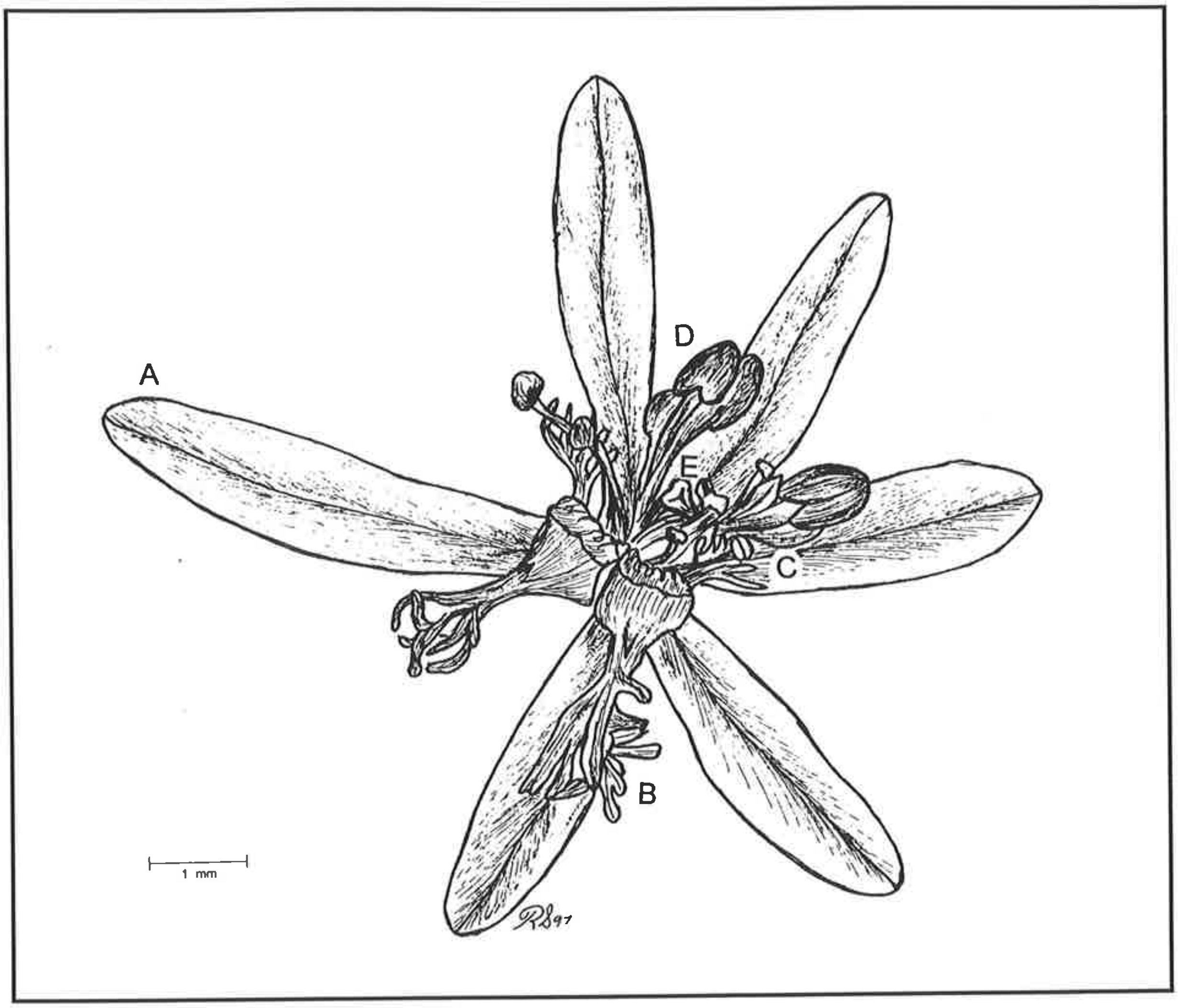

Figure 3.5 ***Reseda phyteuma*** **L. Flower showing A. Sepals. B. Superior petal C. Lateral petal. D. Stamen. E. Ovary.**

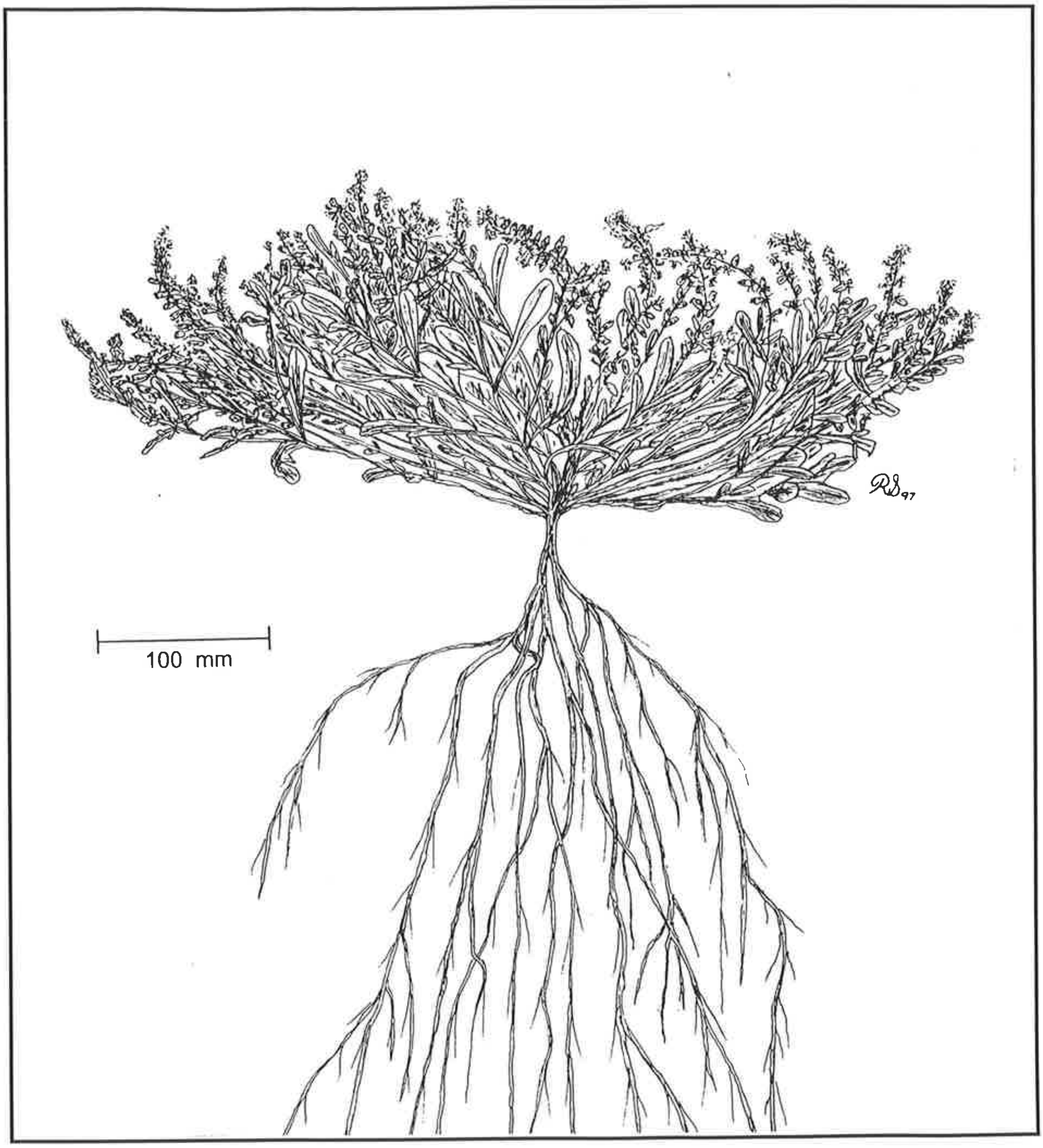

Figure 3.6 ***Reseda phyteuma* L. Prostrate to semi-erect plant habit and root structure.**

3.2 REPRODUCTION

3.2.1 FLORAL BIOLOGY

A flowering raceme bears approximately 20 flowers along its length (Figure 3.4). It is indeterminant in growth and when in full flower bears approximately 10 capsules on the basal end of the raceme and 10 flowers on the tip end of the raceme. The pedicels appear along the raceme within a 2 mm bract. The pedicels are approximately 5 mm long and terminate at 6 outstanding conspicuous sepals (Figure 3.1). The petals are white to off white or cream coloured. Hanf (1984) described the flowers as whitish. At full flower a distinct sweet smell is evident and this is different from the description of Abdallah and De Wit (1978) who judged it to be goat-like, unpleasant, nearly similar to that of *Orchis hircina*. Identified extracts in the flowers and fruits of rampion mignonette are beta-sitosterol, 7 amino acids, a C30 hydrocarbon, kaempferol, quercetol, 3 phenolic acids and linoleic acid (Susplugas *et al*. 1984).

3.2.2 FLOWERING PERIOD AND POLLINATION

At Clare in South Australia rampion mignonette has been observed to flower in autumn (April-May), spring (September-October-November) and summer (December). Common insects observed visiting the flowers are bees and ants. In the northern hemisphere it may be found in flower all through the spring and summer, but sometimes flowers in October or even December or January (Abdallah and De Wit 1978). Hanf (1978) reports that rampion mignonette flowers from July to September in the Northern hemisphere.. In northern Egypt the flowering season for rampion mignonette is from February to April (Khalil 1994).

3.2.3 SEED PRODUCTION AND DISPERSAL

Capsules were counted on single vigorous 40 cm diameter isolated plants of rampion mignonette which supported 21 main stems, 16 lateral stems with all stems bearing a total of 628 capsules. With approximately 21 seeds per capsule the plant has the potential to produce 13,041 seeds (Appendix 5). A second capsule count on a 75 cm diameter isolated plant produced 831 capsules and 17,451 seeds at 21 seeds per capsule, this plant's measurement was made on 15 May 1997. With a single plant on bare ground able to produce approximately 15,000 seeds and at three plants per m^2 there is potential for seed production to be in the order of 45,000 seeds per m^2 or 450,000,000 seeds per ha in any one year. This compares with the broadacre production of seeds from cutleaf mignonette (*R.lutea*) of 140,000 to 420,000 seeds per ha (Heap *et al.* 1987).

Seeds turn brown in December and fall from the capsules adding to the soil seed bank. Ants were observed transporting seeds. Seeds in the soil are able to be dispersed by mechanical means such as the movement of farm implements or on shoes and boots.

3.2.4 VIABILITY OF SEED AND GERMINATION

Germination, as indicated by radicle emergence, began within 48 hours at temperatures of 15 - 27^{o} C and 10 - 20^{o} C.

3.2.5 VEGETATIVE REPRODUCTION

There is no evidence of spread by asexual means.

3.2.6 HYBRIDS

There have been no reports of hybrids of rampion mignonette.

3.3 PHOTOGRAPHS OF RAMPION MIGNONETTE

Plate 3.1 Rampion mignonette plant showing abundance of capsules, photographed 15 May 1997.

Plate 3.2 An opened capsule of rampion mignonette showing the seeds which occur as three rows of approximately 7 seeds and the darker colour of more mature seeds, photographed 15 May 1997.

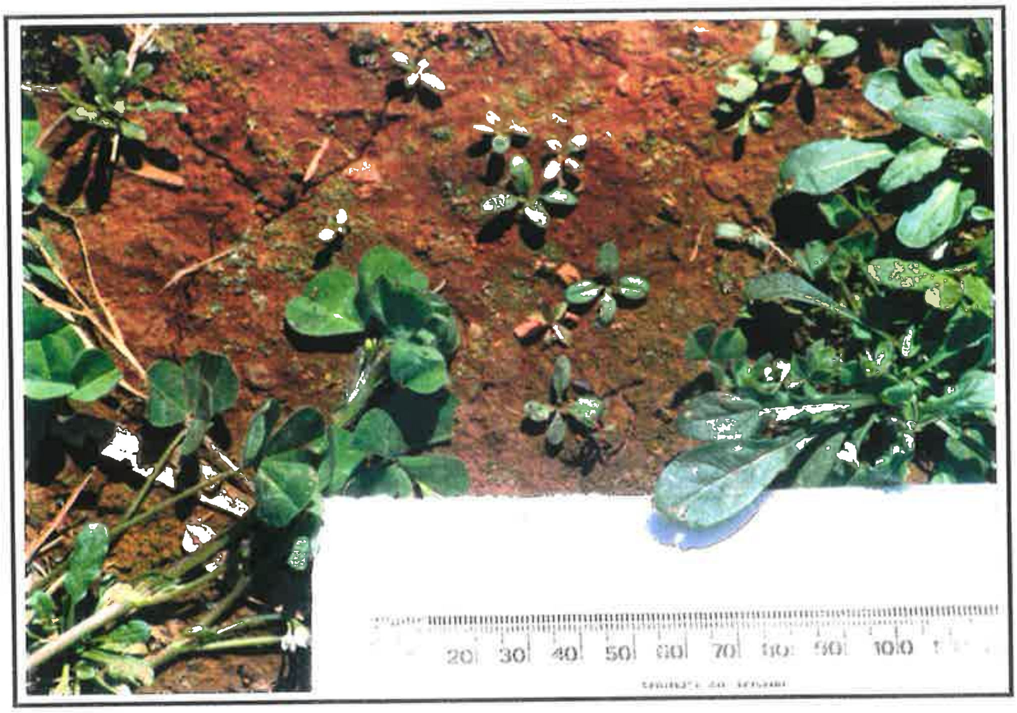

Plate 3.3 Rampion mignonette seedlings (upper centre of photograph) with the cotyledons and the first two true leaves, photographed 29 September 1993.

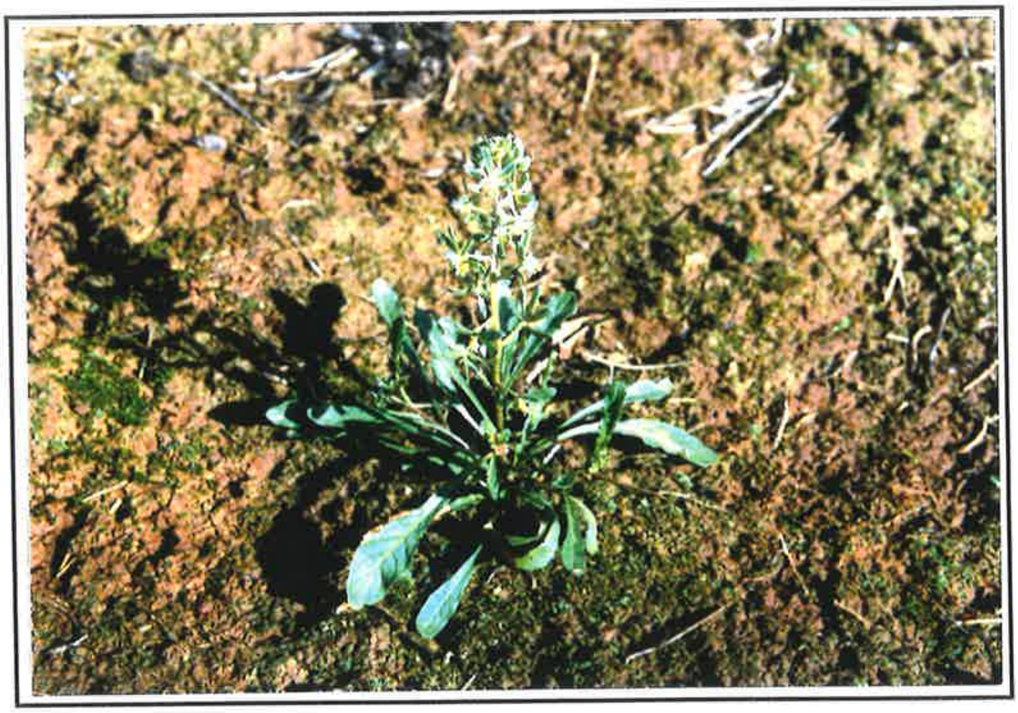

Plate 3.4 Rampion mignonette plant with aerial raceme commencing to flower, photographed April 1992.

Plate 3.5 Rampion mignonette plants in a newly established vineyard, photographed 15 May 1997.

Plate 3.6 The prostrate to semi erect habit of rampion mignonette, photographed 15 April 1992.

CHAPTER 4

4 SURVEY OF PLANT DISTRIBUTION AT CLARE.

4.1 SITE OF THE SURVEY

The survey was conducted at Clare, South Australia in the Clare East Vine Site. The Clare East Vine Site is an area of approximately 500 ha of vines surrounded by scattered eucalypt trees, grazing and cropping land. In 1991 rampion mignonette was known to have established in at least two locations approximately a kilometre apart in this vine site.

4.1.1 THE CLIMATE OF THE SITE

Clare has a Mediterranean climate with cool mild humid winters and hot dry summers. Table 4.1 displays the mean monthly rainfall and evaporation totals for Leasingham vineyards at Clare (Smith 1996). Approximately 75% of the rainfall falls in between April and October. Thunderstorms occur occasionally in between December and March. Clare has a seven month growing season. Table 4.2 displays mean temperatures for Leasingham vineyards at Clare.

Table 4.1 Mean monthly rainfall and evaporation totals for Leasingham vineyards, Clare, South Australia (Evaporation Class A pan).

	Rainfall (mm)	Evaporation (mm)
January	25	267
February	14	232
March	29	181
April	42	110
May	57	61
June	91	41
July	96	43
August	98	62
September	79	87
October	55	140
November	41	186
December	32	226
Yearly total	659	1636

Table 4.2 Mean monthly minimum, maximum and mean temperature for Leasingham vineyards, Clare, South Australia.

	Mean Monthly Maximum Temperature °C	Mean Monthly Minimum Temperature °C	Mean Monthly Temperature °C
January	30	14	22.0
February	29	14	21.5
March	27	12	19.5
April	22	9	15.5
May	17	6	11.5
June	15	4	9.5
July	13	3	8.0
August	14	4	9.0
September	17	5	11.0
October	21	8	14.5
November	25	10	17.5
December	27	12	19.5
Annual mean	21.4	8.4	14.9

4.1.2 THE SOILS OF THE SITE

The Clare East Vine Site has a land use classification of Class 3 and is regarded to be of low risk of erosion. The soils are Red Chromosols (Isbell 1996) and are not strongly acid and not sodic. They are typical crusty red duplex soils (Dr1) (Northcote 1979) being highly alkaline in the B horizon (Plate 4.1). Surface pH measurements varied from acid, pH 6 to alkaline, pH 8. Observations made on the 15th of October 1996 between vine rows in vine block 114 found no rampion mignonette growing in a 40 m strip of acid soil (surface pH 6). Plants growing in this strip were subterranean clover and capeweed. In an adjoining 40 m strip of alkaline soil (surface pH 8) rampion mignonette plants were found to be growing. It is unknown whether this was a chance observation or indicative of a strong relationship between plant species and soil pH; however such relationships are known. Reisinger (1992) found soil texture, humus content and pH influenced the abundance and presence of certain weed species, especially dominant weeds.

Plate 4.1 Typical crusty red duplex soil (Dr1) showing an abundance of free lime extracted when post holes were bored, photographed 15 May 1997.

4.2 THE SURVEY

4.2.1 INTRODUCTION

In 1991 an initial estimation of the extent of the infestation of rampion mignonette at Clare in South Australia was made. Cooke (1991) documented a minor occurrence to the west of Clare in Section 121 of the Hundred of Clare and estimated a larger colonisation of 38 ha to the east of Clare. This survey was limited to the larger Clare East Vine Site colonisation in sections 3026, 3027, 3068, 3069, 3070, 3071, 3039, 211, 285, 546 and 545. There was a need to accurately quantify rampion mignonette's geographic distribution and abundance over the whole Clare East Vine Site to define the nature and size of the infestation and for use in determining the rate of migration or reduction over time. Küchler and Zonneveld (1988) outline the generally used criteria for the floristic analysis of vegetation as measured by cover, abundance, occurrence or mass. Cover is expressed as a percentage, abundance is expressed as either frequency (relative number/area) or density (absolute number/area), occurrence is expressed as yes or no and mass as weight/area.

In this survey it was decided to measure the abundance of rampion mignonette by frequency as this would be a useful index for monitoring changes in the abundance over time.

The aim of this study was to survey portions of vines to the east of Clare and to accurately determine the level of abundance, the distribution of rampion mignonette, any changes in the distribution and abundance over time and the potential to spread and likely rate of spread to other vineyards.

4.2.2 METHODOLOGY

The Clare East Vine Site is shown in the aerial photograph (Figure 4.1). From an enlarged aerial photograph separate blocks, containing approximately 15 rows of vines, were delineated and with other land units a map was produced containing 368 numbered sections. The map was used to display the abundance of rampion mignonette at any point of time. The map, with infestation levels in the summer of 1991 is displayed in Figure 4.2. A field work survey sheet was drawn to record measurements of the occurrence of rampion mignonette (Appendix 6). For the survey a plan of movement from vine block to vine block was drawn up. To mark the vine row surveyed an engraved numbered roofing nail was used. The nail was driven into the centre row post at the beginning of a row in a block of vines.

4.2.3 DATA COLLECTION

The surveyor entered the vine row to the right of the nailed post and walked along the row and recorded whether the weed had been observed or not after every 10 paces. Frequency of distribution as a percentage was determined for the row surveyed within a numbered block and displayed in tables and on maps.

Figure 4.1 Aerial photograph of the Clare East Vine Site to the east of Clare, South Australia, photographed 23rd of October 1991.

4.2.4 RESULTS AND DISCUSSION

Table 4.3 shows no change in the level of rampion mignonette in the surveys of summer 1991 and autumn 1992 (both means were 29%). The reduction to a mean of 16% in summer 1992 was due to herbicide and cultivation control applied prior to this survey. Figures 4.2 and 4.3 show the location of blocks in the 500 ha Clare East Vine Site and their relationship to each other.

Table 4.3 Frequency of occurrence of rampion mignonette in vineyard blocks at Clare, South Australia at summer and autumn periods over 1 year. Summer (18 Dec 1991) abundance are shown in Figure 4.2 and Autumn (13 May 1992) abundance in Figure 4.3.

Block Number	Summer 18 Dec 1991	Autumn 13 May 1992	Summer 10 Dec 1992
	%	%	%
100 (A)	81	93	45
109 (A)	100	100	100
110 (A)	82	95	17
102 (A)	50	64	42
103 (A)	25	47	6
111 (A)	100	100	88
113 (A)	71	94	74
114 (A)	86	100	25
115 (A)	74	100	10
116 (A)	80	23	9
123 (A)	73	86	46
117 (A)	69	73	7
118 (A)	0	0	0
119 (A)	0	0	0
120 (A)	24	23	16
131 (B)	4	0	7
132 (B)	0	0	0
133 (B)	0	0	0
134 (B)	3	10	10
135 (B)	3	7	0
136 (B)	0	3	0
137 (B)	6	3	3
138 (B)	3	0	0
139 (B)	11	5	0
140 (B)	4	4	4
141 (B)	68	15	13
142 (B)	21	26	17
143 (B)	0	0	0
144 (B)	9	7	0
249 (C)	0	0	0
253 (C)	0	0	0
250 (C)	0	0	0
254 (C)	0	0	0
255 (C)	0	0	0
251 (C)	0	0	0
252 (C)	21	14	33
256 (C)	5	5	0
257 (C)	81	81	74
258 (C)	23	24	13
259 (C)	0	0	0
260 (C)	0	0	0
MEAN	29	29	16

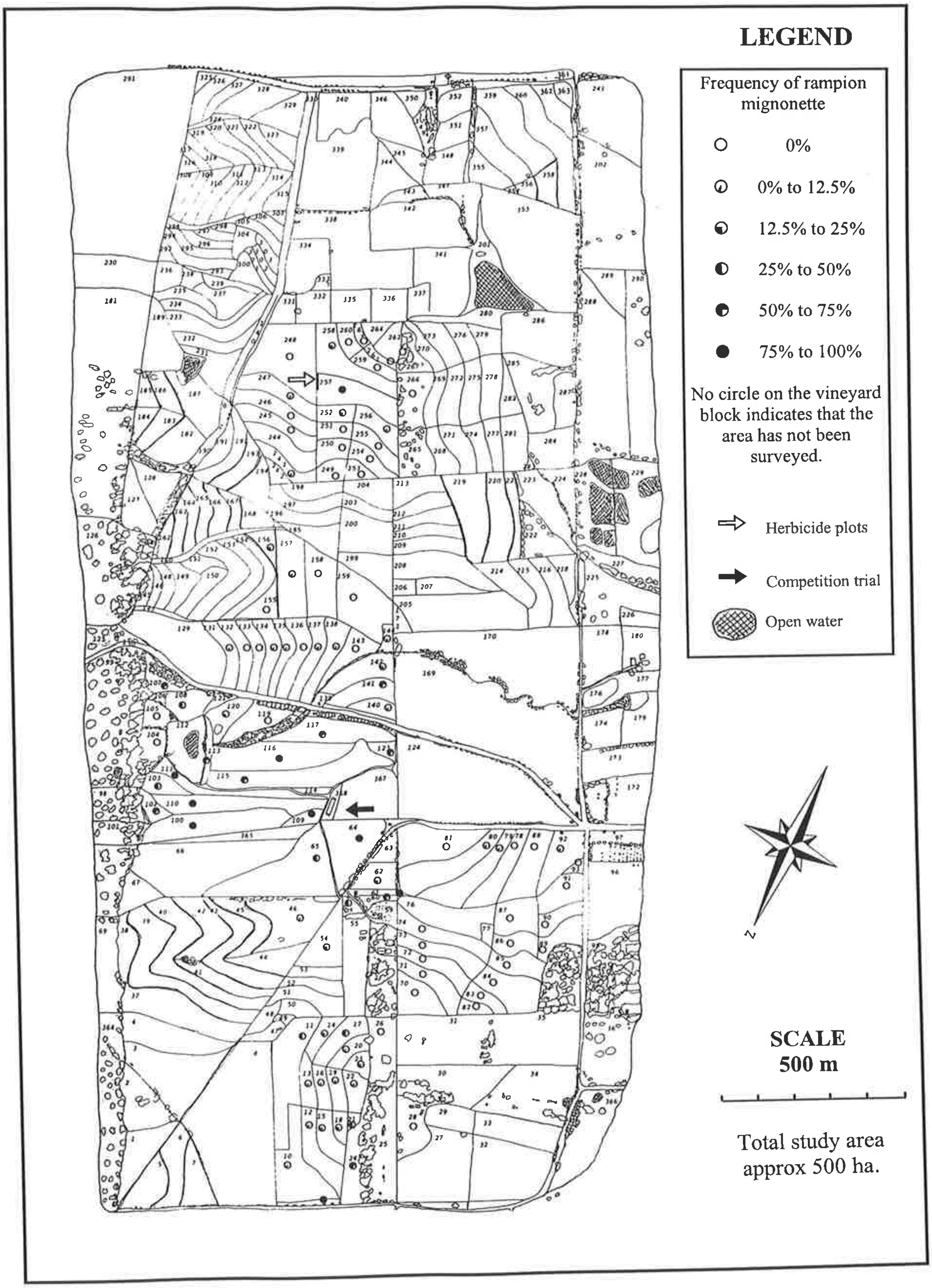

Figure 4.2 Map of survey area to the east of Clare, South Australia showing infestation levels as surveyed in the summer of 1991, blocks 100 to 262 and 1992, blocks 9 to 93.

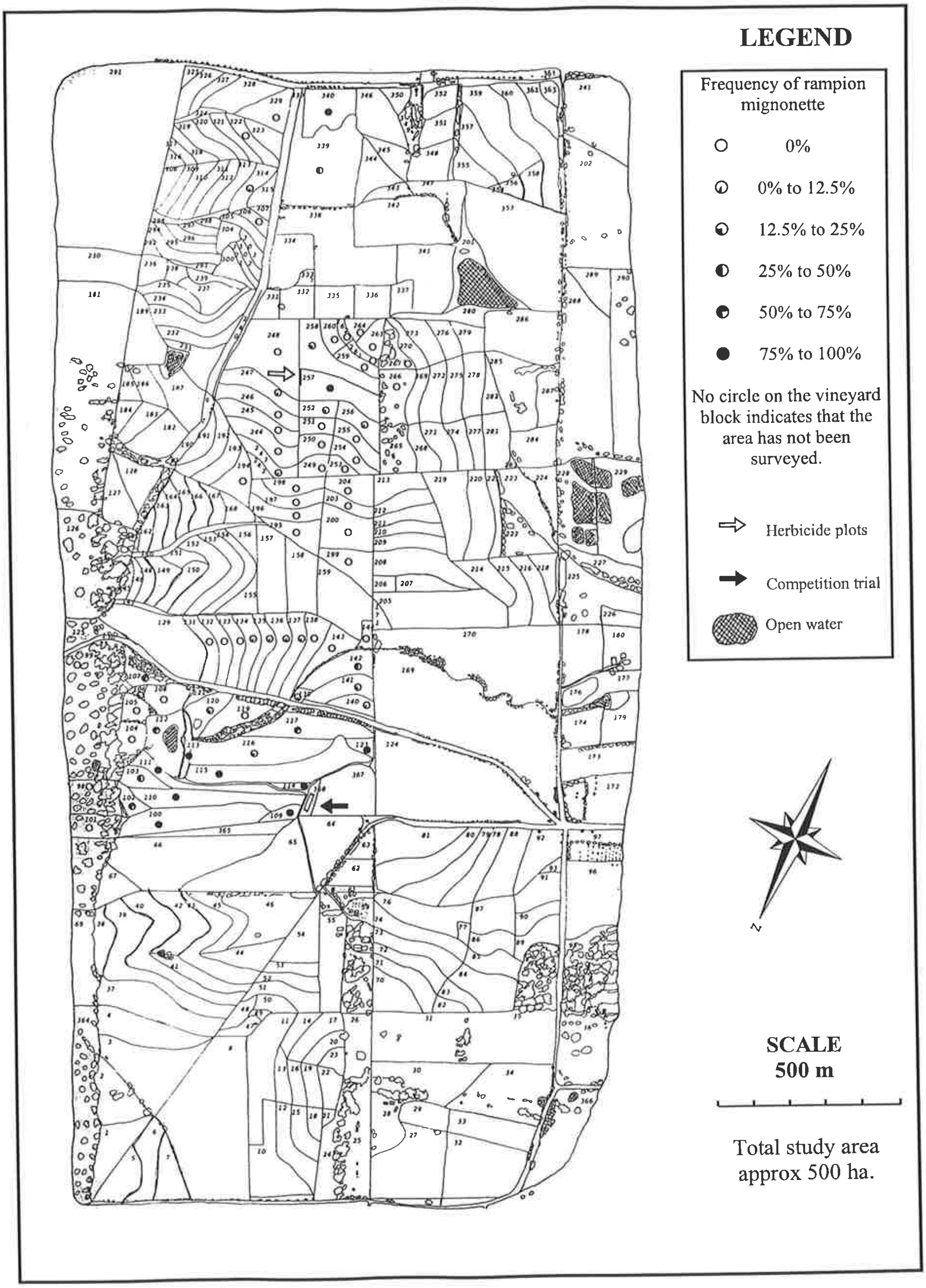

Figure 4.3 Map of survey area to the east of Clare, South Australia showing infestation levels as surveyed in the autumn of 1992.

Table 4.4 shows an overall reduction in the level of rampion mignonette over a five year period. This reduction was due to implementation of chemical and cultural weed control.

Table 4.4 Frequency of occurrence of rampion mignonette in vineyard blocks at Clare, South Australia in autumn 5 years apart. Blocks were managed by three different managers (A,B and C).

Block Number (Manager)	Autumn 13 May 1992	Autumn 15 May 1997
	%	%
115 (A)	100	95
116 (A)	23	10
117 (A)	73	75
120 (A)	23	38
131 (B)	0	0
132 (B)	0	0
137 (B)	3	31
138 (B)	0	0
155 (B)	0	0
156 (B)	26	0
157 (B)	8	0
158 (B)	0	0
159 (B)	0	0
243 (B)	4	0
244 (B)	0	0
245 (B)	0	0
246 (B)	0	0
247 (B)	6	0
248 (B)	0	0
249 (C)	0	0
253 (C)	0	0
250 (C)	0	0
254 (C)	0	0
255 (C)	0	0
251 (C)	0	0
252 (C)	14	0
256 (C)	5	0
257 (C)	81	47
258 (C)	24	7
259 (C)	0	0
260 (C)	0	0
MEAN	13	10

Tables 4.5, 4.6 and 4.7 show surveys over a six year period, note that the blocks are listed in order of adjacency in the field. There was no migration of the weed into blocks which did not have rampion mignonette present in 1991 except in block 136 where 3% showed up on 13 May 1992.

Table 4.5 shows levels of rampion mignonette from 1991 to 1997 under manager A. The summer 1991 survey was conducted prior to any control measures being implemented. Integrated control measures with herbicides and cover cropping prior to 10 December 1992 reduced the level of rampion mignonette plants as indicated by the summer 1992 measurements.

Control measures in blocks 100 to 120 using subterranean clover in winter 1993 reduced rampion mignonette plants and seed set in spring of 1993 and summer of 1993/1994. However the seed bank produced by the previous season's seed production remained to produce an abundance of plants, as shown in the Autumn 1997 survey conducted on the 15th of May 1997.

Table 4.5 Frequency of occurrence of rampion mignonette in vineyard blocks at Clare, South Australia at summer and autumn periods over 6 years. Blocks managed by manager A. Summer (10 Dec 1992 and 20 Feb 1993) abundance are shown in Figure 4.4 and Autumn (15 May 1997) abundance in Figure 4.5.

Block Number	Summer 18 Dec 1991	Autumn 13 May 1992	Summer 10 Dec 1992	Summer 20 Feb 1993	Autumn 15 May 1997
	%	%	%	%	%
100 (A)	81	93	45	100	85
109 (A)	100	100	100	100	94
110 (A)	82	95	17	100	86
102 (A)	50	64	42	72	59
103 (A)	25	47	6	87	61
111 (A)	100	100	88	100	93
113 (A)	71	94	74	82	77
114 (A)	86	100	25	100	86
115 (A)	74	100	10	100	95
116 (A)	80	23	9	86	10
123 (A)	73	86	46	100	62
117 (A)	69	73	7	54	75
118 (A)	0	0	0	0	0
119 (A)	0	0	0	0	0
120 (A)	24	23	16	0	38
MEAN	61	67	32	72	61

Table 4.6 shows levels of rampion mignonette from 1991 to 1997 under manager B. Continuous integrated control measures over the six year period have produced a steady reduction in the abundance of rampion mignonette as indicated by the mean values. Continuation of control measures may well cause eradication of rampion mignonette in the blocks shown.

Table 4.6 Frequency of occurrence of rampion mignonette in vineyard blocks at Clare, South Australia at summer and autumn periods over 6 years. Blocks managed by manager B. Summer (10 Dec 1992 and 20 Feb 1993) abundance are shown in Figure 4.4 and Autumn (15 May 1997) abundance in Figure 4.5.

Block Number	Summer 18 Dec 1991	Autumn 13 May 1992	Summer 10 Dec 1992	Summer 20 Feb 1993	Autumn 15 May 1997
	%	%	%	%	%
131 (B)	4	0	7	0	0
132 (B)	0	0	0	0	0
133 (B)	0	0	0	0	0
134 (B)	3	10	10	0	0
135 (B)	3	7	0	0	0
136 (B)	0	3	0	0	0
137 (B)	6	3	3	0	31
138 (B)	3	0	0	0	0
139 (B)	11	5	0	0	0
140 (B)	4	4	4	0	0
141 (B)	68	15	13	7	2
142 (B)	21	26	17	12	1
143 (B)	0	0	0	0	0
144 (B)	9	7	0	0	0
155 (B)	0	0	0	0	0
156 (B)	32	26	14	22	0
157 (B)	7	8	6	0	0
158 (B)	0	0	0	0	0
159 (B)	0	0	0	0	0
243 (B)	5	4	2	0	0
244 (B)	0	0	0	0	0
245 (B)	0	0	0	0	0
246 (B)	0	0	0	0	0
247 (B)	7	6	3	0	0
248 (B)	0	0	0	0	0
MEAN	8	5	3	2	1

Table 4.7 shows levels of rampion mignonette from 1991 to 1997 under manager C. Little reduction of abundance of rampion mignonette occurred over the first few years, although control measures over the six year period produced a reduction of approximately half in the level of abundance of rampion mignonette.

Table 4.7 Frequency of occurrence of rampion mignonette in vineyard blocks at Clare, South Australia in summer and autumn over 6 years. Blocks managed by manager C. Summer (10 Dec 1992 and 20 Feb 1993) abundance is shown in Figure 4.4 and Autumn (15 May 1997) abundance in Figure 4.5.

Block Number	Summer 18 Dec 1991	Autumn 13 May 1992	Summer 10 Dec 1992	Summer 20 Feb 1993	Autumn 15 May 1997
	%	%	%	%	%
249 (C)	0	0	0	0	0
253 (C)	0	0	0	0	0
250 (C)	0	0	0	0	0
254 (C)	0	0	0	0	0
255 (C)	0	0	0	0	0
251 (C)	0	0	0	0	0
252 (C)	21	14	33	28	0
256 (C)	5	5	0	0	0
257 (C)	81	81	74	68	47
258 (C)	23	24	13	13	7
259 (C)	0	0	0	0	0
260 (C)	0	0	0	0	0
MEAN	11	10	10	9	5

VINEYARD MANAGERS' MANAGEMENT OPERATIONS

The three tables show variations in the frequency of occurrence under three different management regimes. Table 4.5 shows little drop in the level of rampion mignonette over six years under the management of manager A . Table 4.6 shows a reduction in the level of rampion mignonette other than in block 137 under manager B. The reason for the increase in block 137 is unknown. Table 4.7 also shows a reduction in the level of rampion mignonette under the management of manager C. The three tables highlight the differences in weed population reduction under different managers. Figures 4.4 and 4.5 show the location of blocks in the 500 ha Clare East Vine Site and their relationship to each other.

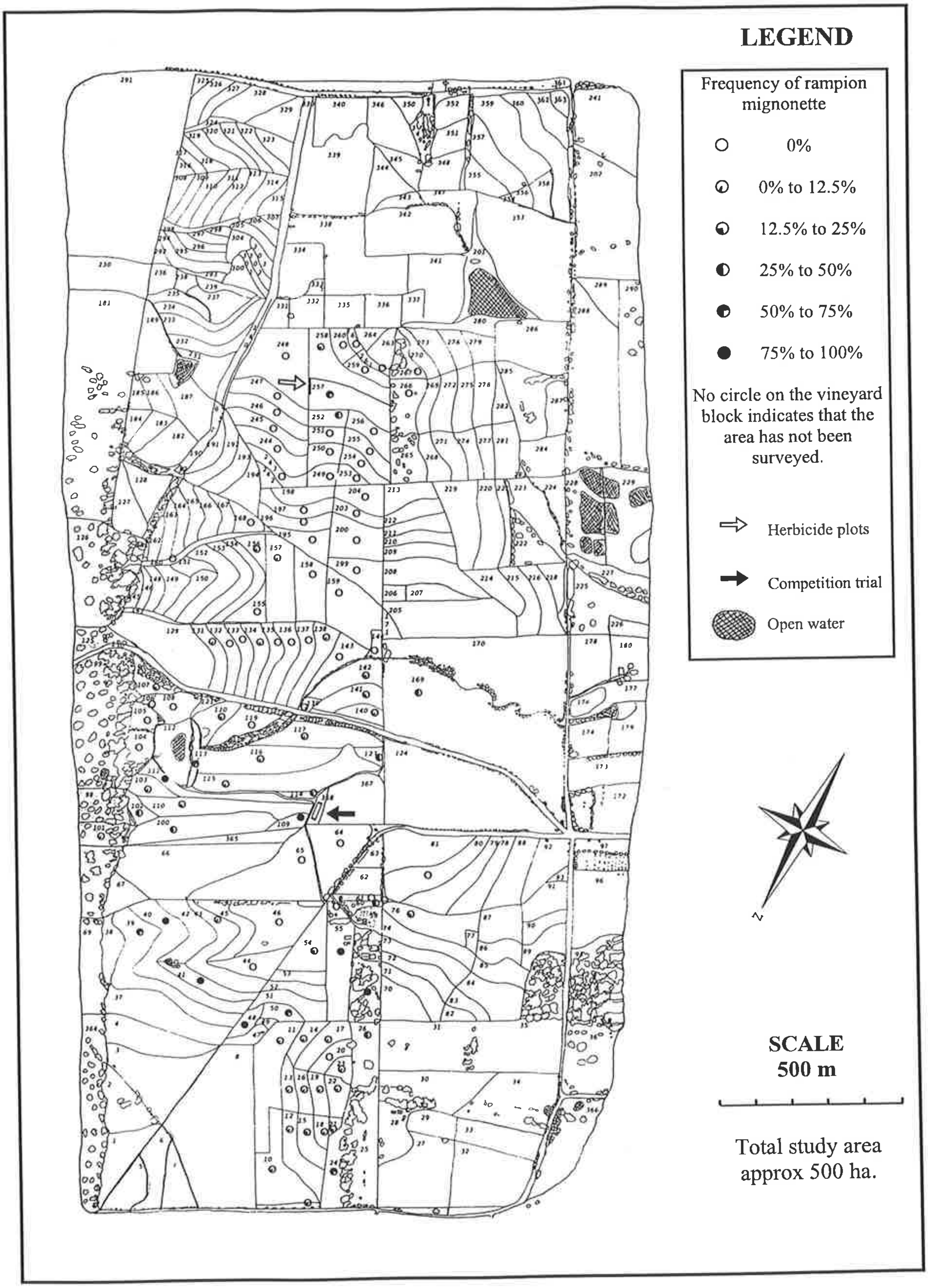

Figure 4.4 **Map of survey area to the east of Clare, South Australia showing infestation levels as surveyed in the summer of 1992 and 1993.**

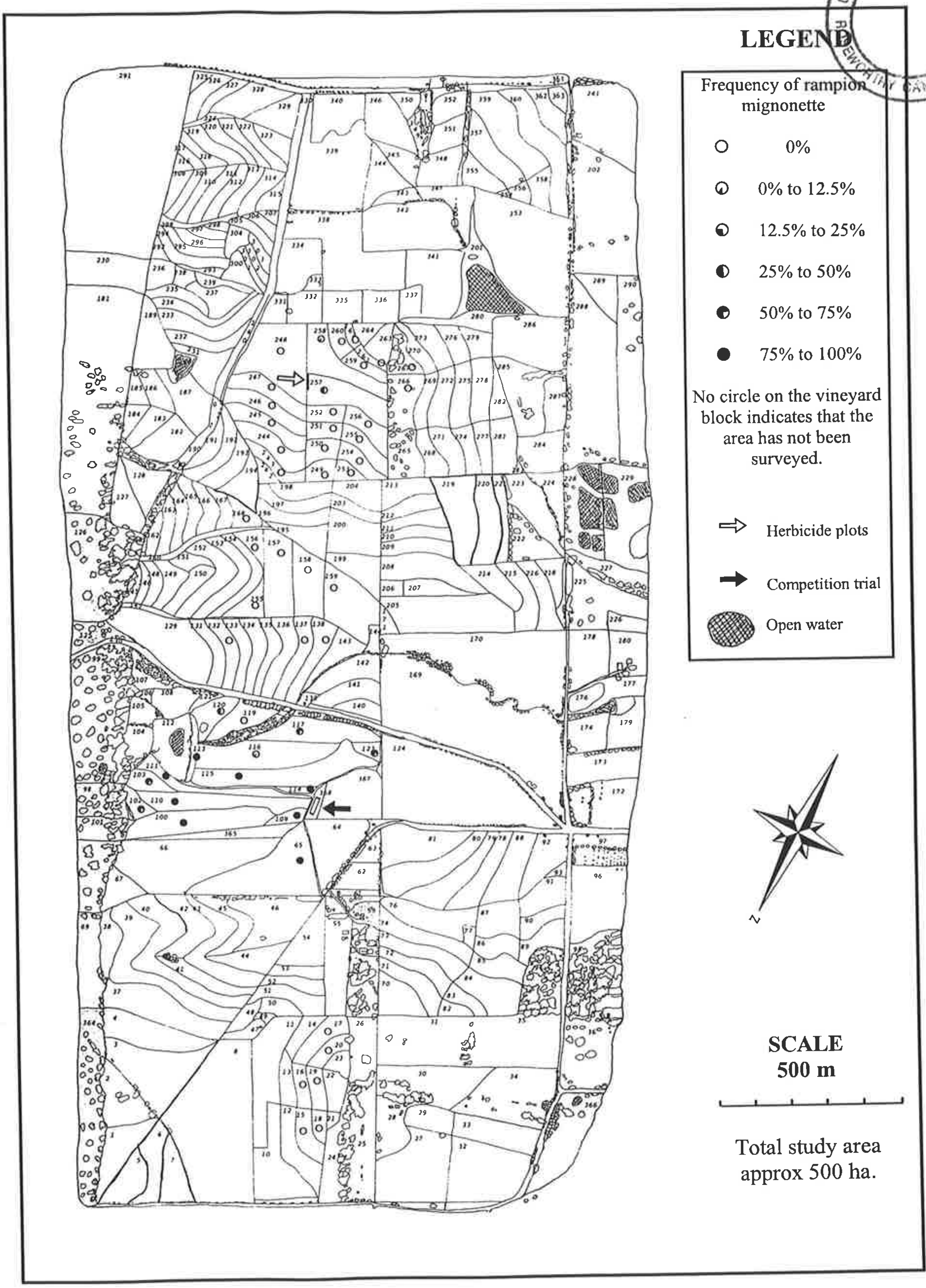

Figure 4.5 **Map of survey area to the east of Clare, South Australia showing infestation levels as surveyed in the autumn of 1997.**

4.2.5 CONCLUSIONS

- Rampion mignonette showed little migration to blocks initially free of the weed. This suggests that currently employed methods of containment are effective.

- Population reduction can be achieved by careful management including both chemical and cultural techniques.

- Migration and increases in abundance are likely to be slow, under commonly practised vineyard management in southern Australia.

CHAPTER 5

5 AGRONOMIC EXPERIMENTS

5.1 EXPERIMENT 1. COMPETITION TRIAL

5.1.1 INTRODUCTION

It has long been known that weeds lower the yields of cereal crops and pasture and that the reduction is largely due to competition for moisture, nutrients and light. Zimdahl (1993) notes environmental interactions between climate, soil and biotic factors. The climatic factors that affect weed growth are light, temperature, moisture, wind and humidity. Changes in environment can be caused by irrigation or tillage. The edaphic or soil and ground factors that affect weed distribution are soil water, aeration, temperature, pH, fertility and the plants present that determine which weeds survive and compete. Clements *et al.* (1929) indicated that two plants no matter how close do not compete with each other so long as the water content, nutrient material, light and heat are in excess of the needs of both. Competition is about limited supply of a resource and the ability of one plant to gain the limited requirement needed over another plant. Yield losses in wheat in southern Australia due to competition with annual grass weeds at a density of 100 plants per m^2 have been widely reported at around 25% (Reeves *et al.* 1973, Philpotts 1975, McNamara 1976, Gill *et al.* 1986, Poole *et al.* 1986, Gill and Poole 1986, Anderson 1978, Wilson 1979 and Radford *et al.* 1980). Gilbey (1974) reported yield losses of 40% in wheat in southern Australia due to competition with three cornered jack (*Emex australis*) at a density of 100 plants per m^2.

The aim of this study was to ascertain the potential of rampion mignonette to compete with wheat, faba beans, subterranean clover and grass pasture of the South Australian dryland farming system and to study the weed in a weed crop ecosystem over time.

5.1.2 MATERIALS AND METHODS

5.1.2.1 Site of the experiment

The trial site was located 2 km East of Clare, 150 km North of Adelaide, South Australia, on the property of Jim Barry Wines. The trial was conducted on crusty red duplex soils with surface gravel in an area with a mean annual rainfall of 659 mm predominantly of winter incidence. More detailed information on the climate and soils of the site are described in chapter 4 (Survey of plant distribution at Clare, South Australia) under sections 4.1.1 and 4.1.2.

5.1.2.2 Trial design and treatments

The trial was conducted in a pasture paddock adjacent to vineyards which had previously been grazed by sheep and horses and was known to have had an even cover of rampion mignonette. The site was fenced to exclude grazing animals and rotary hoed on 3 June 1992 to incorporate vegetable matter and mignonette seed and to produce an even and friable seed bed. The sown area was 10m x 45m. Twenty six main plots 1.7m wide and 10m long were sown (Figure 5.1). Buffer plots of wheat were sown at each end of the trial. The trial was a split plot design where the factor plants (wheat, bean, clover and grass) were randomly assigned to the whole plots and the factor treatments (fixed quadrats) + + -, + - - , - + - and + + + (Table 5.1) were randomly allocated to the subplots (Figure 5.1).

Table 5.1 Factor treatments within the fixed quadrats. Plus (+) indicates the presence of the crop, pasture, rampion mignonette or other weed. Minus(-) indicates the absence of crop, pasture, rampion mignonette or other weeds being removed by hand weeding.

Field Flag Colour	Quadrat Identification	Crop Pasture Present	Reseda Present	Other Weeds
Yellow	+ + -	+	+	-
Orange	+ - -	+	-	-
Pink	- + -	-	+	-
Green	+++	+	+	+

	I				II				III				IV				V				VI				
	Crop	Crop	Past	Past	Crop	Past	Past	Crop	Crop	Past	Past	Crop	Past	Crop	Crop	Past	Crop	Past	Crop	Past	Crop	Past	Past	Crop	
Wheat	Wheat	Bean	Clover	Grass	Bean	Grass	Clover	Wheat	Bean	Clover	Grass	Wheat	Clover	Wheat	Bean	Grass	Bean	Grass	Wheat	Clover	Bean	Clover	Grass	Wheat	Wheat
Border Buffer	++-	+--	+++	++-	+--	+--	++-	-+-	-+-	+++	++-	+++	-+-	++-	-+-	+--	-+-	++-	-+-	++-	+--	-+-	++-	-+-	Border Buffer
	+++	++-	-+-	+--	+++	+++	+++	+++	++-	+--	+++	+--	+++	-+-	+--	++-	+++	+--	++-	-+-	-+-	++-	+++	++-	
	-+-	+++	++-	+++	-+-	++-	-+-	+--	+++	-+-	-+-	-+-	++-	+--	++-	+++	+--	+++	+++	+--	++-	+++	+--	+--	
	+--	-+-	+--	-+-	++-	-+-	+--	++-	+--	++-	+--	++-	+--	+++	+++	-+-	++-	-+-	+--	+++	+++	+--	-+-	+++	

++- Plus C or P, plus Reseda (*), minus other weeds. +-- Plus C or P, minus Reseda (*), minus other weeds. -+- Minus C or P, plus Reseda (**), minus other weeds. +++ Plus C or P, plus Reseda (*), plus other weeds.

C = Crops; P = Pastures and Reseda = rampion mignonette.

NOTE:- (*) No reseda established in these fixed quadrats. (**) Reseda established in these bare earth quadrats in November 1992. Other weeds were predominantly annual ryegrass.

Figure: 5.1 Plan of the competition trial sown at Clare, South Australia showing the six replicates of sown wheat, beans, clover and grass plots and the coding used for the four fixed quadrats in each subplot.

The trial was replicated six times. Each replicate contained four plots, two crop and two pasture. The two crops were wheat, *Triticum aestivum* L., `Machette′ and faba beans, *Vicia faba* L., `Fiord′. The two pastures were subterranean clover, *Trifolium brachycalycinum* L., `Clare′ and tall fescue, *Festuca arundinacea* L., `Demeter′. Plots were sown on 17 June 1992 using a Connor Shea three point linkage ten tyne drill with 15 cm row spacings. The wheat, faba beans, subterranean clover and tall fescue were drilled to 5 cm, 5 cm, 1 cm and 1 cm depth and sown at 60 kg/ha, 150 kg/ha, 20 kg/ha and 18 kg/ha respectively. After emergence, four fixed 0.5 m^2 quadrats were randomly located in each plot. The quadrats were aligned 1m along the rows and 0.5m across the rows each containing three sown rows. The wheat, beans, clover, grass and other weeds were hand weeded from the - + - fixed quadrats on the 28th of July, 29th of September, 20th of October and 2nd of December, 6, 15, 18, 21 and 24 weeks respectively after sowing. Other weeds were hand weeded from the + + - and the + - - fixed quadrat plots on the 18th of August, 8th of September, 20th of October and 11th of November, 9, 12, 18 and 21 weeks after sowing.

Data collection and analysis

Observations were made every three weeks in the trial and an adjoining vineyard (Table 5.3). Measurements were made of soil temperature at 100 mm depth, plant height and diameter. Rampion mignonette plants were observed in both the trial and the adjoining vineyard. Records were kept of the stage of development of the grapevines. Subterranean clover was harvested on the 11th of November 1992. On the same day annual ryegrass was harvested in the tall fescue plots as tall fescue had not established. Pasture plant herbage yields were obtained by cutting one $0.10m^2$ quadrat from each $0.50m^2$ fixed quadrat, oven drying for 24 hrs at 80^o C and weighing. Bean yields were obtained by hand harvesting of all pods in the 0.50 m^2 fixed quadrats on 2 December 1992. Wheat yields were obtained by hand harvesting all grain heads in the 0.50 m^2 fixed quadrats on 22 December 1992. Data were analysed by two way analysis of variance using Excel 5.

5.1.4 RESULTS AND DISCUSSION

Table 5.2 shows the rainfall at Leasingham vineyards for the periods 1991 to 1993. The competition trial which was sown on the 17th of June 1992 was followed by above average rainfall over the period of the trial. Plate 5.1 shows a general view of the competition trial in September 1992.

Table 5.2 Monthly rainfall totals for Leasingham vineyards, Clare, South Australia for 1991 to 1993.

Month	Rainfall (mm) 1991	Rainfall (mm) 1992	Rainfall (mm) 1993
January	15	1	127
February	1	71	15
March	8	36	7
April	68	73	3
May	15	93	29
June	149	62	81
July	75	63	132
August	117	181	51
September	119	159	70
October	17	130	79
November	38	94	36
December	6	111	61
Yearly total	628	1074	691

Plate 5.1 General view of the competition trial across the sown rows, photographed 29 September 1992.

Plate 5.2 shows the fixed quadrat markers within the rows of wheat. A bare earth plot resulting from hand weeding of wheat and other weeds can be seen in the plot marked with a pink flag to the far right.

Plate 5.2 A view along a plot of wheat showing fixed quadrat markers, photographed 29 September 1992.

Table 5.3 shows that wheat, beans, subterranean clover and fescue had all established three weeks after sowing but no rampion mignonette had established in any of the crop or pasture plots. Rampion mignonette only established after 15 weeks in the fixed quadrats that had all plants physically removed (Tables 5.4 and 5.5). Table 5.3 also shows that rampion mignonette on bare ground in the vineyard took 9 weeks to develop from a 60 mm diameter plant (18 Aug 92) to a 300 mm diameter plant with capsules (20 Oct 92). Rampion mignonette on bare ground in the competition trial took only 6 weeks to develop from a 60 mm diameter plant (2 Dec 92) to a 300 mm diameter plant with capsules (13 Jan 93). This indicates that rampion mignonette grows more rapidly during warmer periods, the same period when the vine is rapidly growing. Table 5.3 further shows vine growth records from bud burst (20 Oct 92) and the rapid development of rampion mignonette for the same period indicating the potential for competition between these plants for water and nutrients.

Table 5.3 **Three weekly observations made at the competition trial and adjoining vineyard of crop, pasture, rampion mignonette and grapevine growth and development. Weeds were removed physically at observation numbers 3, 4, 5, 6, 7, 8, and 9.**

	TIME			COMPETITION TRIAL						VINEYARD	
OBS	DATE	TIME SINCE SOWN		SOIL TEMP	WHEAT HEIGHT	BEAN HEIGHT	SUB CLOVER	TALL FESCUE	Rampion mignonette	VINE GROWTH	Rampion mignonette
#		DAYS	WEEKS	100 mm °C	mm	mm	Diam mm	Height mm	Diam mm		Diam mm
1	17 June 92 (sown)	0	0								
2	8 July 92	21	3		30 mm	5 mm	5 mm	1 mm	NO SEEDLINGS		
3	28 July 92	42	6		80 mm THREE LEAF	50 mm	12 mm	35 mm	NO SEEDLINGS		30 mm
4	18 Aug 92	63	9		130 mm FOUR LEAF	150 mm	30 mm	30 mm	NO SEEDLINGS		60 mm
5	8 Sep 92	84	12	12°C 2.00 PM	140 mm FOUR LEAF	170 mm	80 mm	40 mm	NO SEEDLINGS		120 mm FLOWER
6	29 Sep 92	105	15	15°C 3.00 PM	250 mm FIVE LEAF	230 mm FLOWERING	90 mm	45 mm	FIRST FEW SEEDLINGS		230 mm FLOWERING
7	20 Oct 92	126	18	17°C 3.00 PM	400 mm BOOTING	400 mm	250 mm	150 mm	FEW SEEDLINGS	30 mm BUD BURST	300 mm CAPSULES
8	11 Nov 92	147	21	13.5°C 9.14 AM	650 mm MILKY DOUGH	580 mm (HARVEST)	(DM CUT) FLOWERING	(DM CUT) 700 mm	SEEDLINGS COUNTED	300 mm FLOWER BUD	300 mm CAPSULES
9	2 Dec 92	168	24	17°C 10.00 AM	650 mm DOUGH	580 mm	FULL FLOWER	700 mm	60 mm	320 mm FLOWER	300 mm CAPSULES BLACK SEED
10	23 Dec 92	189	27	20°C 9.50 AM	650 mm RIPE (HARVEST)	580 mm	FRUIT	700 mm	120 mm	700 mm 1 mm BERRY	400 mm CAPSULES FULL FLOWER
11	13 JAN 93	210	30	21°C 10.00 AM	650 mm DRY STUBBLE	580 mm DRY STUBBLE	YELLOW DRYING	700 mm	300 mm CAPSULES	BUNCHES 1000 mm 4 mm BERRY	400 mm CAPSULES FULL FLOWER

Smith (1997) reports that rampion mignonette extracts water from the top 300 mm of soil and that this is in direct competition to the vines in their Clare vineyards, he estimated lost grape production of about 1 t/ha . Table 5.4 shows the establishment level of rampion mignonette seedlings on the day of pasture harvest (11 November 1992). These results indicate that rampion mignonette is a poor competitor and a weed of disturbed bare ground.

Table 5.4 Mean number of rampion mignonette seedlings per m^2 at 11-11-92.

TREATMENT	Crop Wheat	Crop Bean	Pasture Clover	Pasture Grass
Crop or Pasture with rampion mignonette* and no other weeds (weeded). (+ + -)	0	0	0	0
Crop or Pasture without rampion mignonette and no other weeds (weeded). (+ - -)	0	0	0	0
Bare fallow ground with the Crop or Pasture removed, with rampion mignonette and no other weeds (weeded). (- + -)	59 a	53 ab	40 bc	36 c
Crop or Pasture with rampion mignonette * and other weeds (mainly ryegrass). (+++)	0	0	0	0

*** Rampion mignonette did not establish in these plots.**
Means followed by different letters are significantly different. l.s.d. = 17 (P=0.05).

The removal of weeds may also affect subsequent germinations although the weeded crop or pasture areas did not show increased germinations. Increased germinations on bare soil may be due to higher soil moisture and temperature levels. Light and CO_2 in the soil may also be affected by the bare surface condition.

Table 5.5 shows the establishment level of rampion mignonette seedlings on the day of the bean harvest (2 December 1992). It also shows further germination when compared to the data of 11 November 1992 (Table 5.4).

Table 5.5 Mean number of rampion mignonette seedlings per m^2 at 2-12-92.

TREATMENT	Crop Wheat	Crop Bean	Pasture Clover	Pasture Grass
Crop or Pasture with rampion mignonette* and no other weeds (weeded). (+ + -)	0	0	0	0
Crop or Pasture without rampion mignonette and no other weeds (weeded). (+ - -)	0	0	0	0
Bare fallow ground with the Crop or Pasture removed, with rampion mignonette and no other weeds (weeded). (- + -)	100 a	84 ab	64 bc	47 c
Crop or Pasture with rampion mignonette * and other weeds (mainly ryegrass). (+++)	0	0	0	0

<u>* Rampion mignonette did not establish in these plots.</u>
Means followed by different letters are significantly different. l.s.d. = 23 (P=0.05).

From Tables 5.4 and 5.5 it can be seen that a greater level of germination occurred in the two crop plots than in the two pasture plots. This is probably due to the crops being sown at 5 cm depth and the pasture at 1 cm depth but could also be due to continuing competition as further pasture plants emerged later whereas most crop plants were removed at the first weeding.

Since rampion mignonette did not establish in either + + - or + - - plots it was decided to harvest only the + - - plots and therefore only two fixed quadrats were required to be harvested. Table 5.6 shows the yields from the two quadrats harvested. There was a significant interaction between crop/pasture type and presence or absence of other weeds. Ryegrass caused a significant reduction in wheat, beans and clover and this was most pronounced in beans. Since ryegrass was not weeded from the pasture ryegrass quadrats there was no significant difference in yield.

Table 5.6 Mean yields of wheat harvest at 22 Dec 92, bean harvest at 2 Dec 92 and clover and ryegrass cuts at 11 Nov 92 in t/ha of seed and dry matter.

TREATMENT	Crop Wheat Grain	Crop Bean Grain	Pasture Clover DM	Pasture Ryegrass DM
	t/ha	t/ha	t/ha	t/ha
Crop or Pasture without rampion mignonette* or other weeds (weeded). (+ - -)	1.6c	1.8c	2.5b	2.9ab
Crop or Pasture with rampion mignonette * and other weeds (mainly ryegrass). (+++)	0.8d	0.5d	1.4c	3.0a

*** Rampion mignonette did not establish in these plots.**

Means followed by different letters are significantly different. l.s.d. = 0.5 (P=0.05).

5.1.5 CONCLUSIONS

- The results indicate that rampion mignonette is a weed which colonises bare ground.

- Rampion mignonette did not establish under growing winter annuals and so therefore is unlikely to have potential to become a major weed of broadacre crops and pastures in the South Australian Dryland Farming System.

- Rampion mignonette has the potential to compete with grapevines and reduce grape yields because it is common practice to maintain bare ground under grapevines during the late spring and summer.

5.2 EXPERIMENT 2.
EFFECT OF SEEDING DEPTH ON SEEDLING EMERGENCE

5.2.1 INTRODUCTION

Seedling emergence is affected by physical soil conditions such as texture and structure as well as environmental factors such as moisture status, temperature and soil gases. Seed attributes that affect emergence include its genetic constitution and dormancy factors. Seed dormancy in weeds is expected to be high as dormancy has in the main been overcome by breeding in commercial crops to allow for even and strong plant establishment (Maguire 1984). These experiments were conducted to determine the effect of seed depth on seedling emergence in rampion mignonette.

5.2.2 MATERIALS AND METHODS

A preliminary experiment was set up on 10 September 1992 to ascertain the bounds of the main experiment which was started on 17 December 1992.

5.2.2.1 Soil used in the experiment

Soil used in these experiments was collected from Clare where the weed had established itself. The soil was taken from 20 to 100 mm below the surface in an area where rampion mignonette was not present but was representative of the type of soil where the weed had colonised. The soil was sterilized at 85^{o} C for 2 hours to kill weed seeds contained within it.

5.2.2.2 Trial design, treatments, data collection and analysis

The experiments were conducted in a glasshouse within pots of 100mm diameter. Soil was screened through a 2mm sieve before adding to the pots. Seed collected on the 19th of December 1991 was tested for germination and 50 unscarified seeds were placed at each specified depth. The trial was replicated 5 times. Pots were evenly watered as required. A thermograph was used to measure air temperature.

Preliminary experiment

Seeds were sown on 10 September 1992 at 5, 10 and 30mm depths. A further 5 pots were not sown to verify that no endemic seeds existed. Seedlings were counted on the 7th, 14th, 21st and 28th days after sowing.

Emergence depth experiment. Seeds were sown on 17 December 1992 at 5, 10, 30, 45, 60, 70, 85 and 100mm depths. A further 5 pots were not sown. Seedlings were counted once 21 days after sowing. Data were analysed by two way analysis of variance using Excel 5.

5.2.3 RESULTS AND DISCUSSION

Germination tests found seed to be 25% germinable and 75% ungerminable. After scarification the sample was found to contain 12% hard seed. Mean daily air temperatures varied between 18° C and 24° C.

Table 5.7 shows that 21 days is sufficient time to record emergence % and that depths of greater than 30 mm were required to give a more comprehensive set of data. It was decided that the sowing depths of the main experiment would be 5, 10, 30, 45, 60, 70, 85, and 100mm and that emergence counts would be made 21 days after sowing as emergence levels had stabilised after 21 days.

Table 5.7 Mean emergence (%) of unscarified (25% germinable) seed sown at three depths on 10 September 1992.

Sowing Depth (mm)	Time (days)			
	7 17/9/92	14 24/9/92	21 1/10/92	28 8/10/92
5	0.4	14.4	16.0	16.4
10	0.0	8.4	10.0	10.8
30	0.0	5.0	9.6	10.0

Table 5.8 shows that emergence decreased significantly with burial depth. Only seed buried 70 mm or less produced emergent seedlings.

Table 5.8 Mean emergence (%) of unscarified rampion mignonette seed (25% germinable) seed sown at a range of depths on 17 December 1992.

Sowing Depth (mm)	Time (days)
	21
5	18.4 % a
10	12.8 % b
30	8.4 % c
45	1.2 % d
60	0.4 % d
70	0.4 % d
85	0.0 % d
100	0.0 % d

Means followed by different letters are significantly different. l.s.d. = 4.0 (P=0.05)

Depth effects may be due to sieved soil, gas tension or soil density. Field emergence may well be different.

5.2.4 CONCLUSIONS

- Rampion mignonette seedlings are able to emerge quite readily from depths of up to 30 mm.
- Rampion mignonette seed was found to be 25% germinable and 75% ungerminable.
- The seed was found to contain 12% hard seed.

5.3 DEMONSTRATION 1.

PRELIMINARY INVESTIGATION INTO THE EFFECTS OF HERBICIDES

5.3.1 INTRODUCTION

After formal identification of rampion mignonette by Kew Gardens, London suggestions were made to Peter Barry of Jim Barry Wines as to how to control it with herbicides; suggestions included Goal ®, Roundup ®, Sprayseed ®, and Weedazole ® (Scholefield 1989). In 1991 a herbicide plot demonstration was set up by Mr Ian Smith and Mr Brenton Baker of Leasingham Wines to assess the effectiveness of 15 herbicides. The demonstration was in an area of weed on the eastern edge of vine block 257 in the Clare East Vineyards.

5.3.2 MATERIALS AND METHODS

The herbicide product and rates used are listed in Table 5.1. Herbicide was applied to mature and emerging seedlings on 28 August 1991 to 1 m^2 plots. Measurements of effectiveness were made on 3 October 1991.

Table 5.1 Herbicide products, active constituent and rate sprayed on 28 August 1991.

	Registered Product	Active Constituent	Rate per ha
1	Roundup CT 45%	Glyphosate	1 L
2	Roundup CT 45%	Glyphosate	3 L
3	Sprayseed	Paraquat and Diquat	3 L
4	Amitrole	Amitrole	4.5 L
5	Basta 20%	Glufosinate Ammonium	5 L
6	Simazine 50%	Simazine	1.2 L
7	Simazine 50%	Simazine	3.5 L
8	Goal 24%	Oxyfluorfen	2 L
9	Surflan 50%	Oryzalin	6 L
10	Diuron 50%	Diuron	1 L
11	Solicam 80%	Norflurazon	4 Kg
12	Devrinol 50%	Napropamide	6 Kg
13	Dacthal 75%	Chlorthal Dimethyl	8 Kg
14	Ronstar 40%	Oxadiazon	8 L
15	Stomp 33%	Pendimethalin	6 L

5.3.3 RESULTS AND DISCUSSION

Table 5.2 shows that Glyphosate , Glufosinate Ammonium, Oxyfluorfen, Oryzalin, Napropamide and Oxadiazon were all effective in controlling rampion mignonette at the rates shown. It was observed that Glyphosate kills rampion mignonette completely and no regrowth occurred.

Table 5.2 Herbicide products, active constituent and rate. Efficacy at 3 October 1991.

	Registered Product	Active Constituent	Rate per ha	Score 0= No Kill 9= Complete Kill
1	Roundup CT 45%	Glyphosate	1 L	7
2	Roundup CT 45%	Glyphosate	3 L	9
3	Sprayseed	Paraquat and Diquat	3 L	0
4	Amitrole	Amitrole	4.5 L	4
5	Basta 20%	Glufosinate Ammonium	5 L	9
6	Simazine 50%	Simazine	1.2 L	3
7	Simazine 50%	Simazine	3.5 L	0
8	Goal 24%	Oxyfluorfen	2 L	7
9	Surflan 50%	Oryzalin	6 L	9
10	Diuron 50%	Diuron	1 L	2
11	Solicam 80%	Norflurazon	4 Kg	0
12	Devrinol 50%	Napropamide	6 Kg	7
13	Dacthal 75%	Chlorthal Dimethyl	8 Kg	2
14	Ronstar 40%	Oxadiazon	8 L	9
15	Stomp 33%	Pendimethalin	6 L	2

Smith (1992) commented that prior to the establishment of rampion mignonette in their vineyards at Clare that one spray of Roundup ® at 3L/ha in June was sufficient to control vineyard weeds. However with rampion mignonette present an extra spray of Roundup ® was required in August and two sprays of Basta ® in February and November. These extra sprays added to the overall grape production costs.

Goal ® 24% at 2L/ha with an efficacy of 7 is shown to be effective. Martí (1994) showed interest in a combination of the active ingredient (Oxyfluorfen) with simazine (Oxyfluorfen is the active ingredient of Goal ®). Martí (1994) further reports that rampion mignonette is resistant to Diuron and is controlled well with

Simazina (Simazine) and that interesting chemical products would be MCPA amine salt plus simazine, glyphosate plus simazine and oxifluorphen plus simazine. Hidalgo (1994) dispatched information from Villarias (1981), which showed that of the 89 herbicides listed rampion mignonette was sensitive to 23 and resistant or tolerant to 22 and no information was available on 44 herbicides. From this work simazine was not indicated to be effective in the control of rampion mignonette

Plate 5.3 shows the effect of Sprayseed ® at 3L per hectare on rampion mignonette plants with an efficacy of 0 (Table 5.2) it was shown to be ineffective.

Plate 5.3 The effect of Sprayseed ® at 3 L per ha. on rampion mignonette plants, 5 weeks after herbicide application on 28 August 1991, photographed 3 October 1991.

Plate 5.4 shows the effect of Surflan ® at 6 L per hectare on rampion mignonette. Surflan acted as an effective pre emergent by not allowing germinating seedlings to survive. Plate 5.5 shows the dead rampion mignonette plants after spraying with Roundup CT 45% ® at 3 L per hectare.

Plate 5.4 **The effect of Surflan ® at 6 L per ha. on rampion mignonette plants, 5 weeks after herbicide application on 28 August 1991, photographed 3 October 1991.**

Plate 5.5 **The effect of Roundup CT ® at 3 L per ha. on rampion mignonette plants, 5 weeks after herbicide application on 28 August 1991, photographed 3 October 1991.**

Table 5.3 shows the cost per hectare of the most effective herbicides. The cost of Smith's practice was $10 per hectare before the invasion of rampion mignonette. The extra cost of Roundup ® and Basta ® 20% increased the weed control cost to $70 per hectare after the invasion of rampion mignonette [costs are based on 0.3 of broadacre prices as only 1/3 of the area is sprayed in vineyards (Baker 1997)].

Table 5.3 Herbicide products, active constituent, rate and cost of product per hectare for the most effective herbicides on rampion mignonette. Based on 1997 costs.

Registered Product	Active Constituent	Rate per ha	Cost at vineyard rate per ha (*)
Roundup CT 45%	Glyphosate	3 L	$10
Basta 20%	Glufosinate Ammonium	5 L	$27
Goal 24%	Oxyfluorfen	2 L	$23
Surflan 50%	Oryzalin	6 L	$53
Devrinol 50%	Napropamide	6 Kg	$67
Ronstar 40%	Oxadiazon	8 L	$20

(*) Based on vineyard spraying costs of 1/3 of broadacre costs.

From these results and discussions with local vignerons it was decided that the following herbicidal management practice may have potential in the control of the weed; a late autumn to winter application of Roundup ® to act as a plant knockdown and a later application and incorporation of Surflan ® into the soil in late winter as this should give residual control of germinating seedlings for 6 months. Both these herbicides have a low user and environmental risk factor. However less expensive pre-emergent alternatives to Surflan ® at 6 L per hectare ($53 per hectare (*)) are Goal ® at 2 L per hectare ($23 per hectare (*)) and Ronstar ® at 8 L per hectare ($20 per hectare (*)).

(*) Based on vineyard spraying costs of 1/3 of broadacre costs.

5.3.4 CONCLUSIONS

- Glyphosate, Glufosinate Ammonium, Oxyfluorfen, Oryzalin, Napropamide and Oxadiazon were all effective in controlling rampion mignonette.

- Effective pre-emergent herbicides for the control of rampion mignonette in vineyards were Surflan ®, Goal 24% ®, Devrinol 50% ® and Ronstar 40% ®.

- Effective post-emergent herbicides for the control of rampion mignonette in vineyards were Roundup CT ® and Basta 20% ®.

CHAPTER 6

6 GENERAL DISCUSSION, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

6.1 GENERAL DISCUSSION

6.1.1 INTRODUCTION

Rampion mignonette is one of many new weeds entering Australia each year. Zimdahl (1993) outlines the migration of weeds as people have travelled around the world and highlights that the majority of naturalised weeds in Australia have originated from Europe rather than from Asia due to the greater level of travel from Europe in the past. Since rampion mignonette originates in Europe this study has fostered international links with scientists in Europe, from where most of the literature relating to rampion mignonette emanates. This study has surveyed its abundance and distribution at Clare in South Australia from 1991 to 1997, evaluated its competitive effect with crops and pastures and studied its biological and ecological characteristics. The knowledge gained will provide the basis for its integrated control and management.

6.1.2 MORPHOLOGY AND REPRODUCTION

Abdallah and De Wit (1978) reported that the leaves were large and herbaceous on fertile soils and this was found to be the case for plants observed at Clare in fertile irrigated vineyards and was particularly evident in plants growing in a newly established vineyard in May 1997. Rampion mignonette is a prolific seed producer as demonstrated by its ability to produce approximately 45,000 seeds per m^2. Actively growing plants on the bare soil under vines compete with vines for water thereby reducing grape yields (Barry 1993).

6.1.3 ENVIRONMENTAL FACTORS

Rampion mignonette is best suited to the range of environmental factors that suit the growth of grapevines. In chapter 2 the South Australian agricultural environment is outlined and in chapter 4 characteristics of the climate and soils of the Clare site detail the suitable environment in that area for the growth of rampion mignonette. Carter's (1993) climate match shows the potential range for its growth in Australia and New Zealand.

6.1.4 GERMINATION AND ESTABLISHMENT

Germination and emergence patterns of rampion mignonette in the field are closely aligned to soil moisture availability and the soil temperature. The first few seedlings were observed in the bare fixed quadrats of the September 1992 competition trial when the soil temperature at 100 mm was greater than 15^{o} C. Variations in moisture and temperature possibly explain the variable germination pattern in rampion mignonette, with the first autumn rains occurring when soil temperatures are greater than 15^{o} C. In September when soil temperatures reach 15^{o} C there is another flush of germination in the moist soil. Emergence is sporadic as observed at Clare where one batch of seedlings emerged in May and others during summer following rainfall.

6.1.5 PLANT GROWTH AND DEVELOPMENT

Vegetative growth of rampion mignonette at Clare occurred mainly in March to May and Sept to December. This result compares with the study of Garcia-Torres (1994) who reported that in southern Spain it was in its vegetative stage in January and February. This is in mid to late winter and differs from observations at Clare where its vegetative stage was mainly in spring and autumn. Rampion mignonette flowered at Clare during April to May and November to December. In comparison Garcia-Torres (1994) reported that in southern Spain rampion mignonette is flowering and fruiting in April or May which is equivalent to October and November in the southern hemisphere. Plate 6.1 shows the outcome of removing a competitive plant species, in this case subterranean clover, leaving bare ground for the establishment of rampion mignonette. This competitive control method was carried out successfully on the property of Jim Barry Wines when a vineyard was undersown with subterranean clover in winter to act as a cover crop which would fix nitrogen and also out compete rampion mignonette.

Plate 6.1 Cover crop of subterranean clover showing where subterranean clover plants were removed allowing rampion mignonette to establish, photographed 29 September 1993.

6.1.6 RESPONSE TO HUMAN MANIPULATION

After cultivation, in 1991 and 1997 rampion mignonette was seen to establish and thrive in newly established vineyards at Clare. Cade (1985) reported that stock would not eat rampion mignonette plants at Nagambie. However rampion mignonette was eaten by sheep and horses as observed in pastures at Clare. These disturbances linked with human movement are the most likely causes of spread.

6.1.7 COLONISATION

Baker (1974) listed 12 characteristics of the ideal weed. Rampion mignonette was found to exhibit at least three of the characteristics, which were; discontinuous germination (internally controlled), continuous seed production for as long as growing conditions permit and very high seed output in favourable environmental circumstances.

The survey indicated that migration and increase in abundance are likely to be slow. This is not unknown as it has been widely reported that up to 50 years may pass between the time a species becomes established and the time a weed becomes abundant and widely noticed (Scott 1997, Dodd 1996, Hobbs 1991 and Heap *et al.* 1987). Scott (1997) reports that many of our future weeds are established but have not yet become abundant and that control could be more effective during the stage of low abundance. He further points out that the spread of a weed will occur more rapidly from many small populations than from one large population spreading at the margins. Rampion mignonette would be regarded as one population which further supports the view of slow migration. This typical expansion rate of a colonising weed highlights the need to control the weed in the early stages of colonisation before the rapid multiplying phase commences. Rampion mignonette was observed to colonise only the disturbed soil in the vineyard and disturbed areas by roadsides and in the field where animals had grazed. No mignonette was observed in a systematic search in adjoining ungrazed and undisturbed native woodland. The anticipated slow migration of rampion mignonette suggests that an eradication programme may still be successful.

6.1.8 NON BIOLOGICAL CONTROL MEASURES

Non biological control measures in vineyards could consist of a cultivation in early March to kill any existing plants and to promote germination for post-emergent spraying with Basta ® at 5 L per hectare ($27 per hectare (at 1/3 broadacre cost)) in mid April. A cover crop of subterranean clover sown in early May. Pre-emergent spraying with Goal ® at 2 L per hectare ($23 per hectare (at 1/3 broadacre cost)) or Ronstar ® at 8 L per hectare ($20 per hectare (at 1/3 broadacre cost)) in August to control spring germinations. Roundup 45% ® at 3 L per hectare ($10 per hectare (at 1/3 broadacre cost)) sprayed in October to control any spring germinations. From early November the subterranean clover cover crop is turned in to incorporate the organic matter, kill any rampion mignonette seedlings and reduce water consumption. If a cover crop was not grown then Roundup 45% ® at 3 L per hectare ($10 per hectare (at 1/3 broadacre cost)) should be applied to kill any rampion mignonette plants. If required a further spray of Roundup 45% ® at 3 L per hectare ($10 per hectare (at 1/3 broadacre cost)) can be applied in December.

The herbicides found to be effective in this study will need to be monitored over time as to the development of resistance in rampion mignonette plants.

6.1.9 BIOLOGICAL CONTROL MEASURES

The possibility of organisms (plant diseases and insects) present in Australia which would specifically attack rampion mignonette is perhaps fairly remote - had any such organisms been present when the potential weed was introduced, control may have been achieved. It is interesting to note that not all introduced plants which develop weediness in Australia are important weeds in the country of origin. This suggests that there could be biological influences within that country which control the plant in its native habitat. Such biological influences may be absent in Australia. Because biocontrol agents are more likely to be found within the country of origin of the weed, research work into the detection of suitable control organisms is generally concentrated in those areas. Preliminary investigatory work into biological control agents which would minimise the growth and development of rampion mignonette would be beneficial before the weed spreads to other vineyards in Australia. It would be appropriate to conduct this work at the C.S.I.R.O. biological station Montpellier, France.

6.1.10 INTEGRATED WEED MANAGEMENT

Martí (1994) reports that it is important to control rampion mignonette in winter in Spain (May to June in Australia) when it is at the flowering and fruiting growth stages. Carter (1992) reports (Westbrooks 1991 and Zamora *et al.* 1989) that early eradication of a weed will prevent it becoming a widespread problem and that later eradication may be too expensive or impractical. The fact that AQIS did not grant funds of AUD $148,000 for Carter's proposal for eradication in 1991 may well see the weed become a major problem in the future. Chemical control has the greatest potential for controlling the plant at present as this technique allows for control of mature plants as well as control of regenerating plants arising from the seed bank. The use of residual herbicides would be the most effective. A constraint to effective control in the Clare outbreak is the variable level of vineyard management. Conradi (1992) reported that it was hard to assess vignerons' time taken to control rampion mignonette and that some vineyard managers spent more time and effort in trying to eradicate the plant than others. Kemp (1996) said that the key to the development of effective Integrated Weed Management (IWM) systems was in an understanding of the ecology and population dynamics of target weeds and the development of population dynamic models will be critical for successful IWM systems.

It is known from the work at Clare that rampion mignonette is a prolific seeder (in the order of 45,000 seeds per m^2). Seed in capsules is at a maximum on mature plants in May or December. Germinations occur in September as the soil temperature increases to 15°C and adequate moisture is available and in April as the soil temperature is approximately 15°C and the opening rains supply adequate moisture. The life cycle of rampion mignonette is approximately 9 months from germination to senescence. No biological control measures are available in Australia at present however the root weevil *Baris morio*, which feeds on rampion mignonette in Spain, may be useful. Control by integrated weed management could include cultivation, competition with other plants and the use of herbicides. Cultivation is used to kill growing plants and to promote seed bank germination prior to control with herbicides. Cover crops can be sown to reduce the establishment of rampion mignonette as it has been shown not to establish when other plants are establishing or growing. Both pre and post-emergent herbicides are successful in the control of rampion mignonette. Knowledge gained on the biology and ecology of the plant in this study may result in more efficient timing of application of herbicides. Overall, it would appear that a combination of control measures including strategic use of herbicides, tillage and establishment of crops and pastures, as cover crops, would be the best current approach to reducing the weed's occurrence. In addition, all machinery leaving affected sites should be thoroughly cleaned before moving on to sites where rampion mignonette does not occur.

6.1.11 LEGISLATION

The knowledge gained from this study suggests that no major changes are required to the original South Australian Animal and Plant Control Commission's coordinated control program and policy document of 1991. It is indicated however that the objectives of the programme be stepped up particularly the eradication clauses.

6.1.12 POTENTIAL AS A WEED IN SOUTH AUSTRALIA AND AUSTRALIA

Carter (1993) has shown the potential range for the growth of rampion mignonette as being south western Western Australia, southern South Australia, New South Wales, Victoria, Tasmania and New Zealand. This study indicated that it is unlikely to become a weed of broadacre crops and pastures but may well be a threat to viticulture and horticulture.

The outbreak of rampion mignonette at Clare is now well established and slowly spreading however Newnham (1997) reported that the outbreak at Nagambie died out in the early 1980's. Nagambie is in the Central Goulburn Valley wine region. The soils are podsolic derived from sedimentary rock and at Nagambie are sandy clay loams with a pH of 6.5. Table 6.1 shows the annual rainfall of Nagambie to be 603 mm which is 56 mm less than Clare and the similarity between the temperatures.

Table 6.1 Comparison of precipitation and temperatures at Clare, South Australia and Nagambie, Victoria.

	Clare	Nagambie
Annual rainfall (mm)	659	603
Mean number of rain days per annum	111	126
Mean Monthly Max Temp (^oC)	21.4	19
Mean Monthly Min Temp (^oC)	8.4	8.1
Mean Monthly Temp (^oC)	14.9	13.6
Frost free period (days)	111	126

The environmental factors all seem to suit rampion mignonette other than the lower pH. The farmer on whose property the incursion occurred vigilantly removed and burnt all plants. The Nagambie outbreak occurred in pasture and crop farming systems and it would be expected that herbicides used regularly in this system are likely to have been the main reason for the eradication of the incursion in the longer term.

6.2 CONCLUSION

The research indicated that rampion mignonette is unlikely to cause major losses to broadacre agriculture but is likely to increase costs and cause losses of production in viticulture.

6.3 SUGGESTIONS FOR FURTHER WORK

1. Continued contact with scientists in Spain and France including investigation of biological control agents such as the root weevil *Baris morio* which is known to feed on rampion mignonette in Spain.

2. Production of a Fact Sheet to enable local identification and knowledge of the characteristics of the plant's growth patterns and potential as a weed species.

3. Further survey of marked vineyard blocks at 5 year intervals to determine the effect of control measures.

4. Determine a weed risk assessment score by the method of Pheloung (1995) for rampion mignonette.

5. Further experiments into seed bank levels, seed dormancy mechanisms, the inability of rampion mignonette to establish with other plants and the viability of seeds after transmission through the intestinal tract of farm animals.

6. Comprehensive herbicide trials including assessment of possible herbicide resistance.

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APPENDICES

APPENDIX 1.

Findings from this research were published in the proceedings of two National Conferences of the Australian Society of Agronomy and in the Australian Journal of the Grape and Wine Industry.

RAMPION MIGNONETTE, A MEDITERRANEAN WEED NEW TO AUSTRALIA

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[1] Department of Agricultural Technology, The University of Adelaide, Roseworthy, SA 5371
[2] Animal and Plant Control Commission, Adelaide SA 5000
Proceedings of the 6th Australian Agronomy Conference, Armidale, New South Wales, 1992.

RAMPION MIGNONETTE - CURRENT RESEARCH INTO A NEW WEED

R. S. St John-Sweeting [1], R.J. Carter [2], E.D. Carter [1] and H.A. Reimers [1]
[1] Department of Agricultural Technology, The University of Adelaide, Roseworthy, SA 5371
[2] Animal and Plant Control Commission, Adelaide SA 5000
Proceedings of the 7th Australian Agronomy Conference, Adelaide, South Australia, 1993.

RAMPION MIGNONETTE SPREADING IN THE CLARE VALLEY

R. S. St John-Sweeting.

Article published in the Australian Grapegrower and Winemaker
Journal of the Grape and Wine Industry, June 1994.

APPENDIX 2.

Abdallah, M.S. and De Wit, H.C.D. (1978). The *Resedaceae* - A taxonomical revision of the family (final instalment). *Mededelingen Landbouwhogeschool Wageningen*, **14**: 99-416.

Drawings showing both subspecies ssp. *phyteuma* and ssp. *collina*.

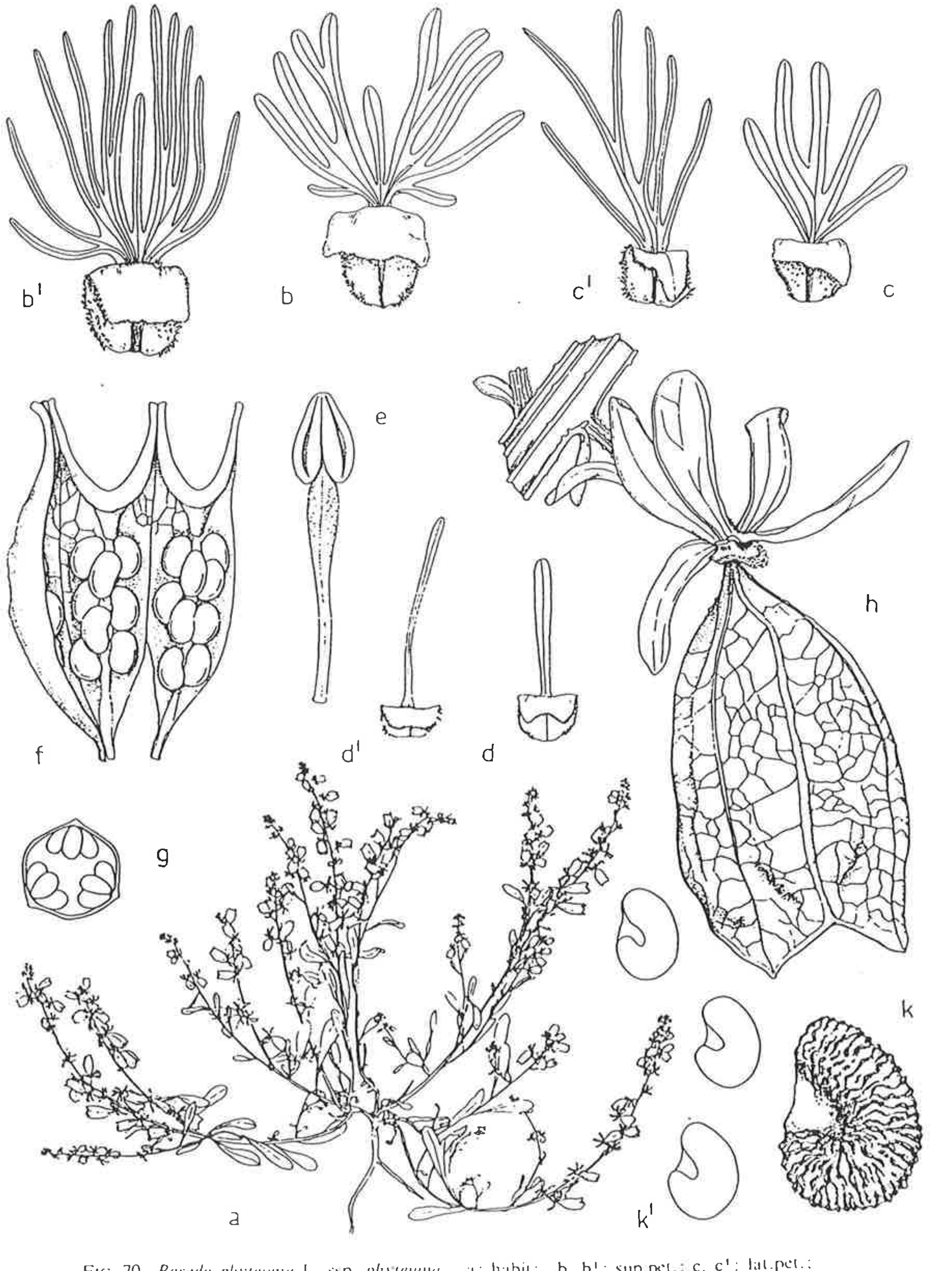

FIG. 70. *Reseda phyteuma* L. ssp. *phyteuma*. — a: habit; b, b': sup.pet.; c, c': lat.pet.; d, d': ant.pet.; e: stamen; f: ovary (opened); g: same, c.-s.; h: capsule; k: seed; k': seeds, shape. — a: $^{1}/_{4}$ ×; b–d, b'–d': 10 ×; e–g, k: 15 ×; h: 5 ×; k': $7^{1}/_{2}$ ×. — a, h, k, k': E. Korb s.n., 19.VI.1907 (W à 1952-2689); b–g: J. P. Fray 24 (W à 1892–10518); b'–d': Faure s.n., 13.V.1909 (DR).

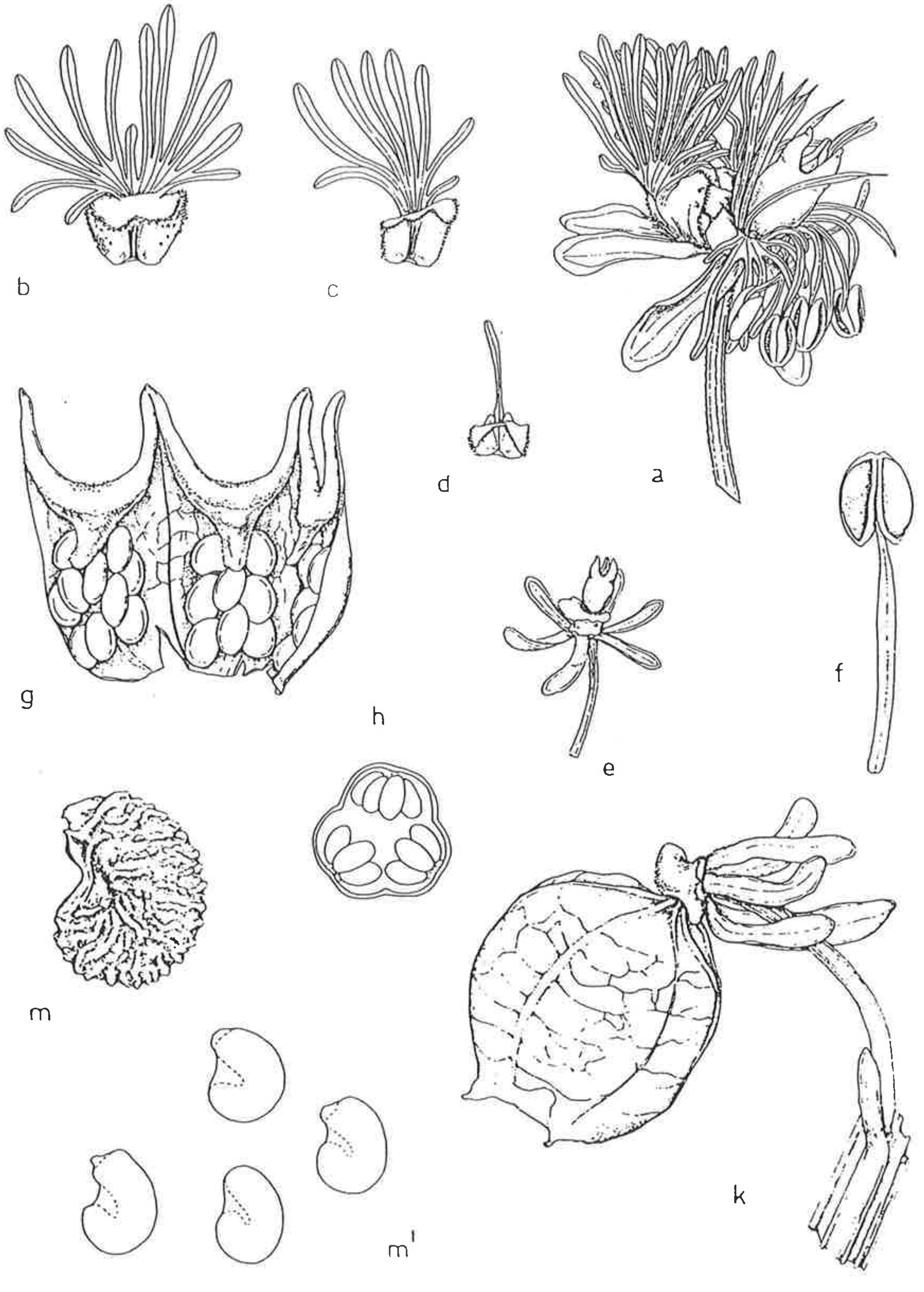

FIG. 71. *Reseda phyteuma* L. ssp. *collina* (J. Gay) Dur. et Schinz – a: fl.; b: sup.pet.; c: lat.pet.; d: ant.pet.; e: fl.-disc; f: stamen; g: ovary (opened); h: same, c.-s.; k: capsule; m: seed; m¹: seeds, shape. – a–d: 10 ×; e, k: 5 ×; f, m: 15 ×; g, h: 20 ×; m¹: 7½ ×. – All. B. Balansa 202 (W à 1889-99380).

APPENDIX 3.

Copy of the letter from K.L. Wilson of the Royal Botanic Gardens, Kew, London informing Dr. H. R. Toelken of the determined classification of Specimen 21 as *Reseda Phyteuma* L.

Royal Botanic Gardens
Kew Richmond Surrey TW9 3AB

Telegrams Kewgar Richmond Surrey Telephone 01-940 1171

Your reference

Our reference

Date

1 September 1989

Dr H.R. Toelken
State Herbarium
Botanic Gardens
North Terrace
ADELAIDE, SA 5000
AUSTRALIA

Dear Helmut

The specimen Heap 21 that you sent me (and thank you on behalf of Kew for it) is Reseda phyteuma L. as you had thought.

It tallies with the description and illustrations in the second part of the revision by Abdallah, published in Belmontia n.s. vol. 8 (1978), and matches material from southern Europe in the herbarium. The petal and capsule shapes, the seed surface, the anther filaments enlarged above, and the occasionally somewhat lobed leaves seem to be a good set of characteristics for recognising this taxon. Fig. 308 in Hegi is misleading, to say the least. If one bypasses the placental character in Abdallah's key, the specimen keys out to R. phyteuma. In Abdallah's key to infraspecific taxa, your specimen keys to subsp. phyteuma var. phyteuma: a taxon that is said to be found over the whole range of the species.

I have found no common name nor any record of it being an aggressive weed, but the European weed literature in this library is probably not complete. Abdallah's comments (pp. 29 & 307) suggest that it is a widespread weed in disturbed places (such as roadsides and abandoned vineyards) but "most Reseda species may occur as weeds but are never aggressive or noxious".

I hope that this answers your enquiry adequately. My apologies for the delay in replying: I was travelling during most of July and then again last week to Leiden, and the Kew staff member who offered to check Reseda for me unfortunately could not find time to do it.

With best wishes

K.L. Wilson
Aust. Bot. Liaison Officer

APPENDIX 4.

Photocopy of Specimen 21 lodged in the Royal Botanic Gardens Herbarium Kew, London.

HERB. HORT. KEW.

Reseda phyteuma L.
ssp. phyteuma

DET. ... 1·ix· 19 89

EX STATE HERBARIUM OF SOUTH AUSTRALIA
ADELAIDE (AD)

Reseda phyteuma L.

South Australia. Region 8:Northern Lofty.

2km W of Clare, in vineyard (Jim Barry Wines)
(Clare is at 33°50'S, 138°37'E)

Dense infestation, several hectares.
Cultivated, disturbed and pasture land in and adjacent to vines. Present since ca 1985. Area sometimes visited by international tourists.
Sprawling; erect flower stems. Rosette leaves entire, divided in most flower stems.Flowers ca 6mm diam.,petals cream to yellow.Capsules green, to 15mm long.

John W. Heap 21 29.vi.1989

APPENDIX 5.

Detail of the number of main stems, secondary stems and capsules on one plant observed on 16 October 1996.

Number of main stems, secondary stems and capsules on one plant observed on 16 October 1996.
Number of seeds is estimated by multiplying capsule number by the 21 seeds per capsule.
621 x 21 = 13041 seeds.

STEM NUMBER MAIN STEM(A) SUB STEMS (B)&(C)	MAIN STEM LENGTH (cm)	CAPSULE SITES NUMBER	
1A	33	33	
1B		4	
1C		4	
2A	33	34	
2B		4	
3A	32	32	
3B		17	
4A	30	38	
4B		14	
4C		12	
5A	30	37	
6A	25	41	
6B		15	
6C		4	
7A	24	20	
7B		12	
7C		4	
8A	23	29	
8B		14	
8C		10	
9A	23	30	
9B		10	
10A	22	15	
10B		10	
10C		12	
11A	22	20	
11B		2	
12A	20	20	
13A	18	23	
14A	18	19	
15A	18	15	
16A	17	25	
17A	15	15	
18A	12	12	
19A	10	10	
20A	10	5	
21A	6	7	
	DISC RD111A	CAPSULE1.XLS	

APPENDIX 6.

Field worksheet for recording presence of rampion mignonette.

Date..............................Observer..

TIME														
BLOCK														
NAIL #														
# of +ve counts over Total # of counts														
Frequency %														
1														
2														
3														
4														
5														
6														
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