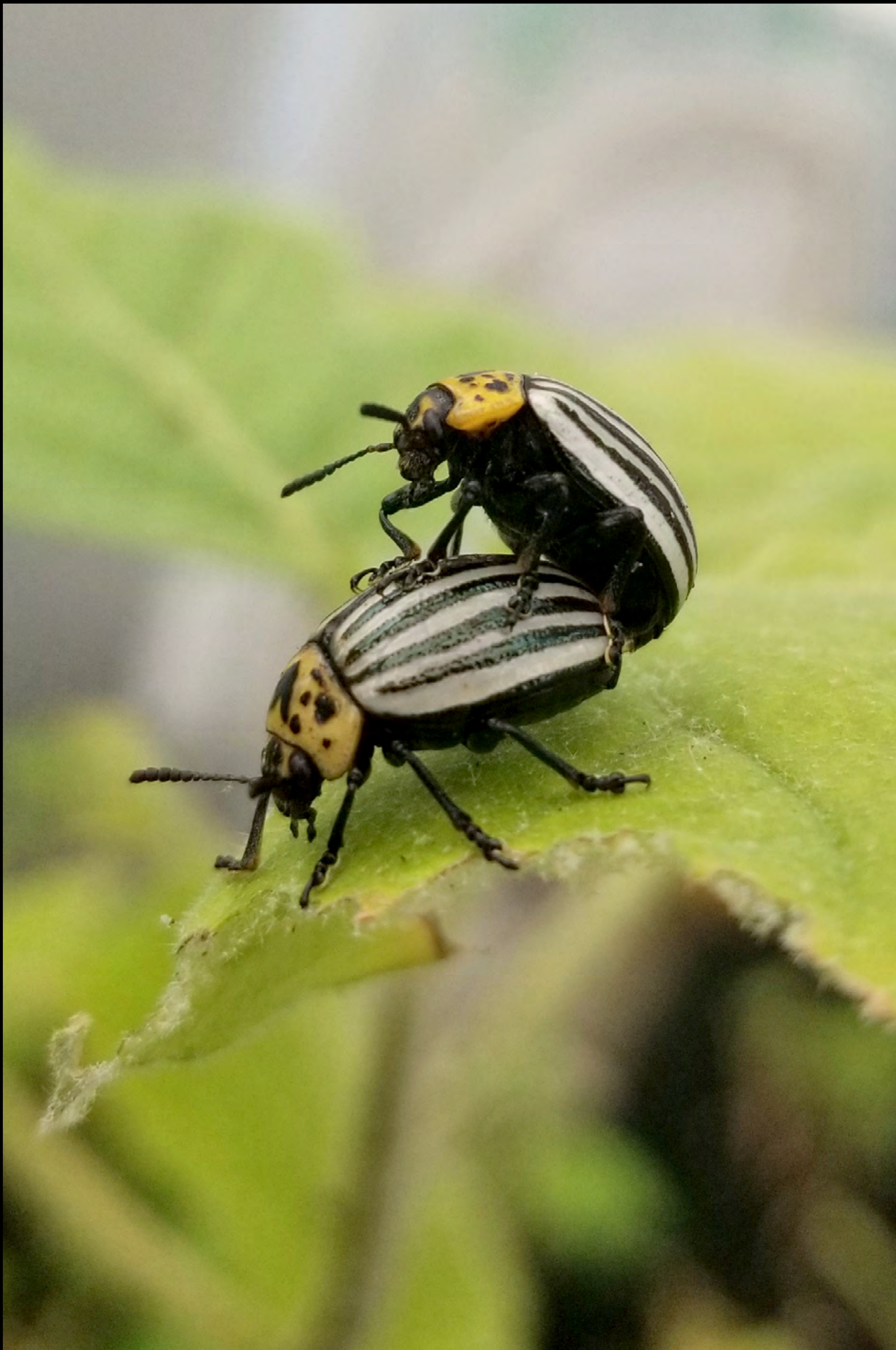
#104

MAY 2023

Manaaki Whenua
Landcare Research

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:
Andrea Clavijo-McCormick, Lindsay Barber, Hugh Gourlay, Ronny Groenteman, Quentin Paynter, Stephanie Morton

COVER IMAGE:
Pico beetle *Leptinotarsa undecimlineata*

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Chemical Communication Between Native and Introduced Plants and Insects

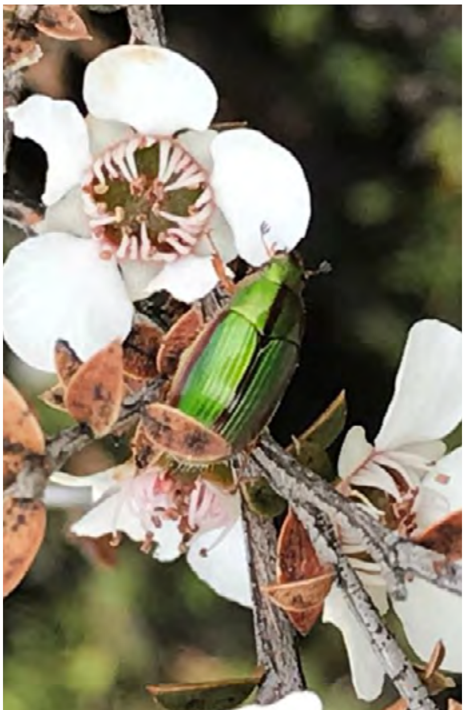
Chemical signals such as plant scents are one of the main mechanisms by which plants communicate with other plants, animals, and microorganisms. For example, floral and fruit aromas in combination with other signals attract pollinators and seed dispersers. Herbivores use plant smells to identify suitable host plants and to make foraging decisions, but plants can also use their scent as a defence mechanism, by repelling herbivores or attracting predators of those herbivores. The interactions between plants and insects are products of a long evolutionary history between co-existing species, involving both the emitter (plant) and receiver (insect), giving rise to a wide variety of plant scents and insect olfactory specialisations.

How is this relevant to weed biocontrol?

When introduced species colonise a new ecosystem they engage in new chemical interactions with the native species, potentially modifying existing interactions between these native species. Dr Andrea Clavijo-McCormick (Massey University) and her team are exploring chemical communication between native and introduced plant and insect species in the Central Plateau of New Zealand. The volcanic plateau, which is a dual UNESCO world heritage site due to its cultural and natural value, is heavily invaded by heather (*Calluna vulgaris*). The heather beetle (*Lochmaea suturalis*) was introduced in 1996 as a biocontrol agent after rigorous host testing to ensure that it will not attack non-host plants. Before the introduction of heather and the heather beetle the area was dominated by native plants and insects, including mānuka (*Leptospermum scoparium*) and the mānuka beetle (*Pyronota festiva*). There are anecdotal suggestions that the mānuka beetle might feed on heather, but this has not been tested scientifically. Dr Clavijo-McCormick's research used a chemical-ecology approach to explore plant–plant and plant–insect interactions between heather, mānuka, the heather beetle, and the mānuka beetle.

Plant–plant interactions

Initial observations from the field suggested that mānuka plants growing in heather-invaded areas produce significantly less scent than when they are paired with other mānuka plants or with other native plant species. In other words, 'they go quiet'. The mechanisms behind this phenomenon remain to be elucidated, but it could be attributed to changes in soil properties brought about by heather, or changes in resource allocation by the native plant to prepare for competition; for example, by investing more energy in root growth than in producing scents, reducing apparency to herbivores to minimise attack, or a combination of these factors. A controlled experiment using potted plants that were not in contact with soil revealed similar results, suggesting that airborne signals are sufficient to carry information



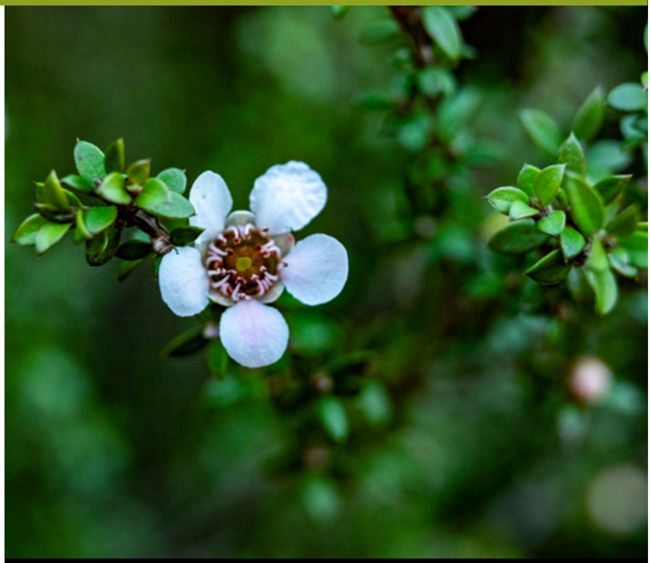
Mānuka beetle

about the identity of nearby plants and elicit a physiological response in the receiving plant.

Plant–insect interactions

A series of laboratory assays was conducted to test the olfactory and feeding preferences of the two beetle species. Beetles were offered their host plant and non-host plant volatiles versus clean air, and their combination in a Y-tube olfactometer. As a follow up, beetles were offered fresh plant material from each plant alone and in combination in a Petri dish. The native mānuka beetle performed poorly in discriminating between its host (manuka) and non-host (heather) plants based on olfactory cues only. However, in the Petri dish tests where other cues (i.e. visual, gustatory, tactile) were present, it showed a preference for mānuka over heather, but fed on heather when it was the only available option. In contrast, the introduced heather beetle showed high host-specificity towards its host in both Y-tube and Petri dish tests.

This work suggests that invasive weeds have the potential to affect chemical communication between native plants and insects by modulating the native plant's chemical emissions. The effects of these changes on native pollinators, herbivores, and their predators require further study. Dr Clavijo-McCormick's study also suggests that some native insects may not be able to efficiently discriminate host vs non-host plants, with more generalist species probably using the invasive plant as an alternative host. Feeding on a non-suitable host can have consequences for insect fitness (growth, reproduction, and survival) and could lead to diminished populations or even local extinction over time. On the flip side, nearly 30 years after its initial release the heather beetle remains highly host specific, posing no risk to native plants.



Mānuka

Further reading

Effah E, Barrett DP, Peterson PG, Potter MA, Holopainen JK, Clavijo-McCormick A 2020. Seasonal and environmental variation in volatile emissions of the New Zealand native plant *Leptospermum scoparium* in weed-invaded and non-invaded sites. Scientific Reports 10: 11736. DOI: 10.1038/s41598-020-68386-4

Effah E, Svendsen L, Barrett DP, Clavijo-McCormick A 2022. Exploring plant volatile-mediated interactions between native and introduced plants and insects. Scientific Reports 12: 15450. DOI: 10.1038/s41598-022-18479-z

This project is funded by the Marsden Fund of the Royal Society of New Zealand

CONTACT
Andrea Clavijo-McCormick – A.C.McCormick@massey.ac.nz

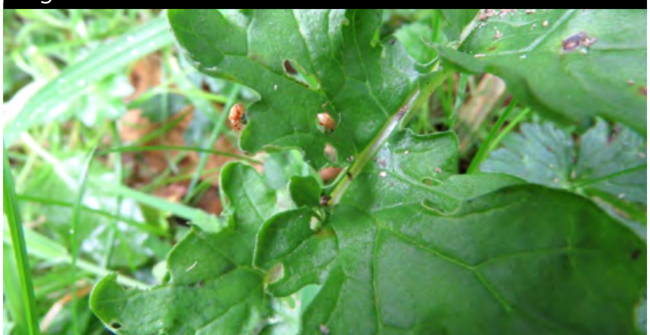
Have You Seen Ragwort?

Reports of new infestations of ragwort from landowners and stakeholder organisations have increased over the past few years, particularly during this last season. These reports have been accompanied by requests for the use of its biocontrol agents, the ragwort flea beetle (*Longitarsus jacobaeae*) and the ragwort plume moth (*Platyptilia isodactyla*). This warrants further investigation to determine whether these very effective biocontrol agents are present at the problematic sites.

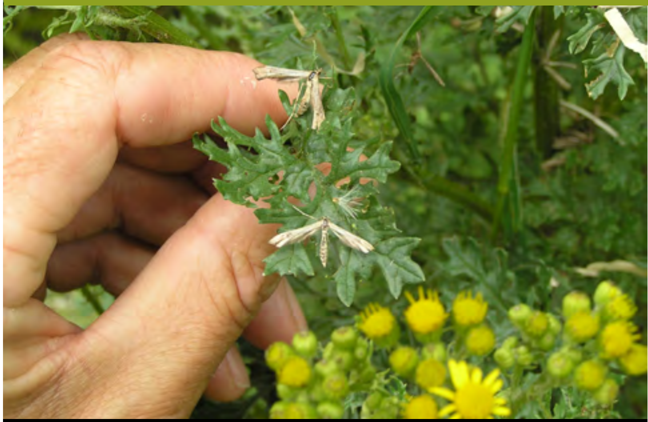
As a start, senior technician Hugh Gourlay contacted several farm owners, and regional council and Department of Conservation staff, to look for the insects, take photos of the damage, and make estimates of the extent of the ragwort infestations.

From the reports Hugh has received so far the flea beetle is present at most of the sites in both the North and South Islands. The plume moth has been absent from most of the sites except for Wellington, although autumn is not the best time of year to be looking for it. If you would like to add to our data set to help us understand the reason for increased

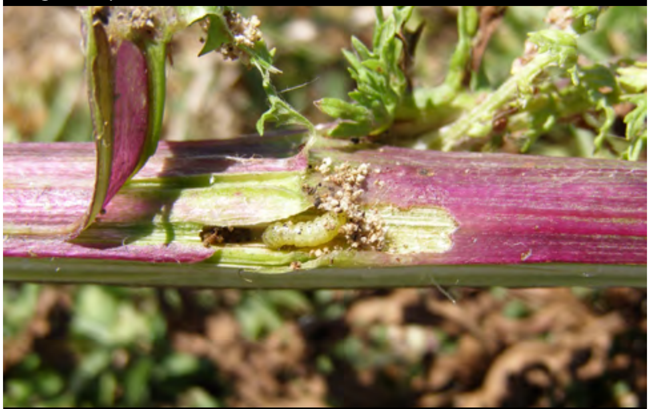
Ragwort flea beetle adult



Beetle feeding damage



Ragwort plume moth



Ragwort plume moth larva

reports of ragwort problems, you can help by following the instructions below.

1. Take a photo of your ragwort infestation.
2. Inspect some ragwort plants to looks for signs of damage, as seen in the photos. Rosette plants have small holes in the leaves like shotgun pellets. You may even see adult beetles.
3. If the plants have upright stems and flowerheads/seedheads, pull the stems apart to see if you can find any larvae, as seen in the photo.

Please return your report, with photographs, to: gourlayh@landcareresearch.co.nz.

Thank you for your help!

CONTACT
Hugh Gourlay – gourlayh@landcareresearch.co.nz

Farewell Lindsay Vaughan

Sadly, Lindsay Vaughan, former Tasman District Council biosecurity/biodiversity coordinator, passed away on 5 April 2023 at the age of 76. Lindsay suffered a recurrence of blood cancer and chose not to undergo chemotherapy again.

Following a long career in the forestry industry Lindsay took up a position at Tasman District Council as a policy planner. In this role he prepared the Tasman–Nelson Regional Biosecurity Strategy 2007–2012 and was later appointed as biosecurity coordinator, responsible for three biosecurity officers. He was also in charge of the rapidly increasing biodiversity realm and oversaw two contractors employed to survey Protected Natural Areas throughout the Tasman region. He was also involved in the Cobb Mitigation Fund and the Tasman Environmental Trust, which fostered and provided funding support for biodiversity work. Lindsay enthusiastically organised Biodiversity Forum meetings, inviting interesting guest speakers with expertise in biodiversity and biosecurity.

After the accidental arrival of Argentine ants to the Tasman region in 2001, Lindsay became avidly involved in the control and mapping of Argentine ants, and followed the research being done on control methods closely. He had a similar interest in the ongoing biocontrol research on invasive vespid wasps being undertaken by Manaaki Whenua – Landcare Research (MWLR).

Lindsay was an enthusiastic advocate for biodiversity and biosecurity and was on the New Zealand Biosecurity Institute Executive for many years as the Top of the South branch chairman. Lindsay actively participated in NZBI's National Education and Training Seminar.

We thank Lindsay for his support of our work at MWLR. He will be missed.

CONTACT
Lindsay Barber – Lindsay.Barber@tasman.govt.nz

Lindsay Vaughan

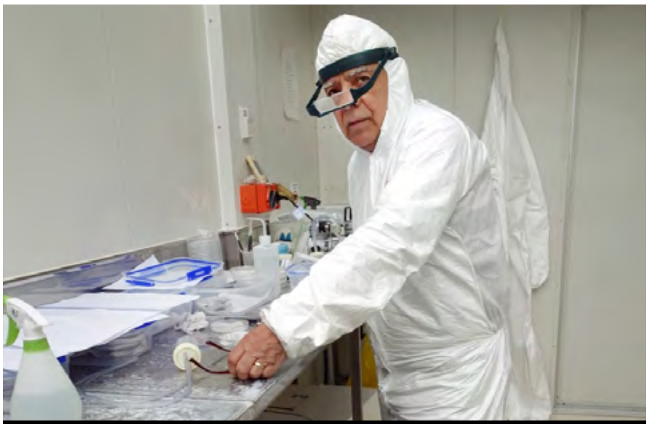
CFC Beetle Living up to its Promise

The Chilean flame creeper leaf beetle [*Blaptea elguetai*] was a serendipitous discovery on Chilean flame creeper [*Tropaeolum speciosum*] in Chile during a 2019 survey for agents for Darwin's barberry. Fast forward to early November 2022 with the New Zealand borders reopened, and our collaborator from Chile, Dr Hernan Norambuena, travelled to Christchurch with a precious cargo of 65 adult beetles and 450 of their eggs. Hernan had to make several collecting trips over several weeks to get enough adults, and since they were already laying eggs he had to slow things down to avoid many of them hatching before arriving in New Zealand. Hernan managed to time everything perfectly! Only a handful of eggs hatched while in transit, and the others started hatching soon after arrival – enabling us to get the host specificity testing underway within a couple of days of Hernan's arrival. The adult beetles continued to lay eggs throughout spring and summer, providing an excellent supply of larvae for the tests.

The first batch of plants on the test list are the species most closely related to Chilean flame creeper: species in the genus *Tropaeolum*. They comprise five climbing *Tropaeolum* species, which are grown as ornamentals [one of which has edible tubers], and two species of nasturtium. Not surprisingly, all of the *Tropaeolum* species are acceptable hosts to the beetle. Interestingly, the climbing *Tropaeolum* species all produce their foliage in winter, when both Chilean flame creeper and the beetle are dormant. It is likely that this seasonal offset will preclude any non-target attack. Also, Hernan could not find the beetle on these potential host plants in the wild in Chile in his late winter/early spring surveys the previous year. In fact we had to grow these hosts in a controlled environment mimicking winter to ensure we had foliage for testing when the beetles are naturally active.

Next, we tested a group of species and genera more phylogenetically distant from the genus *Tropaeolum*. The closest relatives in this group are two tropical species, papaya and moringa, two unlikely candidates to ever be in proximity of Chilean flame creeper, which is a serious weed in climatically cool regions of the South Island. These test plants also had to be maintained in a controlled environment to encourage growth, except in this case it was a perpetual summer environment that had to be mimicked.

The largest group of species we tested are in the family Brassicaceae, the cabbage family, which is in the plant order Brassicales along with the genus *Tropaeolum*. The Brassicaceae was a crucial family to test, with numerous native and economically important species and varieties. "We needed to think hard about which species and varieties will be sufficiently representative of the family," explained Ronny Groenteman, who is leading the project. "After much deliberation, we landed on five indigenous species and five commercially grown species, two of them represented by three varieties each," she added.


Hernan in containment

All of the tests Ronny and team conducted were 'no-choice', meaning that the beetle larvae were presented with the test species alone in Petri dishes. Under such conditions we do expect larvae that must eat or die to nibble on some test plants that are closely related to the target weed. Indeed, some larvae did nibble on some hosts, and a few even managed to develop through a few larval stages. One individual each managed to develop to the adult stage on moringa, Chinese cabbage, and pak choi.

A preliminary data analysis calculated a risk score for moringa and Chinese cabbage becoming field hosts at less than 5%. This is before taking into account the low likelihood of these potential host plants growing in the vicinity of Chilean flame creeper. The risk score for pak choi was higher at around 24%, which is slightly more concerning, warranting further investigation into this species next spring to adequately assess the potential risk.

During testing we learnt a lot more about the biology of the beetle. Under stable conditions in the containment room the new generation adults started ovipositing fertile eggs without going through a dormant period. This may suggest that a winter diapause for egg production is not obligatory, or perhaps that the beetle has multiple generations per year.

There is still a lot to learn about this beetle, but suffice to say it is looking sufficiently host specific for release in New Zealand. We will soon start pre-application consultation for an EPA release application for the Chilean flame creeper leaf beetle.

This project is funded by the Ministry for Primary Industries' Sustainable Food, Fibre and Futures Fund [Grant #20095] and the National Biocontrol Collective.

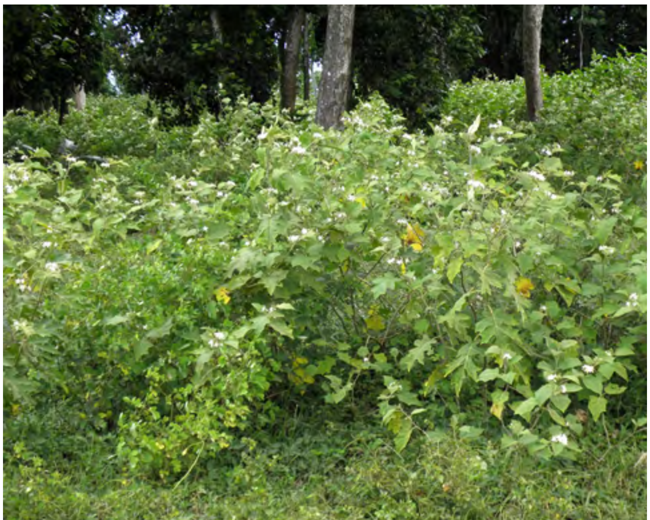
CONTACT
Ronny Groenteman – groentemanr@landcareresearch.co.nz

On the Way to Solving a Prickly Problem

Solanum torvum is known by many names, including pico, prickly solanum, turkey berry, and Devil's fig, perhaps reflecting its status as a widespread problematic weed. This prickly shrub is currently considered a weed in 32 countries and a serious or principal weed in seven of them. Regions affected include much of sub-Saharan Africa, South and South-East Asia, Australia, and the Pacific, although fortunately not New Zealand, where only one plant has ever been reported (in Auckland in the 1990s) and it is no longer present.

A major problem in pastures, roadsides, and wasteland, *S. torvum* can grow up to 6 m tall and form dense, impenetrable thickets. Like most *Solanum* species the fruits are readily eaten by birds, which then spread the seeds. In addition to being a pasture weed, *S. torvum* is a reservoir host of fruit flies (*Ceratitis capitata, Bactrocera dorsalis,* and *B. latifrons*) that are pests of fruit and vegetable crops. Although the fruits of *S. torvum* plants are sometimes used in cooking, there are reports of poisoning associated with people eating unripe berries or more toxic phenotypes. There is evidence that the plant is poisonous to livestock, although they generally do not eat it, and so it can quickly form dense stands that shade out desirable pasture plants. "Pico is having a major impact on the beef industry in Vanuatu, so we were asked to look for natural enemies to better manage it there," said Quentin Paynter, who is leading this project.

Deciding where to prospect for natural enemies was tricky due to uncertainty regarding the native range. Some authors consider *S. torvum* to be native from Florida and southern Alabama through to the West Indies, and from Mexico through Central America and South America through to Brazil, while others believe it is native to the Antilles but has been dispersed to many tropical regions in both the New and Old Worlds. This



Solanum torvum in Vanuatu

is a very large area covering numerous countries and islands, so we needed some clues about the best places to look for potential natural enemies to refine our search. A literature review indicated that most natural enemies that are likely to be specific to *S. torvum* occur in the Antilles, Mexico, and Central America. "We prioritised Jamaica as the first place to look because host-specific natural enemies should be present, and it was a relatively easy place to work, in terms of logistics, such as arranging export permits," said Quentin.

"To support the literature review we undertook a molecular study, which has shown that populations of *S. torvum* in the Pacific are genetically very similar to those in the Antilles," said Caroline Mitchell, who analysed the samples and the data. The study confirmed the Antilles to be the best place to look for natural enemies.

A literature review turned up a beetle (*Leptinotarsa undecimlineata*) that looked like a promising candidate. We were fortunate to be able to obtain some of these beetles from Jamaica shortly before the Covid-19 pandemic struck, bringing all overseas exploration to a halt for several years. The beetles have been intensively studied inside our containment facility in Auckland ever since. Both the adults and larvae feed on the foliage and, being quite a large beetle (1 cm long) are quite voracious. "We have had to periodically cull some beetles to avoid being eaten out of house and home," said Zane McGrath, who has been caring for the colony.

When confined in laboratory conditions, some candidate agents feed and develop on plants they would not attack in the field, particularly in no-choice tests, either through desperation or disruption of normal host-seeking behaviour. Rejecting an agent because it can develop on a non-target plant species in a no-choice scenario risks erroneously rejecting a safe agent. When a candidate behaves unusually under laboratory conditions, considerably more testing is required to work out what is going on and to evaluate safety. There are many economically important species in the *Solanum* genus, including potatoes, tomatoes, and eggplants, as well species that are native to the Pacific. "Some of these species, such as eggplant, belong to *Leptostemonum*, the same subgenus as *S. torvum*, so we suspected that the host-range testing required was likely to be quite complex," said Quent.

Nevertheless, no-choice tests ruled out all test plants as beetle hosts except for eggplant (*S. melongena*), but there was very strong evidence that the no-choice tests overestimated the risk posed to eggplant. Eggplant is cultivated extensively throughout the regions where *L. undecimlineata* is present, and the literature review found no records of eggplant being attacked over the bulk of the beetle's range in Mexico, Colombia, and the Antilles, including Jamaica, where the beetles were sourced. "There was just one record of *L. undecimlineata* feeding on eggplant in Central America, which was described as minor and rare, and was likely to be a case of spillover attack from beetles dispersing from nearby native *Solanum* hosts," said Quent.

Confining candidate agents on test and target plants in a no-choice manner does not allow them to use their normal host-seeking cues during pre-alightment. Test plants that can support the development of a candidate agent are likely to be at low risk of significant non-target attack if a candidate agent is not attracted to the olfactory and/or visual cues they produce. "Fortuitously a study had been done in the 1970s looking at the response of *L. undecimlineata* beetles to odour cues in Cuba, which found they were attracted by the scent of *S. torvum* but not eggplant," confirmed Quent. This may explain why, during both no-choice and choice tests, beetles laid many more eggs on *S. torvum* compared to eggplant, even in relatively constrained laboratory conditions.

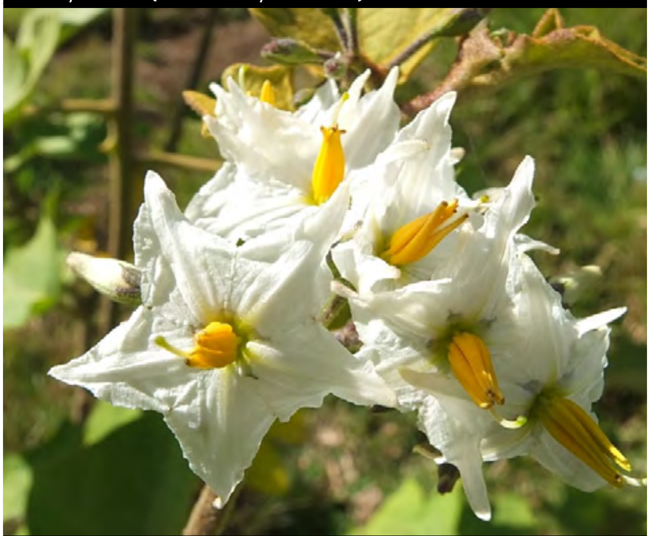
Furthermore, a multiple generation test indicated that eggplant is a very poor long-term host. Adult female beetles reared on eggplant laid fewer eggs than those reared on *S. torvum*, and the survival of the resulting F2 offspring was 19 times higher on *S. torvum* compared to eggplant. "For every pair of F1 beetles reared on *S. torvum* we reared 32.3 adult F2 beetles, indicating strong population growth. In contrast, for every pair of F1 beetles reared on eggplant we only reared 0.03 adult F2 beetles, indicating that *L. undecimlineata* reared exclusively on eggplant will soon decline to extinction, so the worst-case scenario could only ever be spillover attack," said Zane. This result also indicates that because eggplant is such a poor host plant there should be a strong selection pressure against females that lay on eggplant. It follows that natural selection is not likely to result in *L. undecimlineata* broadening its host range to include eggplant.

So, after 3 years of careful testing it has been concluded that while minor spillover feeding on eggplant cannot be ruled out, the benefits of releasing *L. undecimlineata* are likely to greatly outweigh the risks. An import risk assessment is now being prepared for Vanuatu.

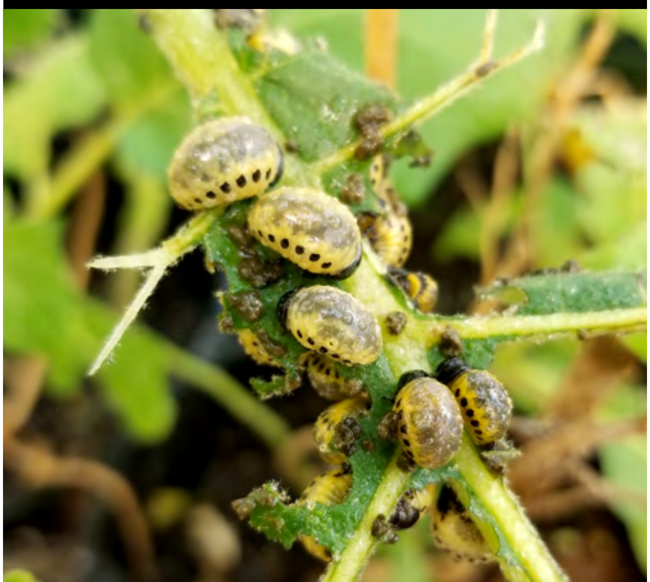
This project is funded by the New Zealand Ministry of Foreign Affairs and Trade.

CONTACT
Quentin Paynter – paynterq@landcareresearch.co.nz

Jimmy Peters (Biosecurity Vanuatu)



Solanum torvum flower



Pico beetle larvae

Refreshed Webpages and on to Social Media

Last month the weed biocontrol team at MWLR moved further into digital science communication and social media. Recognising that digital platforms are a very important avenue for generating public awareness and perceptions of weed biocontrol, we have undertaken a restructuring of our website pages and completed the mammoth task of converting all our educational information on weed biocontrol into HTML content. Along with this refurbishment, we launched a brand-new social media campaign designed to help the weed biocontrol team reach wider audiences.

Those of you who have been following the team for a while will be familiar with the *Biocontrol of Weeds* book. This is an educational PDF resource containing information on 79 weeds and their biocontrol agents that have been worked on by the weed biocontrol team at MWLR over the years. From this year on the book will take on a new form as website HTML pages. The upgrade will make weed biocontrol information easier to find with modern internet search tools and more accessible to view across different devices. The content will also be easier to update as new research is completed and new biocontrol agents are approved. We are in the process of sourcing and creating new imagery to provide our users with more, and better, visual resources for learning about our often shy and sometimes tiny biocontrol agents.

In addition to the 104 new weed and agent fact pages created, the wider content architecture has been rethought. The weed biocontrol landing page now has six subsections catering to different questions a user may ask when they visit the weed biocontrol pages on MWLR's website:

About biocontrol: a page for the public to learn about what biocontrol is, how it is used, and how safe it is.

Our research: at the time of writing this page is still under construction, but it will showcase our science and the contributions our team have made to the field of weed biocontrol.

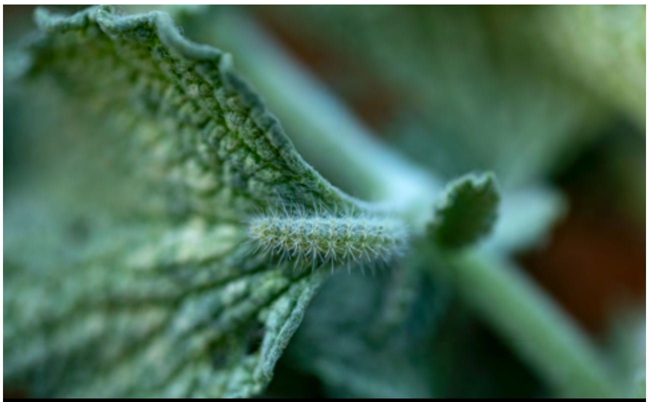
Weeds and biocontrol agents: links to all our newly created weed project pages and biocontrol agent pages.

Applications to release biocontrol agents: a page displaying all current and past applications to release biocontrol agents, information on the process, and how people can get involved.

Weed biocontrol newsletter: links to our *Weed Biocontrol, What's New?* newsletter and sign-up form.

Resources: downloadable content, such as forms, guidelines/instructions, and learning resources.

In addition to the website changes, the team has enlisted the help of science communication contractor Jenny Leonard to develop and implement a new social media campaign. The purpose of the campaign is to raise awareness of weed biocontrol within farming communities, rural professionals, iwi, hapū, community groups and councils.



Landing page image, the horehound plume moth

Keeping the social media preferences of these different audiences in mind, Jenny selected two platforms to promote weed biocontrol: Twitter and Facebook. "Communities and individuals use a broad range of social platforms," said Jenny. "However, Facebook and Twitter are the most popular among regional councils. Using these two platforms should give us the best reach," she added.

The social media content strategy focuses on offering fun and educational content highlighting the principles of biological control science, as well as real examples of weed biocontrol successes that have been achieved in New Zealand. Just a week after launching we had dozens of followers on Twitter and over a hundred followers on Facebook. We hope these new platforms will increase our target audience and drive more traffic to our site, as well as create general interest in weed biocontrol as a tool for weedy problems.

If you would like to follow the weed biocontrol team's activities and get involved in the conversation, please follow us on Facebook and Twitter using the links below. And be sure to check out our new webpages:

Twitter: @WeedBiocontrol

Facebook: https://www.facebook.com/weed.biocontrol/

Website landing page: https://www.landcareresearch.co.nz/discover-our-research/biodiversity-biosecurity/weed-biocontrol/

This project is funded by the Ministry for Primary Industries' Sustainable Food, Fibre and Futures Fund [Grant #20095] and the National Biocontrol Collective.

CONTACT
Stephanie Morton – mortons@landcareresearch.co.nz