European hawkweeds are invasive in North American pastures, where mechanical methods of control are difficult and ineffective. Chemical control with broad-spectrum herbicides is not selective and relatively expensive, with the weed often recolonising untreated pastures. Insects that feed on hawkweeds in Europe have been studied as potential biological control agents for North America since 2000. Two agents have been released in Canada – the gall wasp *Aulacidea subterminalis* in 2011 and the hoverfly *Cheilosia urbana* in 2017.
The problem

European hawkweeds (*Pilosella* spp.) were introduced into New Zealand and North America where several species have become troublesome weeds in pastures, clear-cut areas and nature reserves. Seven *Pilosella* species are noxious weeds in the northwestern USA and British Columbia in Canada: *Pilosella officinarum* (mouse-ear hawkweed), *P. aurantiaca* (orange hawkweed), *P. caespitosa* (meadow hawkweed), *P. flagellaris* (whiplash hawkweed), *P. piloselloides* (tall hawkweed), *P. glomerata* (yellowdevil hawkweed) and *P. floribunda* (kingdevil hawkweed). They reproduce by seed and vegetatively, the latter resulting in mat-forming growth that outcompetes native and desirable vegetation. A lack of specialized natural enemies to keep them in check is thought to be one of the main reasons for hawkweeds becoming invasive outside their native range.

What we are doing

The project to control *P. officinarum* (syn. *Hieracium pilosella*) started in the early 1990s on behalf of a consortium of New Zealand donors. Biological control seeks to introduce host-specific natural enemies to reduce the impact of invasive weeds. A guiding principle is that these agents should not damage other plants. Five European insect species associated with *P. officinarum* were studied to assess their suitability: the plume moth *Oxyptilus pilosellae*, the gall wasp *Aulacidea subterminalis*, the gall midge *Macrolabis pilosellae* and the two hoverflies *Cheilosia urbana* and *C. psilophthalma*. All five were released in New Zealand and the two gall-forming insects established in the field.

Since 2000, the CABI team has been looking for natural enemies that could be used to control invasive hawkweeds in North America. This poses a new challenge because, in contrast to New Zealand, there are closely related native species (*Hieracium* spp.) in North America. Insects are likely to attack plants related to their natural host, so potential biological control agents for the invasive *Pilosella* spp. have to be shown not to pose a risk to these native species in the introduced range.

Results so far

Two of the species released in New Zealand were shown to be sufficiently specific for release in North America. The gall wasp *A. subterminalis* was released in Canada and the USA in 2011 and established on *P. flagellaris*. The root-feeding hoverfly *C. urbana* was approved for release by the Canadian Food Inspection Agency in 2016 and recommended for release by the USDA-APHIS Technical Advisory Group. In 2017 and 2018, eggs and adults of the hoverfly were sent to Agriculture and Agri-Food Canada (AAFC) in Lethbridge for field release.

We are investigating another gall wasp, *Aulacidea pilosellae*, in collaboration with Dr Rosemarie DeClerck-Floate (AAFC, Lethbridge) and Dr Jeffrey Littlefield (Montana State University, Bozeman). Two lineages have been identified: one is univoltine and develops on several invasive hawkweed species, and the other one is bivoltine and prefers mouse-ear hawkweed (*P. officinarum*). Under no-choice conditions (offering one plant species at a time), three or four native North American *Hieracium* species sustained limited attack from both lineages. When these species were offered together with target *Pilosella* spp. only *H. argutum* sustained attack, but only one gall was found on the test plant compared to 10 galls on the control. Both *A. pilosellae* lineages appear to have a very narrow host range. Additional host range tests are ongoing.

The rust pathogen *Puccinia hieracii var. piloselloidarum* is found on several *Pilosella* spp. in Europe but attempts at AAFC, Lethbridge to obtain sustained infection on invasive *Pilosella* spp. failed and studies with this pathogen were discontinued.

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CABI Project Manager
Ghislaine Cortat

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