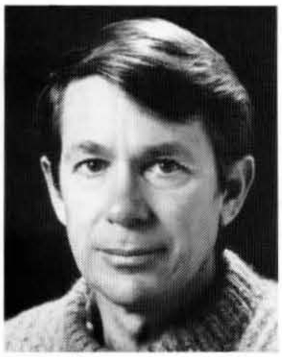
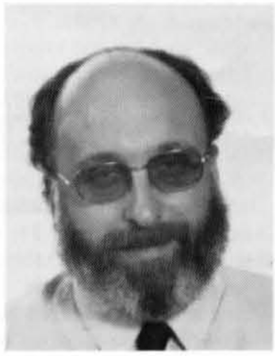
REVIEWS

The Biology of Australian Weeds 17. *Reseda lutea* L.

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Name

Reseda lutea L. (Resedaceae)
Standard common name:
Cutleaf mignonette

Reseda is believed to have been named by Pliny, who stated that 'near Ariminum a herb is known which is called Reseda; it calms diseases, and all inflammations' (Abdallah and De Wit 1978). *'Reseda'* therefore may be derived from the Latin 'sedere', to becalm, to calm or recede. The species name, *lutea*, almost certainly refers to the yellow colour of the flowers.

The common name, 'mignonette', is derived from the French 'mignon', which means small and delicately formed, perhaps a reference to the flowers. 'Cutleaf mignonette', refers to the pinnatifid leaves which develop after the initial growth of entire rosette leaves. The common name 'wild mignonette' *(R. luteola)* has been misapplied to *R. lutea* and has caused confusion between the two species.

Description

Perennial herb, sprawling to erect, 20–80 cm high, with basal rosette; glabrous or scabrous-papillose (Figure 1). Leaves often with 1–2 glands near base; basal leaves usually entire, ± petiolate; cauline leaves pinnatifid, with 3–7 mucronate lobes 2–6 cm long and 1–7 mm wide. Raceme up to 40 cm long; bracts narrowly lanceolate, 2–5 mm long, caducous; pedicels mostly 2–6 mm long. Sepals 6, linear, 1.5–4 mm long. Petals 5, deeply 2–3-lobed, the lobes narrowly linear or broadly falcate; claws with obovate ciliate appendages. Disc 1.5–2 mm wide, pilose. Stamens 14–18; anthers 1–1.5 mm long; filaments 2 mm long, falling off after flowering. Ovary densely papillose, with 3 prominent teeth. Capsule 8–13 mm long, 4–6 mm wide, contracted below apex; ribs papillose. Seeds smooth, brown, shiny (Pearce 1982).

The determination of *Reseda* species is difficult and complete specimens with mature seeds are needed to show the diagnostic taxonomic characters (Abdallah 1967). The morphology of species which occur in Australia *(R. alba, R. lutea, R. luteola* and *R. odorata)* has been compared with that of overseas material and the degree of variation found to be similar (Pearce 1982).

Considerable intra-specific variation is recorded in *R. lutea.* Clapham *et al.* (1962) noted variation in leaf shape and the roughness of stems and capsules. Two subspecies of *R. lutea* have been recognized—*R. lutea* L. ssp. *lutea*, and *R. lutea* L. ssp. *neglecta* (Muell.) Arg. (Abdallah and De Wit 1978). Detailed taxonomic studies are needed in Australia to determine which subspecies are present.

Cytological data on the Resedaceae is very limited. The chromosome number of *R. lutea* is $2n = 48$ (Eigsti 1936). Eigsti noted that cytological similarities seen in the Resedaceae and Brassicaceae confirm taxonomic, morphological and phylogenetic connections made in the nineteenth century.

Distribution

R. lutea is indigenous to the Mediterranean Basin and Asia Minor, occurring in Algeria, Egypt, France, Greece, Iran, Iraq, Israel, Italy, Jordan, Lebanon, Libya, Morocco, Spain, Syria, Turkey and Yugoslavia. It has spread widely around the world and has been recorded in Australia, Austria, Belgium, Czechoslovakia, Denmark, Finland, Germany, Great Britain, Hungary, Norway, Romania, Sweden, Switzerland, U.S.A. and U.S.S.R. (Abdallah and De Wit 1978).

Although *R. lutea* is present in Queensland, New South Wales, Victoria and Tasmania (Figure 2), it has not become an important weed there. There is only a single record from Western Australia (Dalwallinu) (Pearce 1982).

R. lutea is found only rarely on the Tasmanian mainland, but is more common on Flinders Island (B. Hyde-Wyatt, pers. comm.).

In South Australia, *R. lutea* is a serious pest plant which occurs, as either sporadic outbreaks or areas of dense infestations, over most of the agricultural areas such as the lower North, Yorke Peninsula and parts of the Eyre Peninsula. It is a weed which is spreading to new parts within South Australia (Figure 3).

Annual rainfall does not appear to control its distribution in the agricultural areas, as it is already established in areas of 225 mm (Northern Murray Mallee) and 625 mm (Robe) (Heap, unpublished data). *R. lutea* grows well on a variety of soils in South Australia, ranging from very light alkaline sandy Mallee soils to red-brown clay loams. The potential for its spread into the pastoral zone is not known, but Moghaddam (1977) reported that in Iran *R. lutea* grows in areas with an annual rainfall as low as 100 mm. The successful invasion of *R. lutea* into the pastoral zone of South Australia would probably depend on seed transport to the area, soil disturbance prior to seedling establishment and the adequacy of the rainfall distribution. Invasion might occur initially around stock troughs and tracks, dams and water courses.

Habitat

R. lutea occurs widely throughout the temperate zones of the world, especially as a weed escaping from cultivated areas and although there seems to be a tendency for it to thrive on calcareous soils it may also occur in non-calcareous soils (Abdallah and De Wit 1978).

In Great Britain *R. lutea* is reported to occur in waste places, disturbed ground, arable land areas cleared of scrub and old rabbit warrens, especially on calcareous substrate (Clapham *et al.* 1962; Grubb 1976). Grubb (1976) also noted that its natural habitats in its areas of origin are large natural clearings such as those created by treefalls, which are spatially and temporally sporadic in occurrence.

In central Europe *R. lutea* prefers stony, porous, easily warmed soils with sparse vegetation. It occurs on quarries, railway

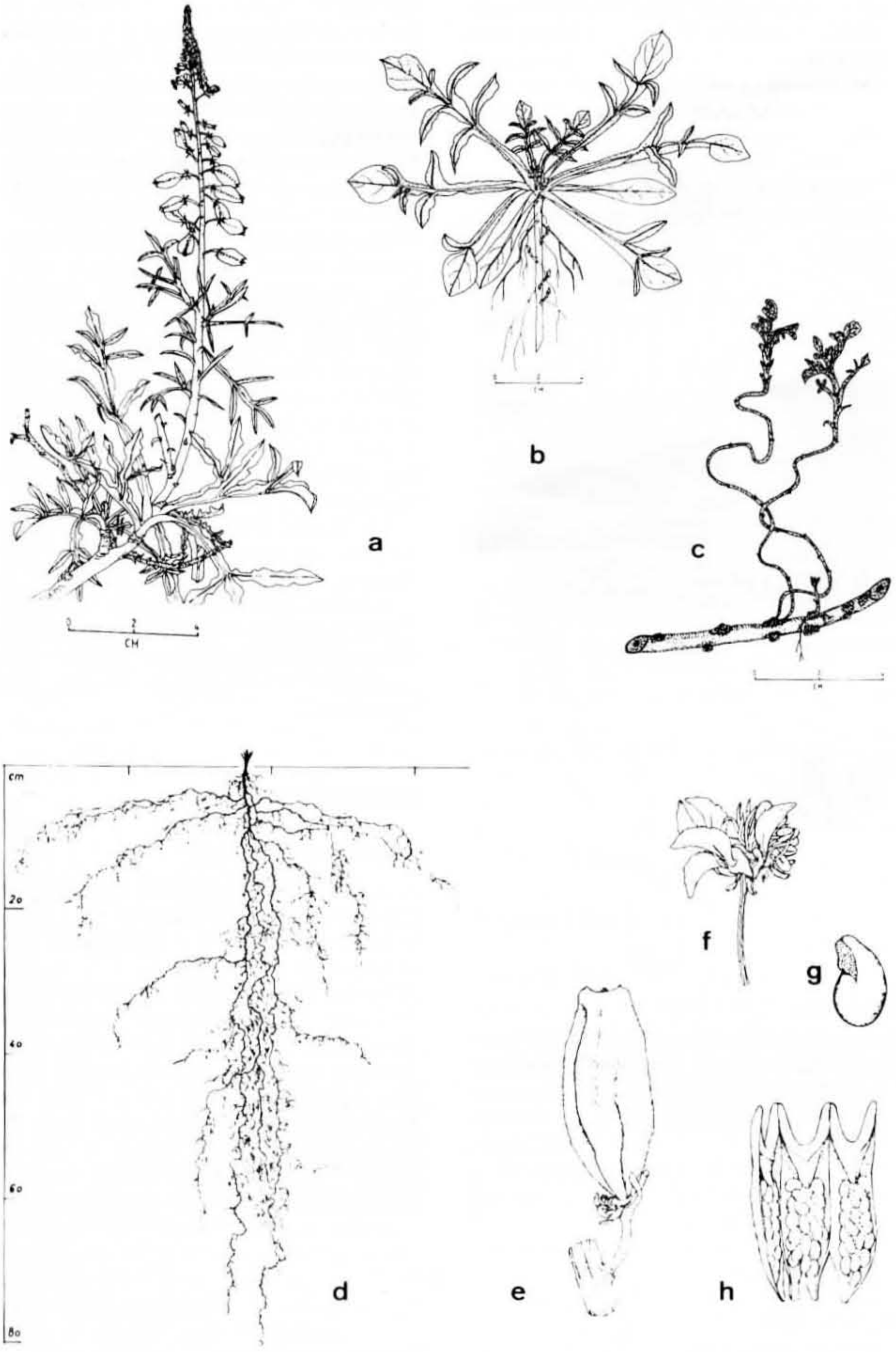

Figure 1 *Reseda lutea* L. *(a)* stem with flowers and capsules, *(b)* seedling, *(c)* shoots arising from root fragment (J. Crocker, unpublished data), *(d)* root system of 35 cm tall flowering plant (after Kutschera 1960), *(e)* capsule, *(f)* flower, *(g)* seed, and *(h)* capsule (opened) (after Abdallah and De Wit (1978).

embankments and gravelly river banks (Kutschera 1960).

R. lutea occurs in calcareous soil in Egypt, France, Italy, Portugal, Romania, Turkey and Morocco. In Egypt it was reported to be on sandy desert ground and in a barley crop. It also occurs frequently in arable fields in Hungary (Abdallah and De Wit 1978).

In Iran it is reported to range from areas with 100 mm annual rainfall (1700 m altitude) to 400 mm (300 m altitude) and from areas with temperature extremes of −25°C to greater than 50°C (Moghaddam 1977).

History

In Australia *R. lutea* was first collected in Hobart in 1875. It has subsequently been recorded in every State but not the Northern Territory. The localities and years of the first collections in each State are as follows:

Queensland: 1954, Toowoomba
New South Wales: 1937, Parkes
Victoria: 1950, Koo Wee Rup
Tasmania: 1875, Hobart
South Australia: 1913, Reynella
Western Australia: 1979, Dalwallinu

It is likely that *R. lutea* was introduced to Australia in ballast as it has been noted as a shipping ballast weed in Norway (Ouren 1979). It may be significant that its congeners *R. luteola* and *R. alba* have been recorded as shipping ballast weeds elsewhere (Martindale 1876; Tovey 1911; Ouren 1979).

It is not clear whether the widely separated infestations within South Australia were the result of independent introductions by foreign shipping or the result of local spread from a single introduction. The first recorded specimen of *R. lutea* in South Australia was at Reynella, near Adelaide, in 1913. Black (1929) recorded *R. lutea* at Kingston, in the South East of the State, and landowners on the Yorke Peninsula believe that *R. lutea* was introduced to their area from Point Turton, north-west of Warooka, during the 1930s. One landowner at the top of Yorke Peninsula claims that *R. lutea* was introduced to his property in 1939 in contaminated oat seed from lower Yorke Peninsula.

R. lutea spread northward from the Lower Yorke Peninsula in contaminated seed grain, hay and stock to infest the remainder of Yorke Peninsula and, later, parts of the Lower and Mid North. The Eyre Peninsula infestations are more recent and can almost certainly be attributed to contaminated stock and hay brought to the area from the Yorke Peninsula in the 1950s.

R. lutea is still spreading in South Australia and although small outbreaks have been found in almost all arable areas, the serious infestations are presently confined to the Yorke Peninsula, parts of the Lower and Mid North, and isolated parts of the Eyre Peninsula.

Growth and development

Morphology

In South Australia *R. lutea* seeds germinate and emerge with simple, opposite leaves in autumn and spring and then produce rosettes which may or may not flower in their first season, depending on their time of emergence (Heap, unpublished data). It has not yet been determined whether seedlings also emerge during winter.

Grubb (1976) observed that *R. lutea* is a strong competitor which has tall shoots and deep roots. These characteristics have made it a formidable weed in South Australia. In Russia the root system has been recorded as penetrating to a depth of 280 cm (Paczosky 1914) and at Curramulka in South Australia one tap root was exposed at a depth of 400 cm during a well excavation (R. Waters, pers. comm.). Horizontal root spread was reported to have a radius of more than 300 cm in some cases in the same district *(Ibid.)*. In one instance in South Australia *R. lutea* was discovered growing on top of a 2.5 m high stone water tank wall which was made of limestone and mortar. Although the tank had not held water for many years the plants were flowering freely, suggesting that the tap roots may have penetrated the height of the wall into the soil below.

Kutschera (1960) described the root system of a 35 cm tall flowering *R. lutea* plant which was growing in a sugar-beet crop in self-mulching black soil (Figure 1). The vigorous primary root system was well developed and divided into equally strong laterals, only a few of which grew downwards, with the majority growing horizontally or in a slight downward curve. Most of the root biomass consisted of deep roots which extended to 82 cm. The larger roots were yellowish brown, while the younger and finer roots were white. Root buds were present on the upper, larger root parts from which arose aerial shoots. The taproot was frequently found to be woody.

In Australia *R. lutea* is drought tolerant despite the occurrence of numerous (60 mm^{-2}) stomata on both surfaces of the leaves. This drought tolerance appears to be facilitated by a number of xerophytic characters including a deep, extensive root system, which contains water storage tissues and dormant shoots, and tracheids in the leaf margins which also store water. Trichomes are also strongly developed in *R. lutea* (Bolle 1936; Abdallah 1967).

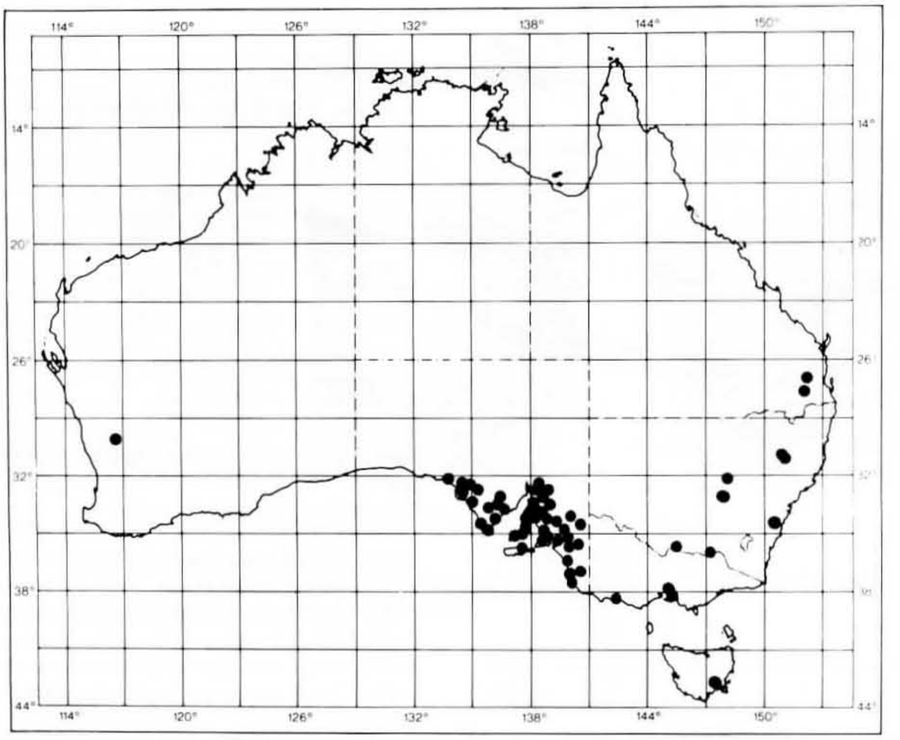

Figure 2 *Reseda lutea* L. distribution in Australia (based on localities from which herbarium specimens have been collected, Australian Barley Board records, Pest Plants Commission records and other sources).

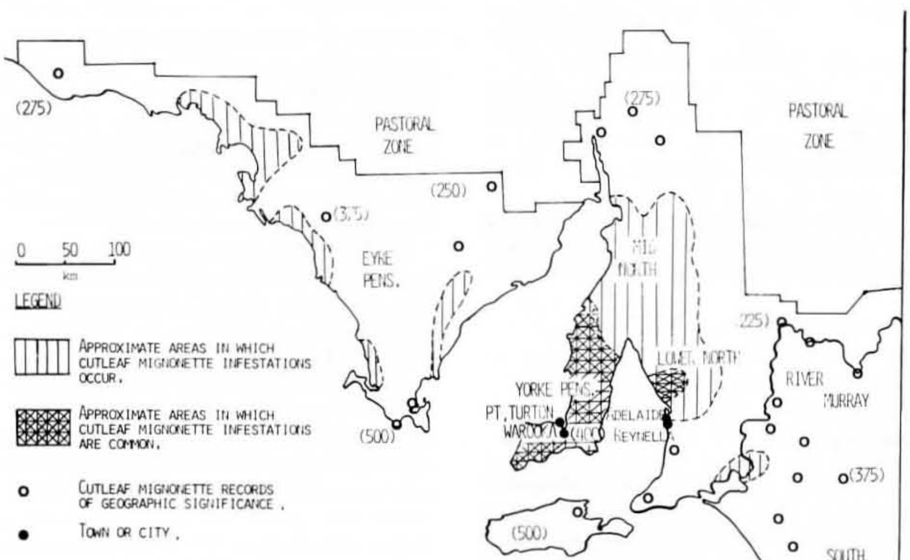

Figure 3 Approximate present distribution of *Reseda lutea* in South Australia.

The stems of *R. lutea* are usually longitudinally ribbed and have pithy centres. The inflorescence is a simple terminal raceme, with the basal flowers developing first. Pale, almost white flowers are observed overseas (Abdallah and DeWit 1978) but no evidence of this has been seen in Australia where only yellow flowers are found. Flowers have been observed throughout the year on *R. lutea* in South Australia.

The leaves, stems and fruit of *R. lutea* turn to an orange-red colour as they senesce, during drought stress or in response to herbicide injury. Abdallah (1967) reported that this is caused by chloroplasts changing into chromoplasts containing rhodoxanthin, carotin and xanthophyll.

Reproduction

Seedling establishment

In a species-rich calcareous grassland of Great Britain *R. lutea* densities were greater in micro-sites with low micro-cover and regeneration was most likely in these areas (Silverton 1981). Grubb (1976) generalized that perennial species usually require gaps for seedling establishment. This character probably restricts *R. lutea* during the seedling regeneration phase and accounts for its prominence in disturbed, open areas. *R. lutea* densities in the range of 600 to 800 m^{-2} were recorded during seedling emergence, which peaked in early autumn. Mortality continued from that time until spring (Silvertown 1981). In studies of seedling survival in perennial chalk grassland plants, Silvertown (1980) found that in the year of study no *R. lutea* seedlings flowered and he observed one population of seedlings decline by 98% in 329 days. The survival half-life was 51 days and it was concluded that recruitment of seedlings to the adult population was probably a rare event. It must be appreciated that these studies were of plants in relatively undisturbed pastures and that seedling survival and establishment may be greater in crops.

In South Australia, where an area was tilled several times in late autumn and then left undisturbed, seedling densities in midwinter were found to be 156 m^{-2}. This had declined to 0.7 seedlings m^{-2} by midsummer owing to a combination of interspecific shading (from *Avena sativa*, *Lolium* spp., *Medicago* spp. and *Oxalis pes-caprae*) and moisture stress. A survey in the same year of a barley *(Hordeum vulgare)* crop recorded 66 seedlings m^{-2} in late spring, but the fate of these seedlings over summer was not recorded. In almost all instances development of the seedlings was very slow, and long periods elapsed without apparent shoot growth (Heap, unpublished data).

It seems likely that *R. lutea* is intolerant of competition during seedling establishment and that, although densities may be high at emergence, these rapidly decline to low levels during establishment.

Perennation and longevity

The life-span of *R. lutea* has been variously described as annual to biennial (Black 1948), biennial (Suffolk Herbs 1984), annual to perennial (Abdallah and De Wit 1978), biennial to perennial (Clapham *et al.* 1962) and perennial (Grubb 1976; Shmida and Ellner 1983). Members of *Reseda* have indeterminant life spans; annuals may behave as biennials and biennials may behave as perennials.

Abdallah (1967) described how most *Reseda* species may become perennial when the swollen tap root remains alive during the dry season, often bearing some short stems (buds) or stolons which grow rapidly, usually after the first rains. Also, within a species, some forms may be annual and others are able to survive and become biennial or perennial. Some selections of *R. odorata* are alleged to have resulted in perennial ornamentals instead of annually sown garden plants. *R. pruinosa* perennates by producing resting buds during droughts which will sprout quickly after rain. A similar mode of perennation was reported for *R. lutea* (Bolle 1936).

The fate of undisturbed *R. lutea* is as yet unclear but studies so far suggest that seedlings emerging in autumn produce rosettes in spring, some of which flower. After seed production the aerial shoots die, but short green shoots arise near the crown of the plant during summer. These small shoots will probably develop slowly until the following spring, when more rapid growth occurs (Heap, unpublished data).

Although no documentation is available, it appears certain that *R. lutea* is a relatively long-lived perennial in disturbed environments such as cropland, pasture and areas which are slashed or graded such as roadsides. Under conditions of repeated disturbance, e.g. grazing, *R. lutea* is able to persist through spring and summer as a clump of short green shoots that do not senesce. Senescence of undisturbed plants may be under the control of a stimulus produced during seed production because fresh green rosettes in cultivated areas are found growing during summer in close proximity to undisturbed plants which have withered after setting seed. Salisbury (1961) also reported that in Britain *R. lutea* can persist on rabbit warrens as a closely grazed perennial.

In fields cropped twice every three years the crowns of *R. lutea* are thick and woody with evidence of shoots from several past seasons (Figure 4). One individual plant, which was found on a frequently mowed city roadside, had a substantial woody crown and an oval-shaped root cross-section that had dimensions of 30 mm × 22 mm. The cross-section of the root also revealed a series of 8 to 10 concentric rings, but it could not be determined whether or not these were annual growth rings (Heap, unpublished data).

Figure 4 *Reseda lutea* L. plant showing a portion of the root system.

Reproduction

Floral biology

R. lutea is a cross-pollinated species and although it normally has hermaphroditic flowers, imperfect flowers are also observed. Self-fertilization succeeds in *R. odorata* but is said to fail in *R. lutea* (Hennig 1929).

In general, species of *Reseda* secrete nectar on the lower surface of the disc extension. The nectar collects in a cup-shaped structure formed by the petal claws of the flower (Abdallah 1967).

Moghaddam (1977) reported that honey bees are more attracted to *R. lutea* than to red clover *(Trifolium pratense)*. Bees are common visitors in South Australia and probably play a large role in pollination.

Abdallah (1967) reported that during flowering the stamens change direction. The filaments, which are curved downwards, stretch and straighten one after the other, the higher preceeding the lower. The opened anthers, by their position and direction, ensure that insect visitors become sprinkled with pollen.

Bolle (1936) reported that *Reseda* flowers are frost tolerant.

Seed production and dispersal

R. lutea is a prolific seeder. Grubb (1976) postulated that this enables a plant such as *R. lutea* to persist and disperse because of the sporadic incidence in time and space of disturbed clearings, which are its natural habitat. The large production of partially dormant seed of *R. lutea* may enable it to survive in these unpredictable habitats.

The fruit capsule is a fleshy yellowish green sac, open at the top where the margin is three-lobed. This opening enlarges as the fruit ripens, allowing mature seeds to sprinkle out. Salisbury (1961) claimed that there may be as many as 24 seeds per fruit, but that the average is 14. The seeds are light coloured during early development, and progress through a mid-brown to shiny black when fully matured. Abdallah (1967) reported that the seeds have a high fatty acid content. They are 1.5 to 2.0 mm long, with an average weight of 0.85 mg. Although some farmers in South Australia wash contaminated cereal grain through a water bath to float out *R. lutea* seeds, it was found in laboratory tests that only a small percentage of ripe seed floated.

Estimates of seed production vary and depend substantially on the environment of individual plants. Salisbury (1961) stated that seed production per plant is often about 14 000, with some individuals producing as many as 220 000. In a study of pasture in Israel only 283 seeds per plant were recorded in a community with very few *R. lutea* plants present however (Shmida and Ellner 1983).

In a South Australian field trial, capsule numbers of 10 000 to 30 000 ha^{-1} were recorded (R. S. Britton, pers. comm.). If the average number of seeds per capsule was 14, then the seed output was between 140 000 to 420 000 seeds ha^{-1}.

Seed dispersal in *R. lutea* appears to be affected by a range of mechanisms. One obvious mechanism is the shaking of seeds from the apical pore of the ripe capsule. This is most pronounced in windy conditions when seeds may be propelled further away from the parent plant.

Ants (Grubb 1976) and birds (Salisbury 1961) are said to aid in its distribution. Wind- and water-assisted seed transport of *R. lutea* are not as important as for many other species, but the possibility of spread by these vectors cannot be discounted. In South Australia *R. lutea* is spread by both seed and root fragments. Long-distance spread is almost certainly by seed as a contaminant of seed grain, stock feed, hay, and machinery. Seed is also set and spread within paddocks and individual farms, no doubt contributing to the spread of *R. lutea*, but the low establishment and high mortality rates (Silvertown 1980) of seedlings in Great Britain suggest that vegetative increase from root fragments may be more important at this level. *R. lutea* appears to respond to the loose soil structure created by cultivation which offers less resistance to root growth. Seed may spread through fencelines into neighbouring paddocks and onto adjoining roadsides. Road grading machines spread *R. lutea* as soil, root fragments and seeds are dragged along roadsides from existing infestations. Sometimes road rubble from depots infested with *R. lutea* has been transported to repair roads at various sites, thereby initiating new infestations. In South Australia circumstantial evidence is extremely strong that *R. lutea* seeds are ingested and subsequently spread to new areas by travelling stock. As *R. lutea* fruits and seeds lack hooks, barbs, spines and adhesive exudates which might otherwise aid in external transport on animals, they have low potential for epizoochory.

Seed viability and germination

Abdallah (1967) and Bolle (1936) agree that seeds of Resedaceae do not remain viable for more than 3 to 4 years and that there is no evidence for seed longevity greater than 4 years in this family. Dorph-Petersen (1924) reported that 93% of *R. luteola* seeds germinate in the first or second spring. Generally, a high percentage of seeds of species of Resedaceae is non-viable. It is possible that the percentage of viable seed is closely linked to the maturity of the seed (Abdallah 1967).

Ozer and Hasimoglu (1977) found in one experiment that only 2.5% of *R. lutea* seeds germinated at 20 to 25°C, although 99.6% were viable. A seed germination test in South Australia recorded 40% germination after 7 days and 73% after 14 days, with 2% viable ungerminated seed and 25% dead seed (Anon. 1973). In another South Australian test, germination was 50% during winter and 26% during summer (Willcocks, unpublished data). In a series of laboratory tests the germination range was 60–70% from presumably mature seed collected in early autumn of the same year (Heap, unpublished data).

The germination percentage of *R. lutea* varies greatly with population and environment. Moghaddam (1977) claimed that in Iran the seeds germinate easily, even under harsh conditions, whilst Grubb (1976) found seed from British chalklands to be dormant in the soil and difficult to germinate. Grubb (1976) placed *R. lutea* in an ecological group which has the characteristics of high seed production and long seed viability. The latter characteristic is not supported in the literature, however.

In a recent catalogue of British wild flowers (Suffolk Herbs 1984) subjection to frost and autumn sowing are recommended for *R. lutea* seeds. Moghaddam (1977) reported that in Iran *R. lutea* grows in areas in which the temperature falls to −25°C. Seeds kept in the dark at 5°C for 7 days prior to germination had a higher germination percentage than those stored at 20°C (Heap, unpublished data). These reports suggest that seeds of *R. lutea* can survive low temperatures, and cold may stimulate germination.

Several studies indicate that *R. lutea* seed passed through the gastro-intestinal tract (G.I.T.) of sheep and cattle retain some viability. Ozer and Hasimoglu (1977) found that 13.7% of seed ingested by sheep was excreted, and of this 93% was viable but only 1.7% germinated. Seed excretion began 14 h after ingestion, peaked in the 24 to 38-h period, dropped to a low level by 72 h, and was almost nil after 96 h. Viability decreased with increasing time of passage through the sheep G.I.T. A similar decline in viability with increasing G.I.T. incubation time is reported in cattle (Dorph-Petersen 1924). It was found also that 6 months' fermentation in a dung heap destroyed *R. lutea* seeds.

Dry cattle dung excreted during summer/autumn was collected in winter and found to contain an average of 7260 seeds kg^{-1} with an average germination percentage in early spring of 22.8% after 23 days (Heap, unpublished data).

Some South Australian farmers believe that neither crushing nor seed grading destroys or removes all *R. lutea* seed.

Vegetative reproduction

R. lutea is a serious weed of South Australian agriculture, mainly because of its ability to form new plants from root segments fragmented by cultivation. Very little research has yet been done on this phenomenon.

Large numbers of root fragments are removed from tillage equipment and placed in heaps during seed-bed preparation in heavily infested areas. It appears likely that many of these fragments have the potential to give rise to new plants. This process appears to be largely responsible for spreading infestations within paddocks and, unless cultivation equipment is cleaned before leaving an infested area, to a lesser extent between paddocks and farms. Root fragments 30 mm long and 3 to 4 mm in diameter placed in a Petri dish have produced up to four shoot buds. Root fragments are often found to give rise to shoots in the field. In one case a root fragment (200 mm long and 4 mm diam.) gave rise to about 50 shoots which ranged in length from 10 to 70 mm. Evidence of vegetative reproduction is also found in the pattern of infestations in cultivated fields, where new plants arise up to several hundred metres down the cultivation line from an established plant or infestation (Heap, unpublished data).

New shoots also arise from perennial root crowns just below the depth of cultivation (75 to 100 mm). These crowns are often thick and woody and have the remnants of old shoots from previous seasons roughly fractured at the cultivation depth. Infestations of *R. lutea* which have been cultivated have the ability to regenerate from these crowns during spring and summer.

R. lutea seedlings grown in a glasshouse during spring developed subterranean shoots within 28 days of their emergence. One individual developed 20, from 51 to 65 mm below the soil surface, with the longest shoot being 5 mm (Heap, unpublished data).

Responses to Natural Enemies

R. lutea plants observed in the field in South Australia are generally very healthy and seem to suffer from few pathogens or pests. Abdallah (1967) remarked that only rarely were herbarium specimens of Resedaceae attacked by insects, whereas specimens from the allied family Brassicaceae were frequently attacked. This suggests that potential biological control agents might be difficult to find and indeed there is little reference to pests and parasites of *R. lutea* in the literature.

Abnormal growth caused by root and crown infection by the larvae of the weevil *Baris paciformis* Marsh. (Curculionidae), however, is commonly found overseas. In this disorder Bolle (1936) reports that instead of pedicels, a more or less branched secondary axis with flowers reduced in all respects are formed with every organ rudimentary or reduced. This condition is probably the product of early infestation and nutritional stress, as some infected individuals develop normal flowers. It is likely that this organism is responsible for similar floral abnormalities found in South Australia, but this has yet to be confirmed.

Other organisms found on *R. lutea* (Bolle 1936; Abdallah 1967) are Physopods (Thysanoptera), a flea beetle, *Phyllotreta nodicornis* Marsh. (Chrysomelidae) and snout beetles of the genus *Urodon* (Cureulionidae). Bolle (1936) also reported that several insects which live on Brassicaceae are also found on *Reseda*. A common predator of Brassicaceae, *Pieris rapae* L. (Pieridae) was found feeding on leaves of *R. lutea* in South Australia (Heap, unpublished).

Several farmers on the lower Yorke Peninsula have reported the sporadic occurrence of a fungus on *R. lutea* in some seasons, although the identity of the pathogen has yet to be investigated. *R. odorata* is known to host the fungus *Cercospora resedae* Fuck. (Dematiaceae), which causes brown leaf lesions (Bolle 1936).

Amiri and Ebrahim-Nesbat (1977) reported that *R. lutea* is a natural host for water melon mosaic virus in Iran. Although not affected by the virus, *R. lutea* occurs as a common weed of cucurbits there, and is thus a ready source of infection.

Importance

General

Abdallah (1967) stated that most *Reseda* species may occur as weeds but are never aggressive or noxious. This is not so in South Australia, where *R. lutea* is an exceptionally persistent, competitive and proclaimed noxious species which is well adapted to cropping areas.

R. lutea has also been described in Iran as a useful multipurpose plant which is good for grazing, hay production, cover to prevent erosion and promote regeneration of road cuttings, mining areas and spoil banks (Moghaddam 1977).

Crops and pastures

R. lutea is widely recognized in South Australia as a serious weed but very few scientific results are available to quantify production loss.

The major effects of *R. lutea* are competition with crops and pastures for light, moisture and nutrients, and cereal grain contamination. *R. lutea* is particularly aggressive in open, cultivated soils which are typical of fallowed fields (Figure 5) and sparse crops. Many landowners claim that crop yield reductions are associated with *R. lutea* infestations, and field observations of

Figure 5 *Reseda lutea* L. flowering in a cultivated field.

pastures suggest that the growth of other species is severely restricted by dense infestations of *R. lutea*. In permanent pastures, or pastures which are infrequently cropped, *R. lutea* is not aggressive and is not generally a problem. Soil disturbance, which favours both vegetative reproduction and seedling establishment, is lacking under this land use.

One of the most serious effects of *R. lutea* in crops is seed contamination of barley. Contaminated barley is liable to be downgraded and hence devalued by the Australian Barley Board. The contamination occurs because green *R. lutea* capsules are present in the upper crop canopy at the time of harvest, usually in early summer. These capsules are difficult to separate from barley grain and in some cases increase the moisture content of the sample, causing machine fouling and breakdown (R. S. Britton, pers. comm.). The capsules rapidly become desiccated and release their seeds, however, and the grain can be cleaned again after 24 h. This additional process at harvest is costly in terms of both time and money.

In an effort to avoid such contamination, selective herbicides and windrowing are employed, with variable results. Wheat is not as susceptible to contamination because of the use of different harvester screens, a later harvest time and a taller grain canopy.

Grazing

The preference of sheep and cattle for *R. lutea* varies and depends on both the presence of alternative pasture species and the developmental stage of *R. lutea*. Bolle (1936) claimed that cattle do not eat *R. lutea* or *R. luteola* in Germany, yet Grubb (1976) noted that *R. lutea* is grazed by rabbits in Great Britain.

Moghaddam (1977) promoted *R. lutea* as a very useful and well adapted arid and semi-arid pasture species for sheep and goats which produces early forage 25 days ahead of other species in Iran. The crude protein before flowering was 17.5% for *R. lutea*, compared to 24.6% for lucerne *(Medicago sativa)*; this, however, changed to 18.8% and 16.8% respectively at flowering. In feeding trials in Iran with range-grazed native sheep, *R. lutea* (40% consumed) was preferred to *Medicago sativa* (28%) and *Agropyron desertorum* (18%). The potential of *R. lutea* as an arid or semi-arid forage species in South Australia is not known.

Observations by South Australian landholders suggest that *R. lutea* is palatable to sheep in moderate quantities, particularly when alternative pasture species are present to provide a balance. One grazier allows his sheep access to adjoining pastures low in *R. lutea* content, in conjunction with fallowed fields dominated by *R. lutea*, to encourage fallow grazing. There is some evidence that sheep acquire a tolerance for grazing *R. lutea*. During the late spring and summer seasons *R. lutea* may be the only green matter available to stock, and it is particularly valuable fodder during drought years when sheep have been observed to excavate root crowns, thus forming a crater in which rain subsequently collects.

Sheep will sometimes reject pasture dominated by *R. lutea* if little alternative feed is available, and also if *R. lutea* is flowering. The leaf and stem material have a taste, to the human palate, not unlike some table vegetables of Brassicaceae. The flowers and seeds do not have a particularly strong or offensive taste but the green capsules have an acrid taste which burns like hot mustard when placed on the tip of the tongue. It is likely, then, that the presence of capsules discourages grazing. Some graziers claim that a high stocking rate is required to prevent flowering of *R. lutea*. In one instance sheep which were introduced at a stocking rate of 2.5 ha^{-1} to a few *R. lutea* plants, at the flowering stage in a large paddock, failed to graze the plants despite the sparseness of alternative feed.

Several South Australian graziers have observed that cattle, like sheep, will graze *R. lutea* only under certain circumstances. There is some evidence to suggest that stock prefer dried or drying material to green material. *R. lutea* is considered to be a valuable pasture species on the Lower Yorke Peninsula, where it is sometimes called 'Warooka lucerne'.

In South Australia *R. lutea* is grazed by free-ranging pigs under some circumstances and one landholder also believed that rabbits grazed the species on his property. No ill-effects to any animals have been reported, although grazed *R. luteola* is suspected of producing anti-thyroid activity and death in sheep (Van Etten 1969).

Meat from stock grazed on *R. lutea* can acquire a strong bitter taint which causes premature deterioration and sometimes renders it unpalatable. This may be overcome by removing the stock from *R. lutea* pastures 2 or 3 days prior to slaughter (D. Cooper, pers. comm.)

R. lutea can taint mutton and beef fat, milk and butter and make them unpalatable for human consumption (L. H. Ellis, pers. comm.).

Disease host

As previously discussed, *R. lutea* presents a potential threat to cucurbit crops in Australia because it is a potential host for water-melon mosaic virus.

Water-melon mosaic virus occurs in South Australia as an economically damaging pest of several cucurbit crops and is spread by aphids (T. J. Wicks, pers. comm.) As yet, *R. lutea* is not a common weed of cucurbits in Australia, but its presence implies a potential agronomic problem in these crops.

Land values

Although no accurate information is available, some South Australian landholders believe that the occurrence of *R. lutea* on a property lowers its market value. One estimated this devaluation to be of the order of 10 to 20%.

The attitude toward land infested with *R. lutea* varies between regions. Generally, *R. lutea* is accepted in the thickly infested areas with the same philosophy with which a particular soil type is accepted. In areas of fewer established infestations land holders often attempt to control the spread of *R. lutea*, but in areas of relatively recent introduction unfamiliarity and hence indifference tends to prevail.

Response to herbicides

A wide range of control methods have been applied to *R. lutea* including herbicides, grazing, mowing and cultivation. Most of these treatments have been unsuccessful, due largely to the underground reserves of the perennial root system. *R. luteola*, in contrast, is reported to be easily controlled by 2,4-D and cultivation (Parsons 1973).

Most farmers aim to suppress *R. lutea* in crops until harvest to avoid grain contamination and machinery problems caused by the moist green capsules. This is usually attempted with 2,4-D applied to *R. lutea* prior to flowering. The maximum recommended rates in South Australia for 2,4-D are 1050 (amine) and 1120 (low volatile ester) g.a.i. ha^{-1}. The success of these treatments are variable and some barley growers windrow their crops instead.

A more recent development is the use of chlorsulfuron which suppresses *R. lutea* in the crop and appears to reduce the population in the following year. Field trials suggest that results from this treatment are also variable but that very good control can be achieved in some situations.

Another two members of the sulfonylurea group of herbicides, metsulfuron-methyl and CGA-131-036, have also shown excellent selective activity against *R. lutea* in barley and wheat (Heap, unpublished data). There is evidence that seedlings of *R. lutea* are easily killed by a range of herbicides, in contrast to established plants.

Spot spraying and non-selective extensive treatments have also been applied to *R. lutea* in South Australia. Glyphosate kills the top growth of *R. lutea* but regrowth from the roots often occurs in subsequent seasons. Sequential treatments with glyphosate undoubtedly reduce and weaken infestations.

Picloram/2,4-D mixtures are currently recommended as a spot-spray treatment in South Australia. Whilst this is successful, it is also expensive and because of the residual nature of picloram in soil it is not suited to extensive use. An area of soil at least 2 m in radius around the target plant must be treated and even then regrowth can occur in subsequent years.

Trichlorobenzoic acid is also reported to be effective against *R. lutea* (S. Wearing, pers. comm.) but this herbicide is no longer available in Australia.

A chlorsulfuron/glyphosate spot-spraying mixture has also been tried with encouraging results (P. Cousins, pers. comm.)

Hexazinone, amitrole/atrazine mixtures and 2,4-D have been applied as a spot spray with limited or variable control.

It is clear that a well-planned spot-spraying program implemented over several years, to control regrowth, has the potential to eradicate individual *R. lutea* plants.

A major problem remains that the shoots of *R. lutea* are relatively easily controlled, but herbicide translocation through the root system appears to be limited. A similar problem has been reported with skeleton weed *(Chondrilla juncea)* (Greenham 1943).

Response to other human manipulation

Grazing and mowing have been tried by South Australian farmers with little success. The extensive root system of *R. lutea* is able to withstand frequent shoot removal without apparent loss of regenerative ability. As discussed above, *R. lutea* is also sometimes unpalatable to stock.

Mowing can remove a large proportion of flowers and pods but some seed is still produced below mowing height. *R. lutea* can persist on graded road-shoulders, suggesting that frequent top removal does not cause death.

McVean (1966) reported that ploughing, or other complete soil disturbance gives the greatest increase in skeleton weed *(Chondrilla juncea)* rosette density. The same appears to be true of *R. lutea*. South Australian farmers are almost unanimous in their belief that cultivation increases the spread of *R. lutea* by transporting viable root fragments.

A program designed to control soursob *(Oxalis pes-caprae)* was implemented by a South Australian farmer in which fields were frequently cultivated during winter and spring. The area was also infested with *R. lutea* which was reported to be more dense in the following autumn than prior to the intensive cultivation operations (G. Cawley, pers. comm.).

Legislation

Weeds were imported into colonial Australia without restriction until 1908 when *An act relating to Quarantine* was implemented which contained an appended list of prohibited species (Maiden 1920). The management of weeds already present was the responsibility of State governments.

R. luteola was the first *Reseda* to be declared a restricted or prohibited species in Australia. It was proclaimed in the Municipality of Nyngan, N.S.W., prior to 1909 and for the Shires of Melton and Bacchus Marsh, Vic., in 1917 under the provisions of the *Thistle Act, 1915*. *R. luteola* was subsequently proclaimed for the Shire of Wangaratta in 1919, and the whole of Victoria in 1929. Interestingly, Parsons (1973) ascribed no significance to *R. lutea* as a noxious weed in Victoria.

R. luteola was declared a Schedule One noxious weed for all of South Australia under the *Noxious Weeds Act, 1934*. The identity of the target weed of this legislation is, however, questionable (C. R. Alcock, pers. comm.) and *R. lutea* may have been mistaken for *R. luteola*. Subsequent developments support this suggestion. Under the *Weeds Act, 1956*, *R. luteola* was relegated to the Second Schedule and afterwards *R. lutea* was placed with it. Subsequently, only *R. lutea* was proclaimed under the *Pest Plants Act, 1975*.

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