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Insects for biological control of hieracium in New Zealand: a progress report

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Abstract. Recently, a biological control programme was initiated to seek suitable insect control agents for four *Hieracium* species (*H. pilosella, H. praealtum, H. caespitosum,* and *H. lepidulum*) that are problem weeds of unimproved grasslands in New Zealand. A nationwide survey has determined key elements in the insect fauna of *Hieracium* species in New Zealand. There is no evidence that potential insect control agents, likely to be introduced from Europe, are already established, and initial results indicate that no other insect species have a significant impact on hieracium. Potential control agents for introduction from Europe include several specialist insects. Host-specificity tests have begun on four species: a pterophorid moth, *Oxyptilus pilosellae*, and a syrphid, *Cheilosia praecox*, both of whose larvae feed in the central growing parts of the rosette and root crown; a cynipid wasp, *Aulacidea subterminalis*, whose larvae induce large swollen galls at the base of hieracium rosettes; and a gall midge, *Macrolabis pilosellae*, whose larvae deform stolon tips and rosettes. There is some controversy as to whether hieracium is a problem weed or a symptom of poor land-management, in which case its removal might accelerate erosion. To test the impact of effective biological control on ground cover, a simulation experiment, in which hieracium is artificially removed, is in progress. Results are being obtained with and without grazing by sheep and rabbits, at three sites.

Introduction

Large areas of the drier hill- and high-country of the eastern South Island and central North Island of New Zealand are dominated by natural and semi-improved tussock grasslands. The traditional land use has been extensive pastoralism through sheep grazing, primarily for wool production. A dramatic change in vegetation composition of major areas of these tussock grasslands has occurred that threatens the established livelihoods of high-country farmers and areas valued for conservation (Kerr 1992; Wilson 1992; Cave 1995). There has been a reduction in the numbers of indigenous plant species, a marked decline in abundance of both *Festuca novae-zelandiae* (fescue tussock) and *Chionochloa* (snow-tussock) species, and a dramatic increase in both *Hieracium pilosella* L. (mouse-ear hawkweed) and *H. praealtum* Gochnat (king devil) (Treskonova 1991; Connor 1992; Kerr 1992; Scott 1993). Factors implicated in the transition are burning, over-grazing by rabbits and by sheep, and invasion of hieracium (Scott 1984; Allen *et al.* 1992; Espie and Meurk 1992; Rose *et al.* 1995).

Four of the nine naturalized species of *Hieracium* have become major problem weeds in the grasslands of New Zealand (Hunter 1991). The most widespread, *H. pilosella*, was first recorded in New Zealand in 1878 and is now abundant in the drier areas of the South Island from Marlborough to Southland, and common in central and eastern parts of the North Island (Webb *et al.* 1988). It can colonize open and vegetated areas forming tight, low mats that exclude other plant species (Hunter 1991). *Hieracium praealtum* was first recorded in 1924 and is now widespread in Canterbury and parts of Marlborough and Otago in the South Island, and on the Central Plateau in the North Island. It has a wider tolerance of both wet and dry conditions than *H. pilosella*, and is moderately shade tolerant, so is more common than *H. pilosella* in relatively intact tussock grasslands.

Hieracium caespitosum Dumort. (field hawkweed) has a more limited distribution, from Marlborough to Otago on the South Island. It is similar to *H. praealtum*, and is sometimes confused with it, leading to speculation that it may be more widespread that had previously been thought. This species was first recorded in New Zealand in 1940. *Hieracium lepidulum* (Stenstroum) Omang. (tussock hawkweed) is the only problem *Hieracium* species belonging to the group that does not produce stolons. It has been present in New Zealand since 1946 and occurs in Taranaki in the North Island, and from Nelson and Marlborough through to Otago in the South Island. Like the other three problem *Hieracium* species, *H. lepidulum* occurs in grassland but it is also common along river and stream banks, in scrub, and in forests (Webb *et al.* 1988).

Biological control of hieracium with insects and pathogens (Morin and Syrett this Volume) was first proposed by Scott (1984). Native broad-nosed weevils (*Nicaeana* spp. and *Irenimus* spp.) have been observed causing damage to *H. pilosella* and *H. praealtum* in Otago (Evans *et al.* 1994), but as these weevils are cosmopolitan feeders that destroy legume seedlings they have little potential for use as biological control agents. Initial work on European insects feeding on hieracium was conducted in Hungary (Syrett and Sárospataki 1993) and exploratory work in Europe was continued by the International Institute of Biological Control in Delémont, Switzerland (Jordan 1993; Grosskopf 1995). This paper describes the current status of the project in New Zealand and Europe comprising: (i) a survey of the insect fauna of the problem hieracium species in New Zealand; (ii) the identification, biology, and host-specificity of four European insects that may be introduced into New Zealand for biological control of hieracium; and (iii) a simulation study of the potential impact on hieracium of introduced biological control agents.

New Zealand insect survey

During the first year, 1993-1994, we collected insects from the four species of *Hieracium* identified as problem weeds (*Hieracium pilosella*, *H. praealtum*, *H. caespitosum*, and *H. lepidulum*), from 33 locations throughout New Zealand (Fig. 1). Methods used were: (i) direct observation and hand collection; (ii) suction sampler (Vortis®); (iii) whole plant removal in a soil plug; and (iv) extraction from flowers and seeds. For hand-collected material, immature insects were reared to adult on the plant species from which they were collected. Insects from the suction sampler were preserved in 70% alcohol. Whole plants were divided into leaves, shoots and roots, and each type of material was placed separately onto wire-mesh trays over dishes

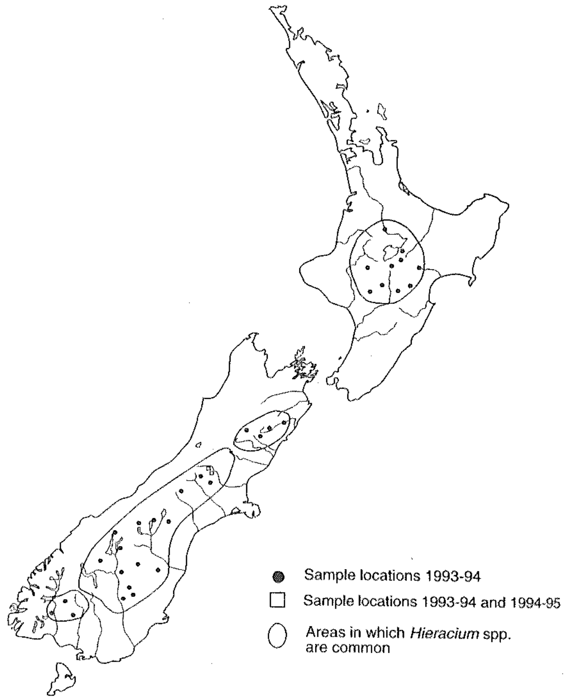

Fig. 1. Map of the New Zealand hieracium insect-survey locations, 1993-1995.

containing a glycerine-alcohol solution. Insects were extracted by applying gentle heat (30°C) and light to the plant material. A similar method was used to extract insects from flowers and seeds.

During the second year, a more intensive survey was conducted of insects from the four *Hieracium* species at two sites in Canterbury. Samples were taken once every two weeks for one summer season from 25 November 1994 to 18 April 1995. The suction sampler was used because it proved to be the most efficient means of collecting insects. For identification purposes, immature insects collected in the suction sampler were kept alive and reared to adults on the *Hieracium* species from which they were collected. Insects from the samples were sorted and identified, and for the more abundant species, the number of individuals per sample was noted for each collection date.

Fifty-seven species of phytophagous insects were identified. A few of these probably cause occasional damage to hieracium, as follows: root-feeding weevils, *Irenimus egens* (Broun), *Nicaeana* spp. (c.f. Evans *et al.* 1994); aphids *Aulacorthum solani* (Kaltenbach), *Macrosiphum euphorbiae* (Thomas), *Myzus persicae* (Sulzer); lygaeids *Metagerra helmsi* (Reuter), *Nysius* *huttoni* White, *Rhypodes anceps* (White); pentatomids *Dictyotus caenosus* (Westwood); tortricids *Epiphyas postvittana* (Walker), *Merophyas leucaniana* (Walker); and a noctuid, *Graphania mutans* (Walker). No specialist hieracium-feeding insects were recorded. We determined seasonal trends in insect numbers and species occurring on *Hieracium*. For example, both the endemic and introduced spittle bugs (*Carystoterpa fingens* (Walker) and *Philaenus spumarius* (L.)) were found on all four *Hieracium* species, and reached peak abundance in mid- to late-December (Fig. 2). Most insect species were present in low numbers and probably have little impact on hieracium plants. Insect damage observed on hieracium plants in the field was very rare, and then only minor.

Insects in Europe

During a two-year survey, insects were collected from *H. pilosella* in the German Upper Rhine Valley, the Black Forest, the Swiss Jura, the Swiss Valais and Eastern Austria. Sites were chosen to represent a variety of climatic regions in Central Europe. Of the phytophagous insects that were found in association with *H. pilosella* during the 1994/1995 field season, nine species are restricted to *Hieracium* species (Table 1). Studies of the life-histories of several of these insects are in progress and host-specificity tests have begun on four species.

Aulacidea subterminalis *Niblett (Hymenoptera: Cynipidae)*

Aulacidea subterminalis is a univoltine gall wasp. Females reproduce parthenogenetically and lay a cluster of eggs into the stolon tips. Between 5-10 eggs per stolon were found during dissections. Probing was observed to last from 1 h 10 min to 2 h 15 min. The eggs were 0.24 mm in length and 0.09 mm in width, with a stalk 1.2 mm long. Larvae induced large, swollen galls at the base of the hieracium rosettes resulting in small deformed leaves at the rosette centre. Infested rosettes were heavily deformed by late summer. Larvae overwintered within the galls to pupate in spring. Adults, which were all females, emerged from field-collected material between the beginning of May and end of June. In multiple-choice oviposition tests, galls were induced on *H. pilosella* EUR (European biotype), *H. pilosella* NZ and on *H. aurantiacum* EUR but not on any of the other 22 plant species (including five other *Hieracium* species).

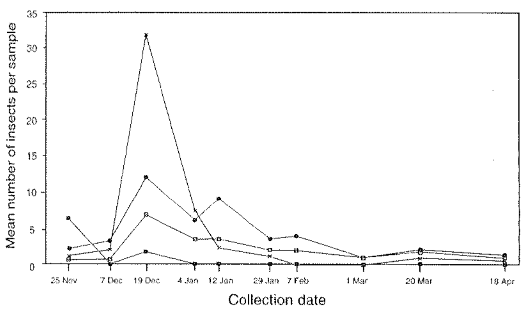

Fig. 2. Number of spittle bugs (*Philaenus spumarius* and *Carystoterpa fingens*) sampled from four *Hieracium* species in mid-Canterbury, New Zealand, during 1994-1995. Closed squares - *H. pilosella*; open squares - *H. caespitosum*; closed circles - *H. praealtum*; crosses - *H. lepidulum*.

Oxyptilus pilosellae *Zeller (Lepidoptera: Pterophoridae)*

Oxyptilus pilosellae is a univoltine species with five larval instars. Adults emerge in June, July and early August in Europe. Females lay their eggs on the hairs covering the upper leaf surface. First- or early-instar larvae overwinter in the rosette centre. The larvae feed in the rosette centre, and on the leaves and the root crown of mother and daughter rosettes. They pupate in a chamber between the lower leaf surface and the hairs covering the lower surface. No-choice larval feeding tests and multiple-choice oviposition tests are underway.

Cheilosia praecox *(Zetterstedt) (Diptera: Syrphidae)*

The larvae of this univoltine syrphid feed on young leaves at the rosette centre, and in the root crown. They pupate on, or just below, the soil surface in autumn, and the adults emerge in early spring. Gravid females lay their eggs singly at the base of the rosette leaves. Claussen (1980) observed a female ovipositing onto *H. pilosella* in the field. Field-collected gravid females provided with honey water produced 27.4 ±8.03 eggs, and the maximum number of eggs from one female was 91 (N = 11). This species develops on *H. pilosella*. Similar larvae have been found on *H. praealtum* and *H. lactucella*, and larvae from *H. praealtum* are expected to emerge in spring 1996. No-choice larval development tests are in progress.

Macrolabis pilosellae *(Binnie) (Diptera: Cecidomyiidae)*

Macrolabis pilosellae is a multivoltine gall midge that deforms stolon tips, rosettes, and adventive

Table 1. Phytophagous insects found associated with *Hieracium pilosella* L. in Europe during the 1994/1995 field season. Only insects restricted to *Hieracium* species (according to the literature) are listed. * species chosen for host-specificity testing: mm = strictly monophagous (recorded exclusively from *H. pilosella*), m = feeding on *Hieracium* spp., ? host species unknown.

Insect species	Site of damage	Specificity	Generations per year	Source
Hymenoptera				
Cynipidae				
Aulacidea pilosellae (Kieffer)	galls leaf mid-ribs, stolons	m	1	Buhr 1964
**Aulacidea subterminalis* Niblett	galls stems	mm	1	Eady and Quinlan 1963
Diptera				
Tephritidae				
Tephritis ruralis (Loew)	flower head, achenes	mm	1	White 1988
Syrphidae				
**Cheilosia praecox* (Zetterstedt) (also on *H. praealtum* and *H. lactucella?)*	rosette centre, root crown, young leaves	?	1	own investigations, Clausen (1980) observed oviposition on *H. pilosella*
Agromyzidae				
Liriomyza hieracii (Kaltenbach)	young leaves, root crown	m	?	Spencer 1972
Cecidomyiidae				
**Macrolabis pilosellae* (Binnie)	deforms developing stolons and rosettes	m	>1	Buhr 1964
Jaapiella sp.	flowerbed	?	?	own investigations
Lepidoptera				
Pterophoridae				
**Oxyptilus pilosellae* Zeller	leaves, root crown	mm	1	Hannemann 1977
Oxyptilus parvidactylus Haworth	leaves, root crown	mm	1	Hannemann 1977

rosettes. The leaves become tightly curled and do not unfold. The short-lived females lay their eggs on the plant tissue at the leaf axis. A method for multiple-choice oviposition tests is being developed.

Effects of simulated biological control on vegetation cover by artificial removal of hieracium

We are simulating the action of successful biological control agents of hieracium to predict their impact on ground cover. To gain permission to release biological control agents for hieracium in New Zealand we must demonstrate that successful biological control will not result in an even more depleted landscape through the partial removal of a group of plants that are not then replaced by others. At three sites, chosen to represent a variety of habitats where hieracium has become dominant, we are artificially removing hieracium from small plots to discover which plants, if any, will replace it.

The three study sites are a tall tussock community (snow tussock grassland with bare ground and invading *H. pilosella, H. praealtum* and *H. lepidulum*) at Lindis Pass; a short tussock partially depleted site (fescue tussock grassland with native turf, some matagouri shrubs (*Discaria toumatou*) and invading *H. pilosella, H. praealtum,* and *H. caespitosum*) at Maryburn Station in the Mackenzie Country; and a severely depleted site (sparse fescue grassland with native herbs, extensive cover of *H. pilosella* and *H. praealtum*, and substantial bare ground) at Sawdon Station near Tekapo.

Treatment plots measured 0.2x0.2 m. This was a suitable size for gaining consistent estimates of cover of predominantly small, low-growing plant species. The 40-60% cover of *Hieracium* spp. present in the treatment plots was judged to be a realistic amount for an 'effective' biological control agent to kill completely. Two treatments were used to suppress hieracium: glyphosate herbicide was hand-painted onto all or 50% of hieracium leaves and stolons in each treatment plot. Treatments were re-applied as necessary to maintain the hieracium cover at 0% and 50% of initial levels, respectively. Cover estimates were made visually by a skilled observer.

Preliminary analysis of the first two years' data indicates that total indigenous vegetation, total exotic vegetation (excluding hieracium), litter, and bare ground have increased in the treated plots. As many of the plant species are slow-growing in these environments at least one more year's data will be necessary before conclusive results are obtained.

Conclusions

Insects occurring on *Hieracium* spp. in New Zealand are having little impact on the plants, and have no significant potential as biological control agents. No insect species specialised on *Hieracium* spp. were found in New Zealand. There are promising biological control agents for introduction from Europe for *H. pilosella* and *H. praealtum*, but we still need to find species to attack the important weed species *H. caespitosum* and *H. lepidulum*. Provided that biological control simulation does not indicate detrimental effects from the removal of hieracium at trial sites, and host-specificity tests are completed to demonstrate the safety of the first two control agents, proposals for their importation will be prepared in 1996.

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