The Biology of Australian Weeds
18. *Hypochoeris radicata* L.

Lesley Cameron
Department of Geography, University of New England, Armidale, New South Wales 2351
Current address: Roseworthy Agricultural College, Roseworthy, South Australia 5371

Name

The taxon *Hypochoeris* L. (family Asteraceae) is a cosmopolitan genus of about 100 species, none of which is indigenous to Australia. Three species are naturalized in Australia, all as introductions from Europe, Asia or North Africa (Beadle 1971). The generic name may be spelled *Hypochaeris* (Hitchcock *et al.* 1955; Clapham *et al.* 1962, 1981) or , more commonly, *Hypochoeris* (Index Kewensis; Flora Europaea). The common name for *Hypochoeris radicata* L. is catsear, flatweed or false dandelion, the latter indicating its close resemblance to *Taraxacum officinale*, a species with which it is often confused. It may also be called long-rooted catsear to distinguish it from *H. glabra* (Maiden 1920).

In the rosette stage, *H. radicata* is distinguished from *Crepis capillaris* (hawksbeard), *Leontodon autumnalis* (autumn hawkbit) and *Taraxacum* spp. (dandelion) by the presence of hairs on the leaf margins, from *H. glabra* (smooth catsear) by the thicker, rough–hairy leaf surface, from *Leontodon taraxacoides* by the simple leaf hairs, and from *Crepis taraxacifolia* (beaked hawksbeard) by the rounded leaf lobes. The branched flower stalks distinguish it from dandelion and hawkbit, the absence of leaves on the flower stalk from all species of *Crepis*, and the larger flower head and lack of dimorphic fruits from the related *H. glabra*; stem galls distinguish the species from all others in the dandelion group except *H. glabra* (Healy 1944).

Description and account of variation

Hypochoeris radicata is a hairy, perennial herb that grows to a height of 5–70 cm from a hard, over-wintering base. Leaves: in a basal rosette, hairy, sinuate to pinnatifid, usually scabrous, 2–20 cm long and 0.5–7 cm wide. Stems: leafless scapes, often several per plant, broader below the heads, scaly, sparsely and minutely bracteate, possessing a milky juice. Flowers: yellow capitula, 20–40 mm wide, usually several. Florets: ligulate, numerous, the outer longer than the involucre and four times as long as wide, golden-yellow but greenish on back. Involucre: 10–15 mm high at anthesis, up to 25 mm in fruit, bracts imbricate, glabrous or hispid. Fruit: an achene, brown, striate, scabrid above and attenuate with long or short smooth beak, pappus plumose with two rows of hairs commonly barbellate.

Cytology

A chromosome number of $2n = 8$ has been obtained for Canadian and British material (Mulligan 1976; Parker 1975; Aarssen 1981). Rare trisomics with $2n = 9$ have been reported for Indian material Panigrahi and Kammathy 1961). A detailed cytological study is given by Dvorak and Dadakova (1977).

Distribution

H. radicata is a cosmopolitan species with a wide global distribution, occurring over a broad latitudinal and altitudinal range. It is native to most of Europe, being recorded at 62°47'N. in Scandinavia and to 1400 m in the Alps, much of northern Asia and parts of North Africa (Burbidge and Gray 1970; Beadle *et al.* 1972; Turkington and Aarssen 1983). It is widely established over the eastern half of North America, the Pacific Northwest, Hawaii, Alaska, the Aleutian Islands and montane Central America. It is a common weed in Argentina, Columbia, Chile and South Africa (Aarssen 1981). It is the most widely distributed introduced weed in New Zealand on both an altitudinal and geographic basis (Healy 1976).

In Australia *H. radicata* is found generally throughout the temperate zone, from sea level to the upper levels of vegetation at about 2000 m (Burbidge and Gray, 1970). It is found in all States (Figure 1) but is most widespread in Tasmania, Victoria and New South Wales.

History

Introduction

The date and place of introduction of *H. radicata* to Australia is uncertain and its subsequent spread a matter of some conjecture. It is likely that it originally entered south-eastern Australia as a ballast plant (Kloot, pers. comm.) in the same way as it was introduced to North America (Perkins 1883). It appears to have been an early arrival, well established by the time serious botanical exploration began. The earliest plant lists and regional floras describe *H. radicata*, including Bentham's 'Flora Australiense' of 1866, though it is not mentioned in Brown's list of 1802–1804.

It has been suggested that species of *Hypochoeris*, including *H. radicata*, were deliberately introduced into the western and northern plains of Victoria in the 1840s in order to replace *Microseris scapigera*, a staple food plant of Aborigines which has been virtually eradicated by domestic

A single plant of *Hypochoeris radicata*

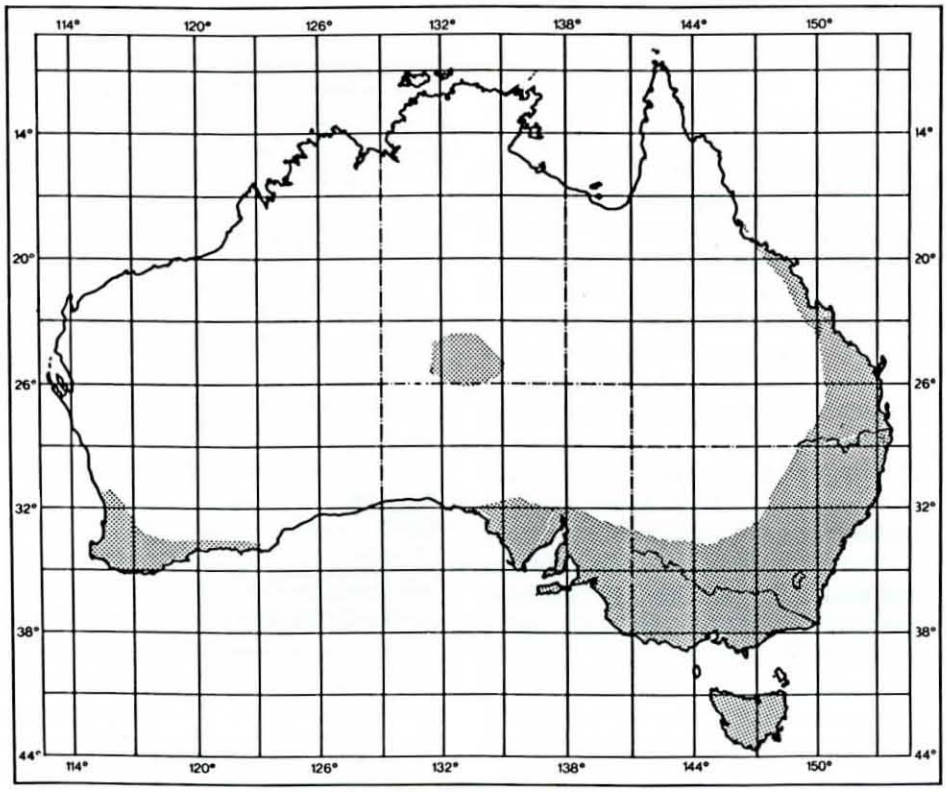

Figure 1 Occurrence of *Hypochoeris radicata* in Australia

livestock (Gott 1983). *H. radicata* does have a small, edible taproot, though much smaller and less palatable than that of *M. scapigera*. It is difficult to assess the extent to which these deliberate introductions extended the range of the species, which was already present in other parts of Victoria at that time.

Status

Despite its global distribution and its widespread and abundant occurrence throughout Australia, there has been little research on *H. radicata*. Maiden (1920) emphasized this problem, pointing out that 'It is one of those plants with which we are so familiar and which has no outstanding characteristics, that little has been written about it' (Maiden 1920, p.124). As a result, the extent to which the species is a problem plant in Australia is hard to determine. Almost all regional floras describe *H. radicata* as a weed: Curtis (1963) for Tasmania, Specht (1972) for South Australia, Willis (1972) for Victoria, Burbidge and Gray (1970) for the Australian Capital Territory, Costin *et al.* (1979) for the Kosciusko region, Beadle *et al.* (1972) for the Sydney region, Cunningham *et al.* (1981) for western New South Wales, Beadle (1980) for northern New South Wales, and Jessop *et al.* (1981) for central Australia. *H. radicata* is also considered in most texts and manuals specifically on weeds: Black (n.d.) for South Australia, Ewart (1972) for Victoria, Bailey (1909) for Queensland and both Whittet (1968) and Lamp and Collet (1976) for Australian weeds generally. The species, however, has never appeared on any list of proscribed weeds in Australia, although those proclaimed in the Commonwealth of Australia Gazette of December 1912 included *H. glabra*. In describing *H. radicata*, Maiden (1917) considered that 'its characters and defects are similar' to *H. glabra*. The species is perhaps best considered as a weed of relatively minor importance in agricultural terms (Clemson 1985) but with some potential for spread given its capabilities proven in Britain and Canada (see later) and its behaviour in natural plant communities in Australia.

Habitat

Climatic requirements

The species is adapted to a wide range of climatic conditions (Aarssen 1981). While its geographical distribution might suggest that climatic limitations are few, its major areas of occurrence are in cooler, temperate locations. The plant is deep-rooted and apparently drought-resistant. In temperate Australia it is found in drier parts, moister sites tending to be populated instead by *Taraxacum officinale*, but is generally absent from the arid zone. In South Australia, *H. radicata* is recorded as widespread in disturbed eucalypt forests in a Mediterranean climate, but is not found in the driest areas (Specht 1972).

The major factors limiting its distribution are not known, though are thought to be, in Europe, winter cold at its northern and eastern limits and summer heat at its southern edge (Turkington and Aarssen 1983). In Australia it is possible that moisture availability is of equal importance to temperature in determining distribution on local and continental scales. In arid and semi-arid central Australia the species is recorded only in the Alice Springs region and there only in disturbed urban environments. In parts of Western Australia where the species is found — mainly in the southern half — it is generally much less common than *H. glabra* (R. J. Hobbs, pers. comm.).

Substratum

H. radicata tolerates a wide range of soil type, texture and pH. It has been recorded on light sands and gravels (Muenscher 1949) and on clays (Saxby 1943) and from soils with pH values ranging from 3.9 to 8.6 (Turkington and Aarssen 1983). It is not, however, ubiquitous. It is absent from sites subject to prolonged waterlogging (although it may be found on swamp margins) and is absent from or rare on highly calcareous soils. World-wide, the species is associated with well-drained soils (Ho 1964) which may be generally moist (Salisbury 1964) or show marked annual fluctuations in moisture content (Rumball 1978). In New Zealand *H. radicata* often colonizes dry microsites in mesotrophic mire vegetation (Healy 1962). In South Australia it may be found on tidal salt marshes but only in sites with a considerably lower soluble salt content than the surrounds and which are rarely, if ever, flooded by tides (Specht 1972). It tolerates relatively nutrient-deficient soils such as Australian soils which are deficient in phosphorus (Leigh and Mulham 1965).

Communities

In Australia *H. radicata* is most often found in pastures (irrigated and dryland), cultivated fields, lawns (Leigh and Mulham 1965; Whittet 1968), fallow paddocks (Cunningham *et al.* 1981), roadsides and waste places (Curtis 1963), disturbed sites and reclamation areas (Costin *et al.* 1979) and in natural plant communities at all elevations (Burbidge and Gray 1970). Other studies report its occurrence on grassy dunes in the U.K. (Clapham *et al.* 1962) and in *Callunetum* communities (Miles 1974), in peat bog in Ireland (Ridley 1930) and in modified tussock grassland in New Zealand (Healy 1962).

Doing (1972) made an exhaustive phytosociological analysis of the pasture and weed communities on the hills and tablelands in the Australian Capital Territory and nearby areas. *H. radicata* is listed under his Group 18 which is described as 'species of grasslands or weed communities, with preference for moist soils. Introduced species . . . invading native pastures on a large scale during a relatively early stage of improvement'.

Two studies in Victoria, one of agricultural and one of natural communities, revealed a number of plant species commonly associated with *H. radicata*. In a study of the vegetation of roadsides and adjacent farmland on the Mornington Peninsula, Lane (1976) found *H. radicata* to be one of the few alien species of the roadside communities which was also common in pastures (Lane 1976). Similarly, in a study of the spread of weeds from roadsides into native sclerophyll forest in northern Victoria, *H. radicata* was found to be the most abundant alien species in each of the three eucalypt communities studied (Amor and Stevens 1976). Most of the roadside associates of *H. radicata* did not invade either the pasture or eucalypt communities.

These studies attribute the differences between plant communities in composition and frequency of alien species to either different types and levels of disturbance (Lane 1976) or to different levels of light intensity (Amor and Stevens 1976). The studies conclude that high levels of both disturbance and light intensity are necessary for the establishment of alien plants. While this may be valid in general, it may not necessarily apply to all species or all communities. *H. radicata* has been recorded from apparently undisturbed sclerophyll communities and from a rainforest where light intensity is very low (Cameron, unpublished data).

Growth and development

Morphology

H. radicata has a prostrate rosette growth habit, with the leaves often very closely appressed to the ground surface, and buds close to the ground. Both characteristics partly protect the plant from mowing and grazing (Fogg 1945; Aarssen 1981). Its perennial root system extends below the root depth of many neighbouring herbaceous species, and this may account for its high content of minerals and trace elements (Struik 1967). The leaves have small epidermal cells and large multicellular hairs (trichomes) which may influence the retention or penetration of herbicidal sprays (Ormrod and Renney 1968; Aarssen 1981).

Perennation

Under favourable conditions, *H. radicata* frequently overwinters as an above-ground, evergreen rosette. This occurs in areas where the average winter temperatures are above freezing, as in British Columbia and in temperate Australia. It can, however, respond to the onset of very cold weather as a true hemicryptophyte, through the dieback of above-ground parts, leaving perennating buds at ground level (Turkington and Aarssen 1983). Under conditions of very high average temperatures, *H. radicata* acts as a therophyte in western New South Wales and other semi-arid areas of Australia, germinating and flowering in the cooler winter months and dying after flowering (Cunningham et al. 1981). Vegetative propagation of *H. radicata* occurs only by perennating buds (Turkington and Aarssen 1981).

Panigrahi and Kammathy (1961) contend that the propagation of the species is largely by vegetative means, the plant splitting up at ground level and producing clones. Specimens from coastal Argentina (Crovetto 1944, cited in Aarssen 1981) and British Columbia (Aarssen 1981) were demonstrated as developing 'axillary vegetative proliferation', in which rosettes of leaves similar to the basal rosette had formed in the axils of the flower stalks. These axillary rosettes were able to initiate adventitious roots and survive when artificially severed from the floral stalks and placed in moist sand (Aarssen 1981). Under favourable conditions, flowering plants can be produced from seed in 2 months (Ho 1964). This rapid development, in conjunction with its clonal spread, contributes to the persistence of the plant as a weed in turf (Ho 1964).

Phenology

H. radicata often overwinters as an above-ground rosette, although in parts of Australia this phenological stage may occur over the hot summer months. Ho (1964) noted that in British Columbia vegetative growth occurred throughout the spring months; flowering was maximal in spring and autumn but continued sporadically throughout the summer; seed production continued from late spring to early autumn. This contrasts slightly with the phenological development of the plant in Australia where, at least in the cooler parts, flowering occurs mostly in the summer and seed production in autumn. In semi-arid Australia, the seasonal behaviour is apparently reversed, the plant flowering in winter and persisting as a basal rosette in summer (Cunningham *et al.* 1964). No detailed study exists of the phenological development of *H. radicata* in Australia.

Physiological data

There has been very little research on the effects of light, water regime, mineral nutrient supply or temperature on the growth of *H. radicata*, or on its rate of photosynthesis and transpiration. Almost no physiological studies on the species appear to have been done with Australian material, the most substantial physiological studies being on Dutch populations.

Lambers (1979) and van de Dijk (1980 *a,b*) conducted comparative physiological studies on the uptake and assimilation of nitrogen by two subspecies of *Hypochoeris radicata*, *H. radicata* ssp. *radicata* and *H. radicata* ssp. *ericetorum*. These subspecies show slightly different distribution patterns in the field, ssp. *radicata* being absent from strongly acidic soils and ssp. *ericetorum* from nutrient-rich soils (Lambers 1979). The shoot/root ratio of ssp. *ericetorum* showed little response to increasing nitrate concentrations, whereas ssp. *radicata* showed a strong response. This, coupled with a sharper decline in growth rate of ssp. *ericetorum* 1 month after sowing, could explain the absence of ssp. *ericetorum* from nutrient-rich soils (van de Dijk 1980a). When grown with ammonium as the only source of nitrogen, ssp. *radicata* had an only slightly higher yield than ssp. *ericetorum*, the difference being greater at pH 4.5 than at pH 6. Van de Dijk (1980b) concluded that both subspecies had similar ammonium-nitrogen requirements and that the absence of ssp. *radicata* from strongly acidic soils could not be explained by the low pH.

Australian material from the Northern Tablelands of New South Wales was used in a mineral deficiency trial, testing the dry weight response of above-ground parts of *H. radicata* to the omission from the growth medium of a range of essential mineral elements (Cameron, unpublished data). In these trials, calcium was found to be the most critical growth element for *H. radicata*, a deficiency of which resulted in seedling death within 4 weeks. This, in conjunction with the plant's absence from highly calcareous soils (Turkington and Aarssen 1983) suggests that *H. radicata* may have a narrow range of tolerance for calcium. Lack of iron had a similar but less extreme effect in retarding seedling growth. Other essential mineral elements were found to be magnesium and phosphorus.

H. radicata seedlings showed a positive response to deprivation of sulfur and micronutrients, and some response to deprivation of nitrogen. Seedlings grown without micronutrients actually exhibited more vigorous growth than those grown in complete nutrients, and those without sulfur only slightly less than the complete.

This response could account for the abundance of *H. radicata* in parts of temperate Australia where the soils are deficient in sulfur or in trace elements. The results for the dry weights were confirmed by the response of the roots under the same treatments. Roots of plants growing without micronutrients, sulfur and nitrogen grew much longer and more densely than those of plants grown with a complete treatment. These data again indicate a physiological basis for the distribution of the species throughout Australia and particularly its presence in unimproved pastures and rangelands.

On a dry weight basis, approximate values of chemical constituents for *H. radicata* plants in New Zealand tussock grasslands are protein 10–15%, fibre 10–29%, calcium 10–20 mg g^{-1}, phosphorus 1.5–5 mg^{-1} and copper 5–10 g g^{-1} (Grace and Scott 1974).

Floral biology

According to most sources, *H. radicata* is cross-pollinated and self-incompatible (Fryxell 1957; Parker 1975). The stylar branches are 1 mm long and not sufficiently recurved to permit automatic self-pollination (Turkington and Aarssen 1983). It has been suggested that self-pollination may be possible by three means: activity of insects of the genus *Thrips* inside the flower head, the opening and closing of the flower head, and the trapping of rain water inside the open head (Hagerup 1954; Aarssen 1981). Kerner and Oliver (1985) specifically list *Hypochoeris* as an autogamous genus. Autogamy (self-fertilization) occurs by elongation of the ligulate corolla and consequent uplifting of the adherent pollen, a pollination device apparently common in plants whose capitula have peripheral ligulate florets longer than the central ones. The pollination mechanism is detailed in Kerner and Oliver (1895, p.375). The average daily pollen yield is 60 mg for 100 plants for British material (Percival 1950). The pollen is 74% viable and there is no apomixis (Panigrahi and Kammathy 1961).

Seed production and dispersal

The dispersal unit of *H. radicata* is an achene with pappus. Each plant produces an average of 44 achenes per capitulum, with an upper limit of 136 being recorded (Salisbury 1964). The number of capitula on each individual plant differs, particularly with time of year, but generally varies from 2 to 11 (Ho 1964), at least for Canadian material. The average weight (air dried) of an achene, including the pappus, is 0.6–0.8 mg (Turkington and Aarssen 1983).

A feathery pappus aids dispersal by wind — for relatively short distances by natural means. However, human agencies may carry the pappus long distances. The very open form of the pappus gives the propagule a high terminal velocity of 40.5 cm s^{-1} (Sheldon and Burrows 1973). Sheldon and Burrows (1973) found maximum dispersal distances of a fruit to be 0.67, 1.33 and 2.00 m at wind speeds of 5.7, 10.9 and 16.4 km h^{-1} respectively. On the ground the achene lies on its side, supported by the hairs of the pappus, from which position it may be carried further by wind gusts (Turkington and Aarssen 1963). The achene may become attached to the substratum by the short processes on its surface. Attachment in this fashion to the feet and plumage of birds has been observed, as has transportation by ants (Aarssen 1981). This latter phenomenon has been studied on the Northern Tablelands of New South Wales (Cameron, unpublished data). Achenes of *H. radicata* placed on the ground in eucalypt woodlands were found to germinate within a 2 m radius of their original location. A significant number of the achenes were not retrieved as seedlings and may have been either destroyed or transported considerably further than 2 m. On a broader scale, achenes can be dispersed over long distances, e.g. as contaminants of commercial grass seeds (Johnston 1962; Wellington 1969). *H. radicata* seedlings were amongst those germinated from sludge collected from a car wash in Canberra by Wace (1977) in a study of the role of motor vehicles in plant dispersal.

Germination

The achenes of *H. radicata* are immediately germinable, exhibiting no dormancy period prior to germination (Ho 1964). Prematurely harvested achenes are nonviable (Gill 1939). Light is required for germination (Ho 1964; Wesson and Wareing, 1967; Aarssen, 1981). Germination patterns vary across the plant's distribution, presumably in response to some climatic parameters. In British Columbia there are two germination peaks, in spring and autumn (Ho 1964), whereas in south-eastern Australia most germination occurs in autumn (Leigh and Mulham 1965). In laboratory experiments in Canada, Ho (1964) found 68% germination immediately after harvesting, decreasing to 58% after 1 month of dry storage at room temperature and after 2 months decreasing markedly to 4%. In contrast, Cameron (unpublished data) using achenes harvested from populations of *H. radicata* on the Northern Tablelands of New South Wales, found under similar storage conditions, that germination varied from 62% to almost 100% for freshly harvested achenes, decreasing to 60% after 1 month of storage and to 34% after 2 months. Even after 12 months' storage at room temperature, the achenes achieved a germination level of 19%.

Hybrids

Hybridization occurs readily between *H. radicata* ($2n = 8$) and *H. glabra* ($2n = 10$), producing an F_1 with $2n = 9$ (Turkington and Aarssen 1983). Hybrids probably occur occasionally where the parents grow together: in Britain they have been recorded occasionally in parts of Wales and southern England and are also known from Germany, Switzerland and Sweden. No hybrids have been recorded in Australia (Everist, pers. comm.), though they possibly exist where both species co-exist. Hybrids are short-lived and have characteristics of leaf and inflorescence intermediate between those of the two parent species. The leaves of the hybrid are usually hairier than in *H. glabra* though the degree of hairiness depends on the *H. radicata* parent. The capitula are intermediate in size between those of the two parents (Turkington and Aarssen 1983). Although fertility of F_1 hybrids is reduced to about 1%, viable backcrosses to *H. radicata* as pollen parent have been produced experimentally and occur in natural populations (Aarssen 1981). Backcrosses with $2n = 8$ are fully infertile with *H. radicata* (Parker 1975).

Population dynamics

H. radicata competes well with other grassland species. It has been known to displace every other plant in pastures in Britain including white clover *(Trifolium repens)* and in less than 3 years to destroy good pastures (Ridley 1930). Although such extensive colonization does not appear to have occurred in Australia, *H. radicata* is a common weed of grasslands and lawns and is a troublesome weed of irrigated pastures on the Riverine Plain (Leigh and Mulham 1965). In Australia the species is a successful colonizer of sclerophyll forests, spreading from roadsides (Amor and Stevens 1976). This contrasts with the situation in Britain where it is almost totally absent from intact woodland.

H. radicata may have allelopathic effects on other species (Aarssen 1981). Leachates

from pots of *H. radicata* reduced the dry weight of shoots of several grassland species (Newman and Rovira 1975). The species appears to be autotoxic, i.e. it is inhibited more by exudate from its own species than from other species (Newman and Rovira 1975). This characteristic has been used to explain an apparent phenomenon of the species being usually found as isolated individuals or small groups of individuals and not as pure stands (Aarssen 1981). However, in Australia Maiden (1917) complained that *H. radicata* often formed patches 'to the exclusion of most other vegetation' (Maiden 1917, p.124). The variability of this aspect of the population dynamics of the species requires clarification.

Importance

Detrimental

H. radicata possesses many typically weedy attributes: prolific reproduction, rapid spread and a large, deep root system making it persistent. It can be a troublesome weed in lawns, golf courses, ploughed fields and along roadsides. Its impact in Australian agriculture has not been dramatic but the plant readily colonizes ploughed fields, untended paddocks, irrigated pastures and unimproved pastures. In Australia, *H. radicata* has been suspected of causing stringhalt in horses, an involuntary flexing of one or both hind legs brought about by ennervated tendons (Hurst 1942). There is no scientific evidence to support this contention (Leigh and Mulham 1965), although cases have been reported from parts of the coast, tablelands and slopes of New South Wales, despite the failure of feeding tests and grazing trials to produce any stringhalt symptoms (Whittet 1968). The plant is, nevertheless, suspected of being unwholesome as fodder (Salisbury 1964) both in Australia and Britain, though it has some attraction for grazing animals (see below). The rosettes of *H. radicata* often harbour slugs which may be injurious to other plants (Healy 1962).

Outside the agricultural arena, *H. radicata* assumes importance in Australia as a weed of native plant communities. It is a very successful colonizer of sclerophyll forests, often spreading from roadsides and other disturbed areas (Amor and Stevens 1976) but also occurring in undisturbed native plant communities (Cameron, unpublished data). Thus, whilst *H. radicata* may be considered 'of minor importance' as a weed in the agricultural sense (Clemson 1985), its presence does have conservational significance.

Uses

H. radicata is eaten readily by stock while green and may provide a considerable portion of forage intake in some situations (Cunningham *et al.* 1981). In Australia and New Zealand it is one of the most palatable species occurring in tussock grasslands and is more productive than other herbs (Coop *et al.* 1953; Healy 1962), especially in winter (Leigh and Mulham 1966). It often invades overgrazed, underfertilized pastures and serves to offset the decline in carrying capacity (Sewell 1950; Lamp and Collet 1976). Sheep will eat *H. radicata* preferentially, often before any other grass or herb (Struik 1976). It is superior to many grasses in nutritive value and is comparable to white clover, being high in protein, low in fibre, exceptionally high in calcium and relatively high in copper content (Coop *et al.* 1953). It has been suggested in Canada that *H. radicata* be sown in grazed grasslands along with a non-aggressive grass (Stapledon 1948) but this possibility apparently has not been recognized in Australia.

The species has importance, too, in natural food chains (Radwan and Campbell 1968). Wild pigs can eat the fleshy roots and, in Canada, snowshoe hares prefer *H. radicata* over other natural vegetation and even over commercial pelleted food (Aarssen 1981).

In Australia, *H. radicata* has apicultural value. Although not a major or reliable source of honey, the plant stimulates brood-rearing in bees by providing some nectar and an abundant supply of pollen (Clemson 1985). Honey produced from the plant is yellowish in colour, with a characteristic bitter taste (Clemson 1985).

Control measures

In 1917, Maiden stated that *H. radicata* could be controlled only by means of 'a hoe or other cutting implement'. This method of control remains effective and disc harrows and rotary hoes are used on arable land. Effective control in badly infested areas is achieved by ploughing and cultivating for a year or two before re-seeding (Aarssen 1981). In other areas where the plant is troublesome, as in pastures, turf and irrigated pastures, it is readily controlled by the application of herbicides, although *H. radicata* is moderately resistant to a number of herbicides such as atrazine, dalapon, paraquat, asulam and picloram (Canada Weed Committee 1967). Spraying with 0.1% 2,4-D is effective, although several treatments may be necessary to control the weed (Whittet 1968).

Response to other human manipulations

H. radicata exhibits various responses in terms of morphology and population dynamics when either the plant itself is treated in some way or the community in which it is growing is subjected to some form of manipulation. The growth responses of *H. radicata* under four defoliation intensities were studied by Struik (1967). The treatments were mowed lawn, heavily grazed pasture, lightly grazed pasture and uncut lawn. Grazing (both light and heavy) favoured optimal sexual reproduction, and heavy grazing also produced maximum vegetative weight. Undisturbed plants produced far fewer flowers and fruits than plants that were grazed and also had significantly fewer leaves (Struik 1967). This response to grazing pressure helps explain the ready ability of *H. radicata* to colonize pastures. It also suggests either that defoliation stimulates the formation of new leaves, or that the presence of old leaves suppresses growth of new leaves (Aarssen 1981). Leaf angles were more upright in the uncut lawn than in the other treatments. In mowed lawns the leaves typically grow very close to the ground (Gilkey 1957).

In a field trial on the Northern Tablelands of New South Wales (Cameron, unpublished data), plots in sclerophyll woodland whose herbaceous layer was dominated by snow grass (*Poa sieberana*) were subjected to a number of treatments simulating natural disturbances—digging, clipping, uprooting, application of herbicide and application of fertilizer. The treated plots were then sown with seeds of *H. radicata* and two other species, namely perennial rye grass *(Lolium perenne)* and white clover *(Trifolium repens)*, both important pasture plants, either singly or in combination. Although overall germination rates were much lower in the field than in the glasshouse, *H. radicata* consistently out-performed the other two species under all treatments. The poorest response was in plots treated with fertilizer, where there was no significant difference in germination and establishment between fertilized and non-fertilized plots. These results do not, however, support the contention that *H. radicata* is suppressed by the application of organic and inorganic fertilizers (Turkington and Aarssen 1983) as the plants surviving under fertilization were much larger and grew more vigorously than those not treated with fertilizer. *H. radicata* established best where the community into which it was introduced had been disturbed by digging. It also established well where herbicide

had been applied prior to sowing and fairly well where the resident vegetation had been uprooted, thereby contradicting the claim that pigs exert some control on the plant by uprooting it (Georgia 1914). Not only can plants tolerate this treatment (Guthrie-Smith 1969), but the uprooting process itself can create sites favourable for the establishment of *H. radicata*. Seeds sown into resident vegetation which had been clipped established less well than in other treatments, but still had significantly higher rates of establishment than the other two species. A considerable number of *H. radicata* plants established in control plots where the resident vegetation of dense *Poa sieberana* was not treated in any way prior to the broadcasting of seeds. This would suggest that disturbance may not always be a prerequisite for the introduction and establishment of this or other weedy species into plant communities.

Response to parasites

Hypochoeris mosaic virus (HMV) is common in *H. radicata* in western Canada (Brunt and Stace-Smith 1978) and in Britain (Turkington and Aarssen 1982) and probably exists on the species in Australia. It is known to occur only in *H. radicata* and is of no known agricultural importance (Aarssen 1981). In New Zealand, *H. radicata* is often infested by the wasp *Aulax hypochaeridis* which causes a swelling of its stems (Parham and Healy 1976).

References

Aarssen, L. W. (1981). The biology of Canadian weeds. 50. *Hypochoeris radicata* L. *Canadian Journal of Plant Science* **61**, 365–82.

Amor, R. L., and Stevens, P. L. (1976). Spread of weeds from a roadside into sclerophyll forests at Dartmouth, Australia. *Weed Research* **16**, 111–18.

Bailey, F. M. (1909). 'Comprehensive Catalogue of Queensland Plants both Indigenous and Naturalised.' (Government Printer: Brisbane.)

Beadle, N. C. W. (1971). 'Students Flora of North Eastern New South Wales.' Botany Department, University of New England, Armidale.

Beadle, N.C.W., Evans, O.D., Caroline, R.C. (1972). 'Flora of the Sydney Region.' (Reed: Sydney.)

Black, J. M. (1909). 'The Naturalised Flora of South Australia.' (Government Printer: Adelaide.)

Brunt, A. A., and Stace-Smith, R. (1978). Some hosts, properties and possible affinities of a labile virus from *Hypochoeris radicata* (Compositae). *Annals of Applied Biology* **90**, 205–14.

Burbidge, N.T., and Gray, M. (1970). 'Flora of the Australian Capital Territory.' (A.N.U. Press: Canberra.)

Canada Weed Committee (1967). Research Report, Western Section. Canada Department of Agriculture, Ottawa.

Clapham, A. R., Tutin, T. G., and Warbug, E. F. (1962). 'Flora of the British Isles', 2nd edition. (Cambridge University Press: Cambridge.)

Clemson, A. (1985). 'Honey and Pollen Flora.' (Inkata Press: Melbourne.)

Coop, I. E., Darling, M., and Anderson, C. M. (1953). Chemical composition of some tussock grassland pastures. *New Zealand Journal of Science and Technology* **34**, 507–20.

Costin, A. B., Gray, M., Totterdell, C. J., and Wimbush, D. J. (1979). 'Kosciusko Alpine Flora.' (CSIRO/Collins: Melbourne.)

Cunningham, G. M., Mulham, W. E., Milthorpe, P. L., and Leigh, J. H. (1981). 'Plants of Western New South Wales.' (Government Printer: Sydney.)

Curtis, W. M. (1963). 'The Students Flora of Tasmania.' (Government Printer: Hobart.)

Doing, H. (1972). Botanical composition of pasture and weed communities in the Southern Tablelands Region, South-eastern Australia. CSIRO, Australia, Division of Plant Industry Technical Paper No. 30.

Dvorak, F., and Dadakova, B. (1972). Contribution to the karyological study of the species of Slovakian flora. *Biologia* **32**, 243–54.

Ewart, A. J. (1927). 'The Weeds, Poison Plants and Naturalized Aliens of Victoria.' (Government Printer: Melbourne.)

Fogg, J. M. (1945). 'Weeds of Lawn and Garden: a Handbook for Eastern Temperate North America.' (University of Pennsylvania Press: Philadelphia.)

Fryxell, P. A. (1957). Modes of reproduction of higher plants. *Botanical Review* **23**, 135–233.

Georgia, A. E. (1914). 'A Manual of Weeds.' (Macmillan: New York.)

Gilkey, H. M. (1957). 'Weeds of the Pacific Northwest.' (Oregon State College: Corvallis.)

Gill, N. T. (1939). Cutting weeds to prevent seeding. *Journal of the Ministry of Agriculture* **45**, 1255–7.

Gott, B. (1983). Murnong — *Microseris scapigera*: a study of a staple food of Victorian Aborigines. *Australian Aboriginal Studies* **2**, 2–18.

Grace, N. D., and Scott, D. (1974). Diet and mineral nutrition of sheep on undeveloped tussock grassland. 1. The macro- and micro-element of blood plasma and herbage. *New Zealand Journal of Agricultural Research* **17**, 165–75.

Guthrie-Smith, H. (1969). 'Tutira: The Story of a New Zealand Sheep Station.' (A. J. and A. W. Reed: Wellington.)

Hagerup, O. (1954). Thrips-pollination in *Hypochoeris radicata*. *Nytt Magasin for Botanikk* Oslo **3**, 55–8.

Healy, A. J. (1944). Some additions to the naturalised flora of New Zealand. *Transactions of the Royal Society of New Zealand* **74**, 221–31.

Healy, A. J. (1962). Dandelion and related rosette weeds in New Zealand. Proceedings 15th New Zealand Weed Control Conference, pp.53–85.

Healy, A. J. (1976). 'Identification of Weeds and Clovers.' (New Zealand Weed and Pest Control Society: Wellington, New Zealand.)

Hitchcock, C. L. A., Cronquist, A., Owenby, M., and Thompson, J. W. (1955). 'Vascular Plants of the Pacific Northwest', Vol. V. (University of Washington Press: Seattle.)

Ho, L. S. (1964). The Biology and Control of Some Turf Weeds. M.S.A. Thesis, University of British Columbia.

Hurst, E. (1942). 'The Poison Plants of New South Wales.' (N.S.W. Poison Plants Committee: Sydney.)

Jessop, J. (1981). 'Flora of Central Australia.' (Reed: Sydney.)

Johnston, M. E. H. (1962). Commonly occurring impurities in pasture seed. *New Zealand Journal of Agriculture* **105**, 122–31.

Kerner, A., and Oliver, F. W. (1895). 'The Natural History of Plants.' (Blackie: London.)

Lambers, H. (1979). Efficiency of root respiration in relation to growth rate, morphology and soil composition. *Physiologia Plantarum* **46**, 194–202.

Lambers, H. and Van de Dijk, S. J. (1979). Cyanide-resistant root respiration and tap root formation in two subspecies of *Hypochoeris radicata*. *Physiologia Plantarum* **45**, 235–9.

Lamp, C., and Collet, F. C. (1976). 'A Field Guide to Weeds in Australia.' (Inkata Press: Melbourne.)

Lane, D. (1976). The vegetation of roadsides and adjacent farmland of the Mornington Peninsula, Victoria, Australia. *Weed Research* **16**, 385–9.

Leigh, J. H., and Mulham, W. E. (1965). 'Pastoral Plants of the Riverine Plain.' (Jacaranda: Melbourne.)

Maiden, J. H. (1917). Weeds of New South Wales. The Cats' Ear or Flatweed (*Hypochoeris radicata* L.). *Agricultural Gazette of New South Wales* **17**, 47–8.

Maiden, J. H. (1920). 'The Weeds of New South Wales.' (Government Printer: Sydney.)

Miles, J. (1974). Effects of experimental interference with stand structure on establishment of seedlings in Callunetum. *Journal of Ecology* **62**, 675–89.

Muenscher, W. C. (1949). 'Weeds.' (Macmillan: New York.)

Mulligan, G. A. (1976). Common Weeds of Canada. Department of Agriculture, Ottawa.

Newman, E. I., and Rovira, A. D. (1975). Allelopathy among some British grassland species. *Journal of Ecology* **63**, 727–37.

Ormrod, D. J., and Renney, A. J. (1968). A survey of weed leaf stomata and trichomes. *Canadian Journal of Plant Science* **48**, 197–209.

Panigrahi, G., and Kammathy, R. V. (1961). Studies on *Hypochoeris radicata* L. (Compositae). A new record for India. *Memoirs of the Indian Botanical Society* **3**, 200–10.

Parham, B. E. V., and Healy, A. J. (1976). 'Common Weeds of New Zealand.' (Government Printer: Auckland.)

Parker, J. S. (1975). Aneuploidy and isolation in two *Hypochoeris* species. *Chromosoma* **52**, 89–101.

Percival, M. (1950). Pollen presentation and pollen collection. *New Phytologist* **49**, 40–63.

Perkins, C. E. (1883). Ballast plants in Boston and vicinity. *Botanical Gazette* **8**, 188–90.

Radwan, M. A., and Campbell, O. I. (1968). Snowshoe hare preference for spotted catsear flowers in western Washington. *Journal of Wildlife Management* **32**, 101–8.

Ridley, H. N. (1930). 'The Dispersal of Plants Throughout the World.' (L. Reeve and Co.: Ashford, Kent.)

Rumball, P. J. (1978). Some effects of a variable water table on soil and pasture in Manawatu sand country. *New Zealand Journal of Experimental Agriculture* **6**, 241–9.

Salisbury, E. J. (1964). 'Weeds and Aliens.' (Collins: London.)

Saxby, S. H. (1943). Perennial weeds. *New Zealand Journal of Experimental Agriculture* **67**, 247–51.

Sewell, T. G. (1950). Improvement of tussock grassland. *New Zealand Journal of Agriculture* **81**, 293–9.

Sheldon, J. C., and Burrows, F. M. (1973). The dispersal effectiveness of the achene-pappus units of selected Compositae in steady winds with convection. *New Phytologist* **72**, 665–75.

Specht, R. L. (1972). 'The Vegetation of South Australia', 2nd edition. (Government Printer: Adelaide.)

Stapledon, R. G. (1948). The nutritive influence of the herbs of grassland. *Farming* **2**, 86–9.

Struik, G. J. (1967). Growth habits of dandelion, daisy, catsear, and hawkbit in some New Zealand grasslands. *New Zealand Journal of Agricultural Research* **10**, 331–44.

Turkington, R., and Aarssen, L. W. (1983). Biological flora of the British Isles. No. 156. *Hypochoeris radicata* L. *Journal of Ecology* **71**, 999–1022.

Van de Dijk, S. J. (1980*a*). Two ecologically distinct subspecies of *Hypochoeris radicata* L. I. Nitrate uptake and nitrate utilization. *Plant and Soil* **56**, 465–73.

Van de Dijk, S. J. (1980*b*). Two ecologically distinct subspecies of *Hypochoeris radicata* L. II. Growth response to nitrate and ammonium, growth strategy and formative aspects. *Plant and Soil* **57**, 111–22.

Wace, N. M. (1983). The botany of the motor car. *In* 'The Best of the Science Show', ed. R. Williams, pp.70–9. (Nelson/CSIRO: Melbourne.)

Wellington, P. S. (1960). Assessment and control of the dissemination of weeds by crop seeds. *In* 'The Biology of Weeds', ed. J. L. Harper, pp.94–107. (Blackwell: Oxford.)

Wesson, G., and Wareing, P. F. (1967). Light requirements of buried seeds. *Nature* **213**, 600–1.

Whittet, J. N. (1968). 'Weeds', 2nd edition. (Government Printer: Sydney.)

Willis, J. H. (1972). 'A Handbook to the Plants in Victoria', Vol. 2. (Melbourne University Press: Melbourne.)