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Manaaki Whenua
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Wed Biocontrol

WHAT'S NEW?

Contents

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Darwin's barberry seed weevil

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First Releases of New Agents

We are pleased to report the first field releases of two insect biocontrol agents – one for giant reed (*Arundo donax*) and another for field horsetail (*Equisetum arvense*). The field release of a pathogen against tradescantia (*Tradescantia fluminensis*) is also imminent.

Field horsetail weevil
In early November the Horsetail Control Group (HCG) released the first adult horsetail weevils (*Grypus equiseti*) at two sites near Bulls in the Manawatū. The first release was made on the edge of a wetland on a Parewanui dairy farm, where Alistair Robertson, chair of the group, was given the privilege of opening the box to give the weevils their first taste of freedom. Alistair Cole (NZ Landcare Trust), Craig Davey (Horizons Regional Council) and Lindsay Smith (Manaaki Whenua – Landcare Research (MWLR)) were also there to oversee the release. "We were able to add further weevils to the same site in late December," said Lindsay Smith, who has been rearing the weevils. The new adults emerge slowly in dribs and drabs, possibly as a survival strategy, so accumulating enough for a release is a slow process.

Weevils were also released in November at a nearby site along a fenced riparian strip, with a further top up in January. "To study the impact of the weevil on field horsetail (*Equisetum arvense*) plants, the releases were made onto one of a paired set of plots at each of the release sites. As the weevil becomes established, we will be able to make comparisons between the 'weevil infested' and 'weevil not infested' plots and quantify the amount of damage that has occurred," explained Lindsay.

Field horsetail is a fern-like plant that arrived from Eurasia around 100 years ago. It is generally a problem in wetter parts of New Zealand, such as the Rangitīkei area, and is difficult to control using herbicide because it has a deep root system. Not only that: it can spread vegetatively via stolons and tubers, which are often moved around on earthmoving equipment or in gravel. Successful biocontrol of the plant would help the agricultural sector as the plant is toxic to stock and displaces valuable pasture. Field horsetail also prevents the recruitment of native seedlings and grows particularly well on riparian margins, blocking waterways and impeding watercourses.

Alistair Robertson releasing field horsetail weevils

Giant reed gall wasp
It was serendipity that led to the release of a gall-forming wasp (*Tetramesa romana*) against giant reed (*Arundo donax*). The gall wasp was originally destined for a more tropical lifestyle in Rarotonga, but the plan changed when it became apparent that giant reed in Rarotonga had mostly been mistaken for a similar-looking plant. Rather than cull the gall wasp colony, which was thriving in our containment facility, a decision was made to apply to release them here, since giant reed is emerging as a new problem.

Although not widespread in New Zealand yet, giant reed is certainly on the radar of the Northland Regional Council, and they fronted the application to release the wasp, together with a scale insect (*Rhizaspidiotus donacis*). "Both of these agents have been released in the USA and Mexico, where the weed is a huge problem," said Chris Winks, who has been working on the project. "It's a bit of a 'David vs Goliath' battle for the tiny wasps, but they can tolerate a wide range of conditions and are expected to do well in the warm and humid conditions found in Northland," Chris added.

The first release of the giant reed gall wasp was made in Kohukohu, in Northland, in early December. Local entomologist Jenny Dymock was on hand to help MWLR staff attach galled stems onto plants in the field. A further release was made in Northland just before Christmas, and two shipments of the wasp were released in the Manawatū–Wanganui Region in January. "Two releases are also planned for the Auckland region this summer, which is the best time to release them at their most active," said Chris.

If the gall wasp releases take successfully, small swellings should begin to appear on giant reed after a few weeks. Since the galls are quite obvious, monitoring to check for signs of establishment can begin this autumn. Terminal galls reduce the height and overall biomass of the plants, and induce the plants to produce more side shoots, which are highly suitable for the scale insect to attack, further reducing the vigour of the plant. Releases of the scale insect are planned to begin next spring. Successful biocontrol of giant reed is expected to deliver environmental gains for vulnerable habitats such as wetlands and riverbanks, which are not suited to herbicide use.

Tradescantia yellow leaf spot fungus
The yellow leaf spot fungus (*Kordyana brasiliensis*) was discovered in south-east Brazil when potential biocontrol agents were being sought for New Zealand. A decision was made to release three beetle biocontrol agents in New Zealand first and see if the yellow leaf spot would be needed. While the beetles were being established in New Zealand, CSIRO (Australia) became interested in the biocontrol of tradescantia and imported the fungus into their containment facility in Canberra. So when we decided that it would be prudent to release the fungus here, we were able to get a shipment from Australia and avoid the pitfalls of shipping a delicate living organism long distance.


Jenny Dymock tying galls on to giant reed

"Testing has shown that the fungus is host specific and that it thrives in damp conditions," explained Chantal Probst, who has been leading the project in Auckland. Spores germinate on the surface of tradescantia leaves and invade leaves through stomata. Obvious yellow spots develop on the upper leaf surface, expand, and the leaf ultimately withers. Assuming there is sufficient humidity, new wind-borne basidiospores are released around 2 weeks later from the affected area, assisting its spread to other plants.

It appears that the ability of the tradescantia beetles to build up high numbers and damage tradescantia can be disrupted by sporadic flooding in both Brazil and New Zealand. "During our visits to Brazil, it was apparent that the fungus was more prevalent close to waterways, suggesting that the fungus quickly moves back into areas that have been recently flooded," said Simon Fowler, the overall project leader. However, an assessment of the data collected in Brazil has shown there is no evidence that the beetles avoid foliage on which the fungus is present, so we hope it will be a perfect partner for them. Permission to take the fungus out of containment was received late last year, and since then Chantal has been working on bulking up the number of infected plants. All going well the first field release will take place at the end of February in the Auckland region.

The field horsetail project is funded by MPI's Sustainable Farming Fund, with smaller contributions from a range of other organisations, and we are grateful to CABI (UK) for supplying the weevils. The giant reed project has been supported by the Ministry for Foreign Affairs and Trade, the Northland, Auckland, Hawke's Bay, Horizons and Greater Wellington regional councils. We are grateful to John Goolsby (USDA) for supplying the giant reed agents. Finally, the tradescantia project is funded by the National Biocontrol Collective, and we thank Robert Barreto and Davi Macedo (University of Viçosa, Brazil) and Louise Morin (CSIRO) for providing the tradescantia fungus.

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New Faces

We would like to introduce some new staff who have joined us recently.

Zane McGrath (Auckland)

Zane has joined Manaaki Whenua – Landcare Research (MWLR) as a weed biocontrol technician. Zane spent his childhood in Canada, so not surprisingly he spends some of his spare time playing ice hockey! Zane recently completed an MSc at the University of Auckland under the guidance of MWLR entomologist Darren Ward, studying an exotic parasitoid wasp in native forests. Following this, Zane worked for a short while as a park ranger at a regional park north of Auckland. Zane is now providing technical support, helping with things like insect rearing, field work and the operation of the containment facility at our Tamaki campus.

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Zane McGrath

Claudia Lange (Lincoln)

Claudia joined MWLR in 2017 as a postdoctoral researcher in molecular ecology. Claudia is originally from Germany but has been in New Zealand for 11 years. Since 2008 she has been associated with the Bio-Protection Research Centre at Lincoln University, as technician, PhD student, postdoc and research fellow. Claudia's expertise is being used to assist with biological control, conservation and biodiversity research, using molecular, genetics and whole genome approaches. Claudia has already provided valuable assistance to a number of weed projects, such as giant buttercup (*Ranunculus acris*), nassella tussock (*Nassella trichotoma*), Californian thistle (*Cirsium arvense*), broom (*Cytisus scoparius*), and horehound (*Marrubium vulgare*). She is particularly interested in the underlying genetic mechanisms affecting environmental dynamics, such as invasion and biological control.

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Claudia Lange

Seona Casonato (Lincoln)

Seona joined us in early February on a part-time secondment from Lincoln University, where she is a senior lecturer in plant pathology. Seona is originally from Australia and has been in New Zealand since 2002, when she ventured over the ditch to complete a postdoc with MWLR. This involved studying the interactions between the mist flower white smut fungus (*Entyloma ageratinae*) and mist flower gall fly (*Procecidochares alani*) to see if these agents work together synergistically (which they do). Since then Seona has been working with Plant and Food on fungicide reduction in kiwifruit orchards and diseases in a range of horticultural crops. Seona also worked back in Australia for a short time with the Department of Primary Industry on cereal crops, where she expanded into the world of nematology. Previously Seona has also been involved in projects in Australia on tutsan (*Hypericum androsaemum*) and nassella tussock, and we welcome the plant pathology expertise she will be able to contribute to our projects.

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Seona Casonato

What Do Weeds Cost?

It is no secret that weeds cost the productive sector a huge amount of money each year, in terms of both control and lost production. But the size of this financial burden is not easily calculated. A recent review by New Zealand scientists has had a close look at the costs of weeds to New Zealand's pastoral, arable and forestry sectors.

"Even a superficial look at the literature shows that most studies have focused on the cost of weeds to pastureland, with few attempts to estimate the costs associated with arable crops or forestry," said lead author John Sanders from Lincoln University. "To develop cost-effective tools for weed management and decision-making, we need to understand the cumulative costs across all three of these industries," said John. "Also, most of the studies reported are limited to assessments of individual weeds rather than assessing their combined impact," explained John. As a result, his review centred on 10 common pastoral weed species in New Zealand (see table).

The total cost estimated for the 10 pasture weeds ($1,306.1 million per year) is likely to be an underestimate, because the costs used in the analysis are largely due to lost production. "The cost to the economy from loss of production for the three biggest culprits (Californian thistle, giant buttercup and yellow bristle grass) is $1,171.20 million alone, and this doesn't include the cost of controlling them!" said co-author Graeme Bourdôt. Also this estimate is only based on 10 of the approximately 187 plant species that occur in New Zealand pastures.

"What became apparent after reviewing the literature was that the cost of each of the pasture weeds had been calculated differently," said John. Some of the weeds are widespread and occur in landscapes where it is not practical to control them with herbicide (e.g. hawkweeds in the high country of the South Island). For these weed species, and others such as giant buttercup in dairy pastures, the economic analysis had been based on loss of productive land and extrapolated to an assumed loss of production for the sheep, beef or dairy industries. By contrast, the economic analysis for other weeds such as broom included the cost of herbicide control as well as the cost of replacing nitrogen into pasture that had occurred because of clover displacement.

Little data was available to assess the cost of weeds in arable systems, but the majority of land is used to grow seed crops such as wheat, barley, maize and herbage seeds (approximately 196,000 ha). "There was very little information available on the costs of weed control for vegetable crops, but they don't really take up a large area of land (about 15% of total arable area), so the cost of controlling the weeds within them may not have added much overall," explained John.

Weed control in the forestry sector largely occurs early in the forest's rotation, while the trees are getting established. These weeds include species such as broom, buddleia (*Buddleja davidii*) and pampas grass (*Cortaderia* spp.), and others such as blackberry, which can affect the form of young trees.

Preparing an in-depth economic analysis relies on having good data on the cost of the weed to begin with. "Many of the studies reviewed implicitly assumed that the weed had fully occupied all its possible habitat, so the potential cost of allowing the weed to spread further was not included," commented Graeme. Also, there are usually multiple weed species growing together, which have an additive effect, and often replacement weeds move in as one is eliminated from the system so the loss of production remains. "This has inevitably led to an underestimate of the true cost of weeds in productive landscapes," agreed John. "Our study highlighted how little was known about the total cost of weeds to the New Zealand economy and how valuable it would be to update old studies under a unified framework," he added.

"Despite the inherent difficulties in accurately calculating the costs of weeds to New Zealand's primary productive sector, it remains vital to have some ball-park figures to enable more cost-effective allocation of funds for weed research and management and to provide context on the extent of the weed problem to funding providers," concluded Graeme.

This work was supported by the Ministry for Business, Innovation and Employment.

Saunders JT, Greer G, Bourdôt G, Saunders C, James T, Rolando C, Monge J, Watt MS 2017. The economic costs of weeds on productive land in New Zealand. International Journal of Agricultural Sustainability. Available at: https://doi.org/10.1080/14735903.2017.1334179.

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Weed	$(2014) million per year
Gorse (*Ulex europaeus*)	72.3
Californian thistle (*Cirsium arvense*)	703.9
Scotch broom (*Cytisus scoparius*)	8.3
Blackberry (*Rubus fruticosus* agg.)	14.3
Chilean needle grass (*Nassella neesiana*)	0.013
Sweet briar (*Rosa rubiginosa*)	7.1
Hawkweeds (*Pilosella* spp.)	5.8
Yellow bristle grass (*Setaria pumila*)	257.7
Giant buttercup (*Ranunculus acris*)	209.6
Nassella tussock (*Nassella trichotoma*)	27.1
10 pasture weeds	1306.1
All arable weeds	18.2
All forestry weeds	333.6
Total	**1,657.9**

Darwin's Barberry: Playing the Numbers Game

Recently there have been some important breakthroughs in the Darwin's barberry (*Berberis darwinii*) project, involving both the seed-feeding weevil (*Berberidicola exaratus*) and the rust fungus (*Puccinia berberidis-darwinii*) in what is really proving to be a numbers game.

Only a handful of releases of the seed-feeding weevil have been made since the first release in Southland in February 2015. It is not possible to mass-rear the weevils, because Darwin's barberry does not grow well enough in pots, especially under artificial conditions, to produce sufficient flowers or fruits. So we developed a direct field release technique instead and proved this could work in 2015/16, when we were able to make seven releases of the weevil in Southland, Wellington and Manawatū–Wanganui.

With the concept proven, we put extra effort into collecting an even larger quantity of infested fruits in Chile in November 2016 with the hopes of having even more weevils to release last summer. It was therefore disappointing and perplexing to have only a handful of weevils emerge from pupation and not the thousands expected. A subsequent review found that in order to accommodate the much larger quantity of infested material, bigger containers were used for pupation, which probably did not provide the conditions the weevils needed. Dehydration, in particular, may have been an issue, but possibly also overcrowding, requiring a rethink about how best to rear through future shipments.


Darwin's barberry fruits infested with rust.

At that point we also reflected on the optimal release and establishment strategy for this species. Often the best way to establish biocontrol agents is to put out the minimum number that experience tells us should generate a viable population, and do this at many sites. This strategy reduces the risk of an unforeseen event such as extreme weather wiping out a fledgling population, and increases the chances they will find conditions to their liking (which can be hard to accurately predict in advance). "However, with an insect like this, which has to survive for many months post-release (including winter) and then find a mate before it can reproduce, it can be more effective to 'put all your eggs in one basket', so to speak, and just load up one or two sites with as many as possible," explained Lindsay Smith. If establishment can be achieved, then the agent can be harvested, once sufficiently abundant, and released more widely. The National Biocontrol Collective, which funds the Darwin's barberry project, agreed to try this approach with the next lot of available weevils and load up existing sites in Southland and Wellington.

Lindsay Smith had a very successful trip collecting infested fruits in Chile in November 2017, and managed to rear through from these several thousand adults, which were released at the Southland and Wellington sites in early February. As a bonus, Randall Milne (Environment Southland) found two adults at the site of the first ever release in early November. This is no small feat given the extensive Darwin's barberry infestation at the site, the small number of weevils released, their tiny size, plus the relatively short time that has elapsed. So it looks very promising that the weevil is already well on the way to successfully establishing at that site. "The extra weevils added recently should ensure establishment and allow collection and redistribution from this site before too long," said Lindsay.

We have also finally managed to work out how to infect Darwin's barberry plants with the rust fungus, considered to be one of the most promising potential agents for this weed. We have imported several shipments of infected leaves and whole plants from Chile into our pathogen containment facility in Auckland, initially for identification purposes and then for further study. No-one has worked with this rust before, and some experimentation has been required to work out the infection process.

A number of techniques tried initially were unsuccessful. The germination rate of the spores was found to be low, suggesting that a large amount of inoculum may be needed for successful infection, as well as ideal humidity and temperature. Lynley Hayes was able to collect a large quantity of rust-infected material in Chile in November 2016 since it was easy to find while collecting fruits infested with the seed weevil. However, it was some relatively rare infected fruits, packed with spores, which provided the breakthrough needed to get infection. "Some Darwin's barberry plants developed a few pustules two and a half months after inoculation, and the technique that worked involved rubbing the leaves directly with rust spores," explained Chantal Probst.

Since then we have been gradually bulking up the rust on live plants to provide sufficient material for host testing trials to begin. The life cycle of the barberry rust is relatively long (around 3 months), so this has been a slow process. However, when Lindsay was collecting more weevils in Chile last November he was able to find lots of the rust-infected fruits to bring back, probably thanks to a wet spring there. This material has allowed some host testing to get underway immediately. The rust fungus is expected to be highly host specific, and with some luck we should be able to confirm that before too long.

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Choosing a Good Release Site

A critical success factor for the successful establishment of new weed biocontrol agents is choosing good release sites. This is even more critical when following the strategy of loading up just a few sites, because the agents are not readily available in large numbers, as described for the Darwin's barberry seed weevil (*Berberidicola exaratus*) in the story above. Here are some tips to consider.

It is best to choose a site that is not intensively managed, or likely to be so in the future. While biocontrol agents can sometimes be established in conjunction with intensive land management activities such as spraying and mowing, this takes careful thought to achieve and for most sites will be too difficult. In a farming situation the best places to make initial releases of biocontrol agents are therefore usually not on the best flat land but in steep gullies or rough areas that machinery can't get too. Conservation land, including covenanted private land, is often ideal since intensive management is unlikely.

Talking to the owners of potential release sites to determine their likely plans for an area is therefore important, as is gauging their interest in trialling biocontrol. If the landowners meet the criteria it is also important to involve them at release time so they know what the agents look like, where they were released, how to manage the site and what to expect. For example, it may be important for them to realise that only subtle signs an agent has established may be present for 5 years following release, so they don't write it off as a failure too soon!

Marking the site with a peg or tape can be useful, especially if follow-up visits may be made by others, and a sign can educate or pique the interest of neighbours or passers-by. Keeping good records, including photos and GPS readings, will also help to locate sites in the future. Fencing off a release site is rarely recommended because it can change the dynamics of plant communities in unwanted ways (e.g. lack of grazing or mowing can allow grass to outcompete some weeds at a time when you want a healthy weed population).

It is also worth checking out the potential for natural hazards to wipe out your release site. While some of these can be difficult to predict in advance, such as accidental fires or slips due to large earthquakes, a propensity of an area to flood is usually well known by locals.

The size of the weed infestation is not too critical, although a really tiny infestation involving only a handful of plants should be avoided. However, small, slightly isolated infestations (around 10–20 m^2) can be useful as nursery sites if harvesting and redistribution are planned for the future. Agents may be easier to collect in good numbers at these sites, provided they do not rapidly disperse. A large infestation offers plenty of choice for the agent, and possibly different micro-climates, but it may take longer to detect establishment or be able to begin harvesting.

The health of plants at potential release sites is a more important consideration. Healthy plants will provide better nutrition for the agents, and are more likely to produce flowers and fruits or pods for those agents that need them. Sites where plants are stressed because they are already being heavily attacked by other biocontrol agents should be avoided. As a general rule, warm, sheltered sites with adequate moisture will allow both the weed and control agents to do better than cold, exposed, excessively wet or dry areas, but there can be exceptions.

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Autumn Activities

There are a few things you might want to fit in before winter.

Gall-forming agents

Autumn is the best time to check many gall-forming agents.

- Check broom gall mite (*Aceria genistae*) sites for signs of galling. Very heavy galling, leading to the death of bushes, has already been observed at some sites. Harvesting of galls is best undertaken from late spring to early summer, when predatory mites are less abundant.
- Check hieracium sites, and if you find large numbers of stolons galled by the hieracium gall wasp (*Aulacidea subterminalis*) you could harvest mature galls and release them at new sites. Look also for the range of deformities caused by the hieracium gall midge (*Macrolabis pilosellae*), but note that this agent is best redistributed by moving whole plants in the spring.
- Check nodding and Scotch thistle sites for gall flies (*Urophora solstitialis* and *U. stylata*). Look for fluffy or odd-looking flowerheads that feel lumpy and hard when squeezed. Collect infested flowerheads and put them in an onion- or wire-mesh bag. At new release sites hang the bags on fences, and over winter the galls will rot down, allowing adult flies to emerge in the spring.
- Check Californian thistle gall fly (*Urophora cardui*) release sites for swollen deformities on the plants. Once these galls have browned off they can be harvested and moved to new sites (where grazing animals will not be an issue) using the same technique as above.

Privet lace bug (*Leptoypha hospita*)

- Check for establishment by examining the undersides of leaves for the adults and nymphs, especially leaves showing signs of bleaching.
- If large numbers are found, cut infested leaf material and put it in chilly bin or large paper rubbish bag, and tie or wedge this material into Chinese privet at new sites. Aim to shift at least 1,000 individuals to each new site.

Tradescantia leaf beetle (*Neolema ogloblini*)

- Look for the shiny metallic bronze adults or the larvae, which have a distinctive protective covering over their backs. Also look for notches in the edges of leaves caused by adult feeding, or leaves that have been skeletonised by larvae grazing off the green tissue.
- If you find them in good numbers, aim to collect and shift 50–100 beetles using a suction device or a small net.

Tradescantia stem beetle (*Lema basicostata*)

- The black knobbly adults can be difficult to see, so look for their feeding damage, which consists of elongated windows in the upper surfaces of leaves, or sometimes whole leaves consumed. Also look for stems showing signs of larval attack: brown, shrivelled or dead-looking.
- If you can find widespread damage you can begin harvesting. If it proves too difficult to collect 50–100 adults with a suction device, remove a quantity of the damaged material and put it in a wool pack or on a tarpaulin and wedge this into tradescantia at new sites (but make sure you have an exemption from MPI that allows you to do this).

Tradescantia tip beetle (*Neolema abbreviata*)

- Look for the adults, which are mostly black with yellow wing cases, and their feeding damage, which, like stem beetle damage, consists of elongated windows in the leaves. Larvae will be difficult to see inside the tips, but brown frass may be visible. When tips are in short supply, the slug-like larvae feed externally on the leaves.
- If you find them in good numbers, aim to collect and shift 50–100 beetles using a suction device or a small net.

Tutsan moth (*Lathronympha strigana*)

- Although the moths were only released last autumn, if you can't wait, look for the small orange adults flying about flowering tutsan plants. They have a similar look and corkscrew flight pattern to the gorse pod moth (*Cydia succedana*). Look also for fruits infested with the larvae.
- It is too soon to consider harvesting and redistribution if you do find the moths.

Woolly nightshade lace bug (*Gargaphia decoris*)

- Check release sites by examining the undersides of leaves for the adults and nymphs, especially leaves showing signs of bleaching or black spotting around the margins.
- It is probably best to leave any harvesting until spring.

National Assessment Protocol

For those taking part in the National Assessment Protocol, autumn is the appropriate time to check for establishment and/or assess population damage levels for the species listed in the table below. You can find out more information about the protocol and instructions for each agent at: www.landcareresearch.co.nz/publications/books/biocontrol-of-weeds-book

Target	When	Agents
Broom	Dec–April	Broom gall mite (*Aceria genistae*)
Lantana	March–May	Blister rust (*Puccinia lantanae*) Leaf rust (*Prospodium tuberculatum*)
Privet	Feb–April	Lace bug (*Leptoypha hospita*)
Tradescantia	Nov–April	Leaf beetle (*Neolema ogloblini*) Stem beetle (*Lema basicostata*) Tip beetle (*Neolema abbreviata*)
Woolly nightshade	Feb–April	Lace bug (*Gargaphia decoris*)

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