Weed Biocontrol

WHAT'S NEW?

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Key contacts

EDITOR: Angela Bownes
Any enquiries to Angela Bownes
bownesa@landcareresearch.co.nz

THANKS TO: Ray Prebble

LAYOUT: Cissy Pan

CONTRIBUTIONS:
Paul Peterson, Ronny Groenteman, Hugh Gourlay

COVER IMAGE:
Honshu white admiral caterpillar

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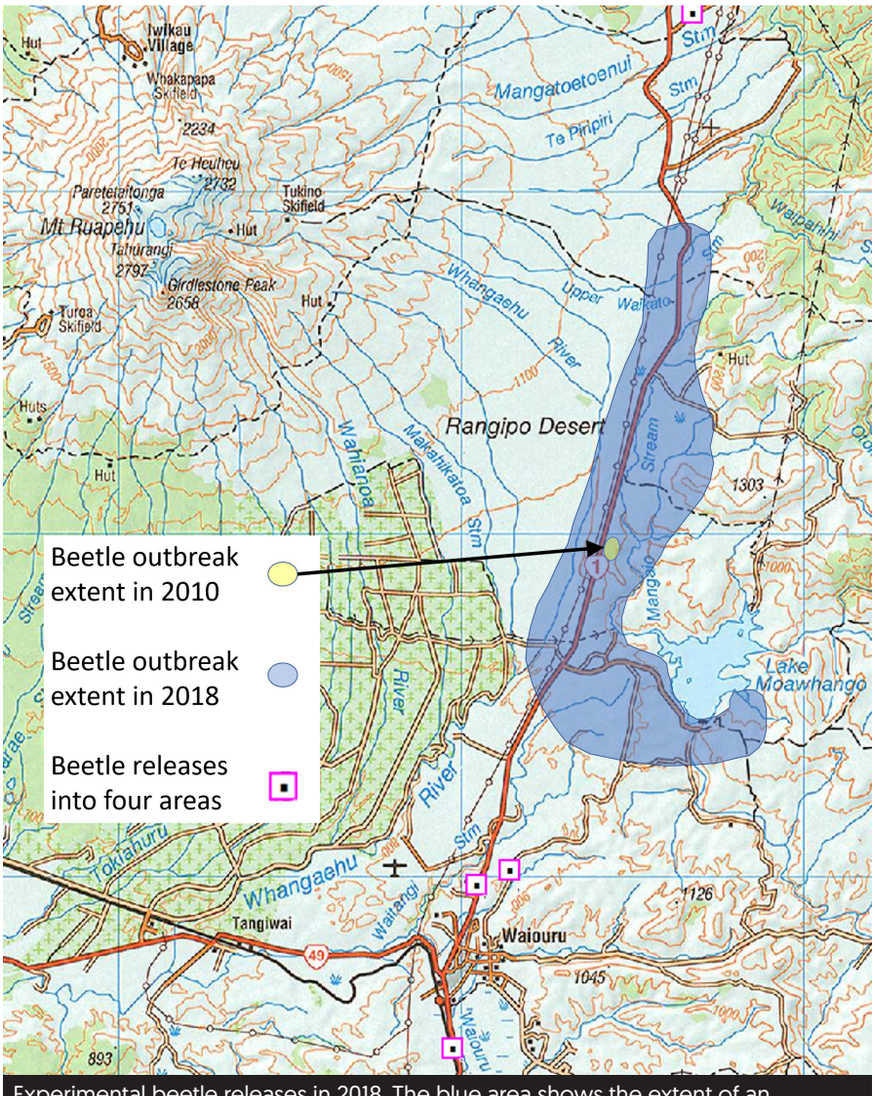
Improved Establishment Success of Heather Beetles, 25 Years Post Release

The heather beetle (*Lochmaea suturalis*) has population outbreaks in its native range in the United Kingdom, periodically causing devastating and unwanted damage to vast swathes of its host plant, heather (*Calluna vulgaris*). The heather beetle was therefore an obvious choice for biocontrol of invasive populations of heather in New Zealand.

However, to the surprise of everyone involved, the beetles initially all but failed to establish, despite the high number of releases conducted between 1996 and 1998. Only one small population survived from a total of 18 releases carried out in Tongariro National Park (TNP) in the North Island over the 3-year period. "Subsequent post-release research identified several factors likely to have contributed to the dismal establishment success of the beetle in New Zealand," said Simon Fowler, who leads the project. "These include harsh climatic conditions of the region, poor nutritional quality of heather foliage in TNP, Allee effects, and a severe genetic bottleneck," he added. Despite the low establishment rate, the one and only successful beetle population slowly increased, eventually allowing collection and redistribution to other heather sites in TNP in the 2000s.



Experimental beetle releases in 2018. The blue area shows the extent of an adjacent heather beetle outbreak in 2018 (3000 hectares) that resulted from a smaller 17-hectare outbreak in 2010 (small yellow area).

"Several of these new beetle populations started to increase nicely, particularly along the Desert Rd just north of Waiouru, which was monitored closely," said Paul Peterson, also a researcher on the project. This population of heather beetles continued to increase and spread, and by 2010 had severely damaged an estimated 17 hectares of heather.

"Then things really started to heat up from 2010 onwards," said Paul. The beetle populations started to disperse rapidly, establishing themselves on heather in and around TNP, causing extensive defoliation of vast stands of the weed. "It was difficult to keep up with the spread of beetles and to estimate the size of the damaged area," added Simon. "In late 2018, we drafted a press release with the Department of Conservation which stated that an estimated 5,000 hectares of heather had been damaged in and around TNP. By the time the article was published in early 2019, the estimate was closer to 10,000 hectares". The fact that new populations were establishing so readily in new areas, spreading so quickly, and performing so well, suggested that something had changed radically to improve the beetles' performance.

While marvelling at the impressive damage and range expansion of the beetles, the researchers began to wonder whether they had adapted to cope with some of the rigours of the TNP environment, after almost failing to establish in the 1990s. To test this hypothesis, they first needed to determine whether establishment success had indeed improved, or whether the high beetle densities were purely the result of exponential population growth. To test this, Paul made experimental releases in four areas where beetles had not yet dispersed in 2018, and monitored their establishment.

The result was amazing: 12 heather beetle populations established from a total of 14 experimental releases (85.7%). This is in comparison to a success rate of only 5.6% in the 1990s, and 38.9% in the 2000s, when 7 out of 18 releases were successful. This demonstrates a clear trend for increasing establishment success of the beetles over more than two decades, with the researchers hypothesizing that the beetle explosion in TNP in the past decade could be the result of adaptation.

However, adaptation by the heather beetle to the rigours of TNP is not the only possible explanation for the dramatically improved establishment rates. Environmental stressors in the TNP region may have been reduced as a result of environmental change. For example, climate change may have ameliorated critical aspects of the harshness of the TNP climate, resulting in shorter, less severe winters, less severe late frosts, and less snowfall in spring. Also, possibly increased air pollution may have resulted in higher nitrogen deposition on the nutrient impoverished soils of TNP, resulting in increased nitrogen uptake by heather and increased foliar nitrogen levels for the beetles (a critical element for insect growth and survival).

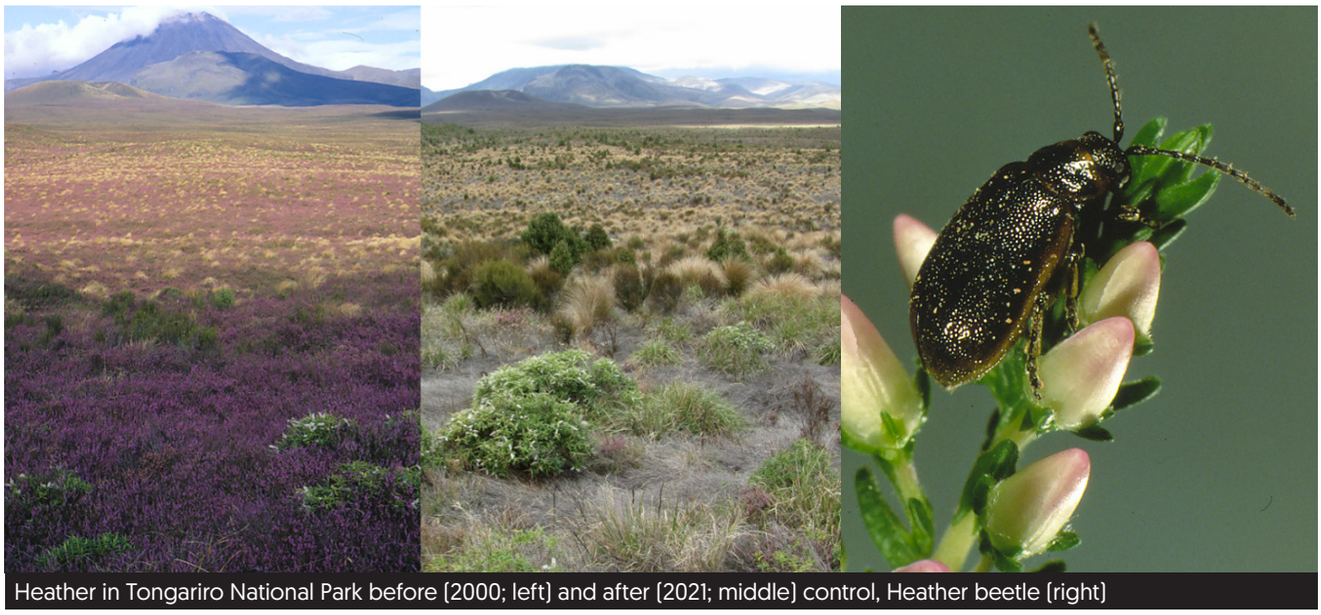
"We are currently testing these hypotheses by comparing the current climate and nitrogen levels with recorded data from earlier decades. If altered environmental conditions fail to explain the dramatically improved establishment success of the beetles, then adaptation to local conditions will be the more likely explanation," explained Paul. Demonstrating genetic adaptation will be difficult, but the following adaptive changes may be indicative: i) an increase in beetle body size, which previous research demonstrated improved overwintering survival; ii) changes to post-overwintering physiology or behaviour, resulting in increased beetle survival in the spring; or iii) improved ability of the beetles to obtain nitrogen from nutrient-deficient heather.

While solving this mystery will take some detailed investigation, heather beetles continue to spread and do the job they were released to do. Dense heather monocultures are fast becoming a thing of the past in and around TNP, and this is now one of New Zealand's great biocontrol success stories, 25 years on.

This project was funded by the Ministry of Business, Innovation and Employment as part of Manaaki Whenua – Landcare Research's Beating Weeds programme.

CONTACT

Paul Peterson – petersonp@landcareresearch.co.nz



Heather in Tongariro National Park before (2000; left) and after (2021; middle) control, Heather beetle (right)

Weeds of the Future: The Survey of Rural Decision Makers Provides a Glimpse

The Survey of Rural Decision Makers is a leading source of information on New Zealand's food and fibre sector. It is conducted by MWLR every 2 years and is completed by thousands of farmers, foresters, growers, and lifestyle block owners nationwide. It is a resource for policy makers, regional councils, industry groups, and businesses, and it is designed to build a picture of decision-making at the farm level. The high number of returns (3,740 in 2019) provides excellent insight into the challenges and opportunities facing the rural sector.

In 2019, we included a question about future weeds. The aim was to determine whether problematic agricultural weeds are flying under the radar. "We want to start scouting for low-hanging fruit – weeds that are not yet a big problem and for which biocontrol is potentially a viable solution," said Ronny Groenteman, who is responsible for analysing the responses to the question about weeds. "Weeds that are not yet a big problem are not an economic burden for farmers, and the best chance to keep them in check could be through repeat or 'piggy-back' biocontrol programmes (i.e. using agents already released against the same target weeds in other parts of the world). Piggy-back programmes are much cheaper when compared to starting a biocontrol programme from scratch," she added.

Choosing the right question on weeds proved to be quite thorny. "We wanted to give respondents the option to highlight weeds that we haven't thought about," said survey director, Pike Stahlmann-Brown. In the end, the question was simple: "Please list up to three species of weeds on your farm that never required management previously, but that you expect will require management within the next 5 years."

The results were both telling and surprising. We received 2,135 responses to the question, and roughly 290 weed species or weed groups (e.g. 'thistles', 'grasses') got at least one mention. Nearly 470 respondents said they could not easily come up with weeds they thought would become a problem in the future, or that 'the same old weeds' that are an ongoing problem will continue to be their key problematic weeds. Most weeds were mentioned only a handful of times (one to five mentions).

However, gorse (*Ulex europeaus*), thistles (*Carduus* spp. and *Cirsium arvense*), and blackberry (*Rubus fruticosus*) were mentioned over 200 times each by respondents from Northland at the tip of the North Island to Southland in the south of the South Island. "This was a surprise to us," said Ronny. "These weeds are not new. Are they becoming a problem in areas where they have not been of great concern before, or did some respondents focus on current problematic weeds rather than weeds of the future?" she questioned. Evidence of the former could be found in some of the responses, such as, "Thistles suddenly appearing … out of nowhere!!", and "in last few years I only had a small amount of gorse in one of my paddocks, that has increased considerably over the last year." However, other scenarios, such as respondents focusing on current weeds, must still be considered when interpreting the results.

Ronny and the team were particularly interested in evidence of weeds that are either expanding into new regions, such as yellow bristle grass (*Setaria pumila*), or that are new weeds on the block, such as carrot weed (*Oenanthe pimpinelloides*) and burdock (*Arctium minus*, *A. lappa*).

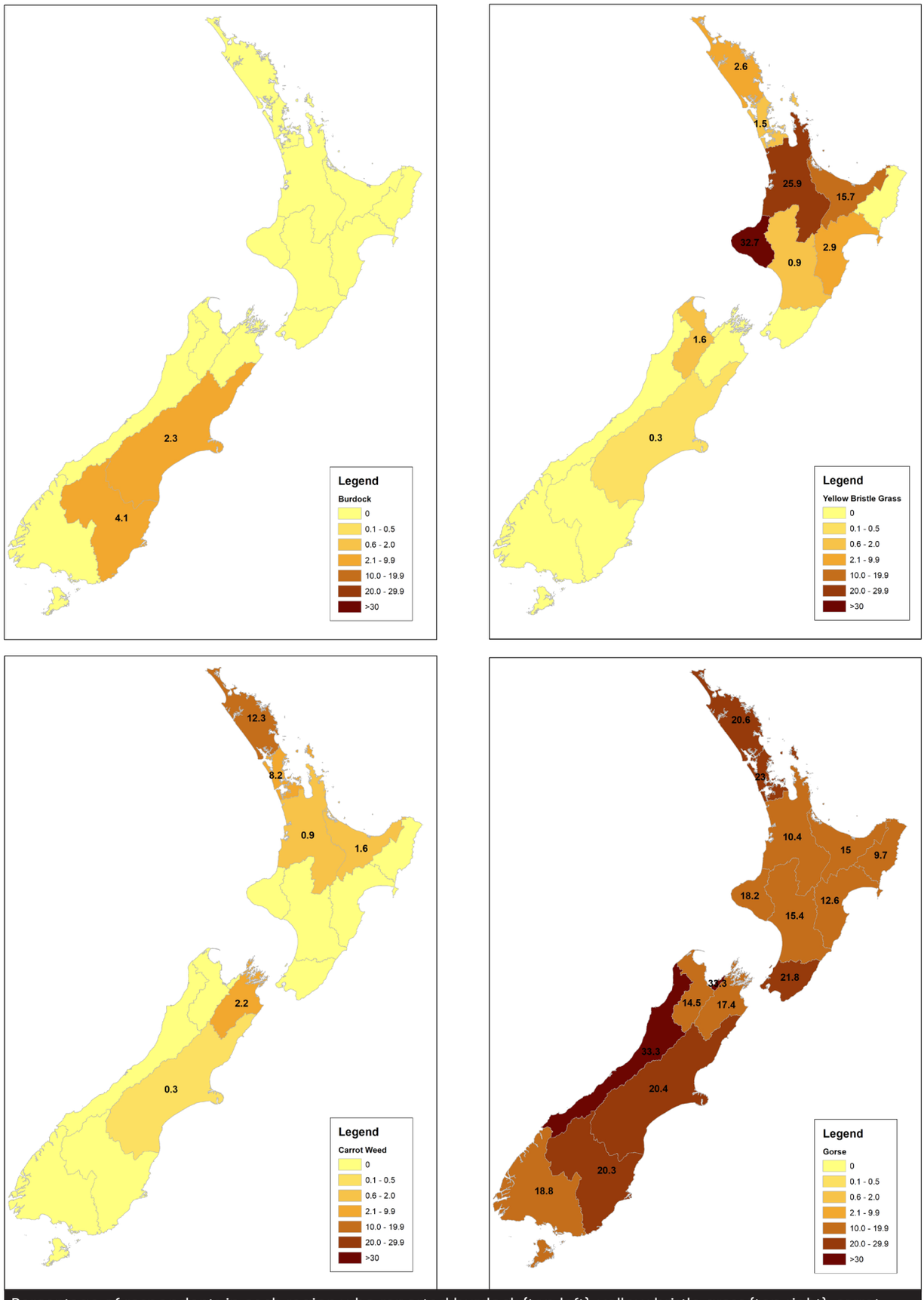
Yellow bristle grass featured in 33% and 26% of Taranaki's and Waikato's responses, respectively, while less than 3% of respondents from Northland, Auckland, Hawke's Bay, Manawatū–Wanganui, and Canterbury mentioned this weed. The 2019 survey results suggest that carrot weed is of increasing concern in Northland (12%) and Auckland (8%), but is currently only an emerging concern for respondents further south in Waikato (1%), Bay of Plenty (1.5%), Marlborough (2%), and Canterbury (0.3%). "This suggests we should watch out for its spread," said Ronny. "Burdock was mentioned in only two regions – Canterbury by 2% and Otago by 4% of respondents – which could be indicative that it is just starting to rear its ugly head," she added.

These are just a few examples of the many weeds we should keep a watchful eye on in future surveys, while actively looking for 'piggy-back' biocontrol options in the interim. The question about weeds will be repeated in future surveys, but for now, three old, notoriously weedy invaders are still high on the minds of rural decision makers when considering the weeds that are likely to make them lose sleep in the coming years.

More details on the Survey of Rural Decision Makers are available here: www.landcareresearch.co.nz/discover-our-research/environment/sustainable-society-and-policy/survey-of-rural-decision-makers/

The 2021 Survey of Rural Decision Makers will be out in June and will remain open for 3 months. Take part in the 2021 Survey of Rural Decision Makers by signing up here: www.surveymonkey.com/r/DP9B8Q7

This project is funded by the Ministry for Primary Industries. The weed question in the Rural Decision Makers Survey was funded by the Ministry of Business, Innovation and Employment as part of Manaaki Whenua – Landcare Research's Beating Weeds programme.



Percentage of respondents in each region who reported burdock (top left), yellow bristle grass (top right), carrot weed (bottom left) and gorse (bottom right) as a future concern.

CONTACT

Pike Stahlmann-Brown – brownp@landcareresearch.co.nz
(Survey of Rural Decision Makers)

Ronny Groenteman – groentemanr@landcareresearch.co.nz
(Weeds of the future in the rural sector)

New Faces

Temo Talie (Auckland)

Temo Talie

Temo joined MWLR in January 2021 as programme co-ordinator of the Natural Enemies Natural Solutions (NENS) programme, which aims to develop weed biocontrol agents for high-priority weeds in Pacific Island countries and territories. Temo is currently based at our Tamaki site in Auckland, but he will eventually relocate to Apia, Samoa. Here, he will work closely with collaborators from the Secretariat of the Pacific Regional Environment Programme (SPREP) to support the co-ordination and successful implementation of the NENS programme.

Before joining MWLR Temo worked as Research Programme Coordinator for the University of Auckland's Bioengineering Institute (ABI). His role at ABI focused on supporting researchers in all aspects of research, including identifying funding opportunities, developing research proposals and budgets, quality assurance of proposals, contracting of awarded grants, and risk identification and mitigation. Temo was also the subject matter expert for US federal funding procedures and financial management procedures for short-term activities conducted at the University of Auckland.

Temo has an academic background in environmental management and has a keen interest in helping to address invasive species problems in the Pacific region, which are the leading driver of biodiversity loss.

CONTACT
Temo Talie – taliet@landcareresearch.co.nz

Alana Den Breeyen (Auckland)

Alana joined MWLR in March 2021 as a plant pathology researcher. Alana is based at our Tamaki site in Auckland, where she will also manage the Beever Plant Pathogen Containment Facility.

Before joining MWLR Alana worked as a plant pathologist in the Weed Research Division at the Agricultural Research Council – Plant Health and Protection (ARC-PHP), based in Stellenbosch, South Africa. Her role at ARC-PHP focused on investigating a diverse suite of fungal pathogens for the control of a wide range of invasive plant species.

Alana has an extensive knowledge of fungal biocontrol agents on invasive plants, and she will contribute to the research on the biological control of weeds using plant pathogens in natural and productive sector ecosystems, both in New Zealand and overseas. She will also contribute to other plant pathogen-based research.

CONTACT
Alana Den Breeyen – denbreeyena@landcareresearch.co.nz

Alana Den Breeyen

Hieracium Biocontrol: Where to from Here?

During January and February 2020 a survey to assess the establishment and impact of the biocontrol agents for hieracium/hawkweed (*Hieracium* and *Pilosella* species) was carried out in the Central Plateau of the North Island, and in Canterbury and Otago in the South Island. Of the five agents released between 1999 and 2002, only two, a gall wasp (*Aulacidea subterminalis*) and a gall midge (*Macrolabis pilosellae*), were recovered.

While establishment and spread of these two biocontrol agents has been extensive, particularly for the gall midge in the North Island and the gall wasp in the South Island, impacts leading to a reduction in hieracium cover have only been recorded from damage by the gall midge in the north (percentage cover was reduced by 18%). According to Paul Peterson, who leads the project, the lack of impact by the gall wasp in the South Island appears to be due to a lack of stolons at the drier, more exposed hieracium sites. "Although an average of 67% of stolons are galled by the wasp, only 7% of hieracium plants growing in these environments have stolons, which would severely limit establishment and population growth of the wasp," explained Paul. "In hindsight, natural enemies that attack the crown or seeds of hieracium may have been more damaging biocontrol agents," he added. Although the gall midge does attack the crown of hieracium plants, it has not established well in the South Island, apparently performing better at wetter, less exposed sites more commonly found at North Island hieracium sites.

Given the limited impacts of the hieracium biocontrol agents, new genotypes of the gall wasp and gall midge, or larger releases of the agents that failed to establish, or new biocontrol agents altogether, may help improve control levels of hieracium in New Zealand. However, before embarking on native range surveys for new agents, it was important to establish the origins of the hieracium species in New Zealand, and to determine whether new forms (genotypes) are present so that we know where to focus our search.

In 2004 a DNA study by Trewick and colleagues found that the majority of mouse-ear hawkweed (*Hieracium pilosella*) samples in New Zealand consisted of only two haplotypes, which indicated this species is primarily reproducing asexually (via parthenogenetic seed), and that it most likely originated from Eastern Europe. This same DNA analysis was recently repeated on hieracium samples collected in 2021 from some of the same sites that Trewick originally sampled in the early 2000s. "We also collected samples from areas of rapid spread of hieracium to help understand which mouse-ear hawkweed genotypes are driving the range expansion," explained Paul. "The results corroborated findings from the 2004 study and provided confirmation that new forms of mouse-ear hawkweed are not present in New Zealand".

Gall midge damage

However, the existing forms of mouse-ear hawkweed, the worst invasive hawkweed species in New Zealand, may still have some capacity for sexual reproduction, which would increase genetic diversity. "Breeding systems in hieracium are very complicated," said Gary Houliston, who is part of the molecular research team. "Consequently, the best way to ensure that potential biocontrol agents found in Eastern Europe will attack our hieracium is to test New Zealand plant material in feeding trials," he added. Interestingly, a Mackenzie Basin farmer, Gavin Loxton, who has had significant input into the project, suggests that if plantings of New Zealand hieracium seeds conducted alongside motorways in Germany in the 1990s and 2000s yielded long-lived populations, it would be an ideal place to initiate the search for agents adapted to New Zealand hieracium.

Although there are a number of promising options available to boost the biocontrol effort against hieracium any further work will be dependent on continued support for the programme. The land tenure review process has resulted in areas of previously unmanaged land becoming intensively managed. This has resulted in the exclusion of hieracium, independent of the impacts of biocontrol, due to irrigation, cultivation and fertilisation. Therefore, 20 years on, concerns over hieracium management have shifted towards the last remaining unmanaged land areas, including the conservation estate. End-user interest in funding further biocontrol research for these areas would need to be reassessed.

This project was funded by AgMardt.

CONTACT
Paul Peterson – petersonp@landcareresearch.co.nz

Educating Our Youth with Honshu White Admiral Butterflies

Waikato District Council, in collaboration with MWLR and Enviroschools, has initiated a weed biocontrol education programme for schools in the Waikato District. Enviroschools is an environmental action-based programme that empowers young people to design and lead sustainability projects in their schools and neighbourhoods.

The focus of this initiative is to teach our next generation about the benefits and practicalities of weed biocontrol. MWLR staff were asked to provide training for schoolchildren in the Waikato district using projects designed for both the field and the classroom. Three schools in the area participated in the introductory phase of the project, where children were taught how to care for Honshu white admiral butterflies (*Limenitis glorifica*), and later how to release them in areas invaded by its weedy host plant, Japanese honeysuckle (*Lonicera japonica*).

A few weeks ago, in April, Hugh Gourlay and Arnaud Cartier visited three schools in the Hamilton region (Tauwhare, Tamahere and Otaua) and spoke to children between ages 6 and 12 at each school. Hugh talked about what makes a weed, how big the problem is in New Zealand, and how biocontrol can help, with particular emphasis on prominent weeds in the Waikato.

As part of the practical component of the project, each class was presented with young Honshu white admiral caterpillars and a few eggs, which they were required to hatch, feed and rear in cages with Japanese honeysuckle plants. Adrienne Grant (Enviroschools NZ), a local advocate for restoration projects, helped to set up the cages with potted Japanese honeysuckle plants in each classroom prior to the arrival of the caterpillars. Adrienne also collected foliage from local Japanese honeysuckle plants for the children to maintain in glass jars, so they had more fresh food available for the caterpillars. With winter nearing, the caterpillars will soon start preparing to overwinter so they shouldn't be too hungry. The children were given a chance to look at the butterfly eggs under the microscope and, for a lucky few, to watch them hatch. Also, as part of the class activity, Hugh handed out gorse (*Ulex europaeus*) pods to open to see if they could find a caterpillar of the gorse pod moth (*Cydia succedana*). Almost every seed pod had a moth caterpillar, much to the excitement and engagement of the children.

Children looking at Honshu white admiral caterpillars

Arnaud helping children with gorse seed pods

"All in all, it was a successful start to the programme, and everyone thoroughly enjoyed themselves, especially me and the kids!" said Hugh. "The next step will be for the children to release the successfully reared caterpillars when they turn into butterflies next spring, which will be another wonderful learning experience," he added.

Follow-up initiatives will build on this pilot project and will explore more educational opportunities to include weed biocontrol in classroom- and field-based activities at these schools.

This project is funded by the Environmental Initiatives Fund and Waikato District Council.

CONTACT

Hugh Gourlay – gourlayh@landcareresearch.co.nz