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LANDCARE RESEARCH
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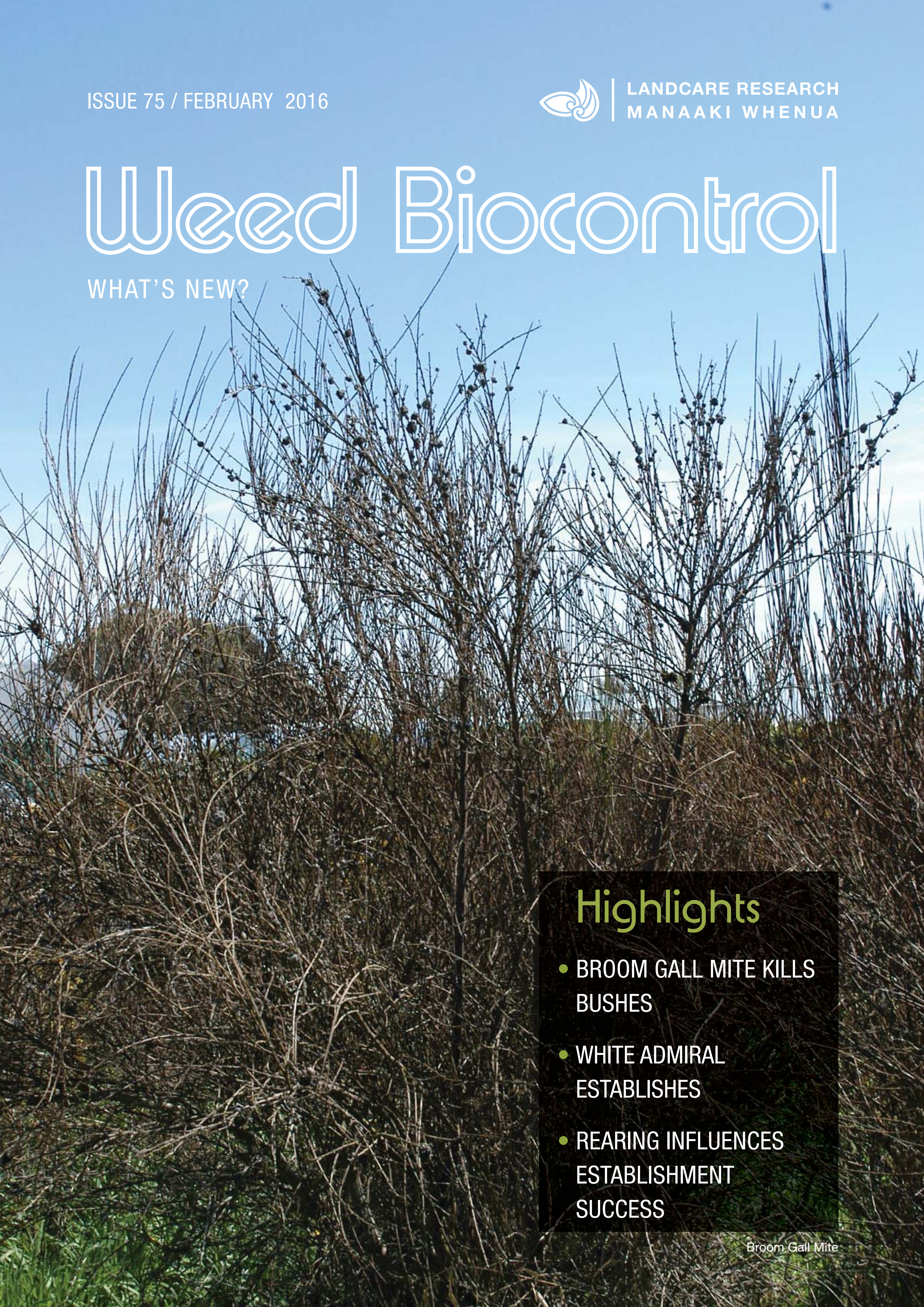
Weed Biocontrol

WHAT'S NEW?



Highlights

- BROOM GALL MITE KILLS BUSHES
- WHITE ADMIRAL ESTABLISHES
- REARING INFLUENCES ESTABLISHMENT SUCCESS

Broom Gall Mite

Contents

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New Year, New Agents

Welcome to 2016! So what can we expect 2016 to hold with regards to new weed biocontrol agents? Well potentially quite a few. Just before Christmas the EPA approved the release of a second agent for moth plant (*Araujia hortorum)*. However, it may be some time before this rust fungus (*Puccinia araujiae*), like the first agent approved against moth plant, the beetle (*Colaspis argentinensis*) can be released in New Zealand. Unfortunately, in recent years it has become extremely difficult to get permits to export prospective biocontrol agents out of Argentina. This is also the reason that the Chilean needle grass rust (*Uromyces pencanus*) has not been released here yet. However, it is hoped that a recent change of government in Argentina will finally make it possible to secure these long awaited export permits, allowing releases of these three new agents to get underway. Fortunately the Japanese honeysuckle (*Lonicera japonica*) project has not struck any permitting issues and the first release of the Japanese honeysuckle longhorn beetle (*Oberea shirahati*) is expected to be made later this year. It is also looking hopeful that widespread releases of the white admiral (*Limenitis glorifica*) can begin then too (see story on page 6).

We will also be keeping the Environmental Protection Authority (EPA) busy with applications to release a number of new agents. The EPA is currently considering applications to release a weevil (*Grypus equiseti*) for field horsetail (*Equisetum arvense*), and a beetle (*Chrysolina abchasica*) and a moth (*Lathronympha strigana*) for tutsan (*Hypericum androsaemum*). If approved, field releases of these insects are likely to begin this spring, and it will be the first time that any of them have been used as biocontrol agents anywhere in the world. An application is currently being prepared to request permission to release a gall-forming wasp (*Tetramesa romana*) and a scale insect (*Rhizaspidiotus donacis*) for giant reed (*Arundo donax*) control. Both species have been established for this purpose in the USA and Mexico. We originally imported these agents with the intention of gaining permission to release them in the Cook Islands, but there was a change of plan when it became apparent that some of the plants thought to be giant reed in Rarotonga were in fact other very similar-looking grasses. Giant reed is of limited distribution currently in New Zealand too, but appears to be spreading and is likely to become a worse problem since it has been nominated as one of 100 of the "World's Worst" invasive species.

Later in 2016 we hope to be in a position, subject to final host-testing delivering suitable results, of being able to prepare EPA applications for a new agent, the leaf curling gall mite (*Aceria vitalbae*) for old man's beard (*Clematis vitalba*), and the first agent for wild ginger (*Hedychium gardnerianum*), which is likely to be the stem-mining fly (*Merchlorops* aff. *dimorphus*). Both will also be world firsts. So 2016 is well and truly shaping up to be another year in which New Zealand leads the world in the development of new weed biocontrol agents.

If you would like to find out more about new agents being put forward for approval, or to make a submission to the EPA, you can find further details on our website (www.landcareresearch.co.nz/science/plants-animals-fungi/plants/weeds/biocontrol/approvals) and/or on the EPA's website (http://www.epa.govt.nz/consultations/new-organisms/Pages/default.aspx).

The field horsetail and tutsan projects are funded by the Lower Rangitikei Horsetail Control Group and Tutsan Action Group respectively, both primarily with funds from the Ministry for Primary Industries Sustainable Farming Fund plus co-funding from a range of sources. The old man's beard, wild ginger, moth plant and Chilean needle grass projects are funded by the National Biocontrol Collective. Members of this collective are also supporting the giant reed project.

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Broom Gall Mite a Decade on

It has been 10 years since the broom gall mite (*Aceria genistae*) was brought to New Zealand to try to reduce the menace caused by Scotch broom (*Cytisus scoparius*). Although the mites are too small to see with the naked eye, the damage they are doing to broom is now becoming obvious. The gall mites spend the winter hiding away in the buds on broom stems, and in the spring feed on the new growth, causing galls to form that can be up to 30 mm in size. As well as damaging the plant, the galls offer a refuge for successive generations of the tiny gall mites and protect them from predation. "We are excited to be finally making progress on this plant, which causes extensive damage to both conservation and productive landscapes," said Quentin Paynter, who has devoted several decades now to studying broom and how best to beat it.

Hugh Gourlay has been checking on the mites' progress at Leslie Hills in North Canterbury where trials have been set up to measure the impact of broom biocontrol agents. He has been surprised at how quickly the mites are getting around. "The mites are being more easily dispersed by the wind than we thought they would," said Hugh. Adults initiate a stand-up posture when they want to be carried by wind, but a number of factors affect this, including wind speed, temperature and humidity," said Landcare Research's mite expert (acarologist) Zhi-Qiang Zhang.

While the mite is proving slow to establish in some regions it is booming in others, such as Canterbury, where it is now killing whole plants in the field. "I marked 144 plants at Leslie Hills to follow and 3 years later half of them were dead and the rest were galled so might still follow suit. Also, at Lincoln 70 out of 72 plants planted out for trial work have died, most likely due to gall mite attack," said Hugh.

Environment Canterbury (ECAN) has been the first agency to see the benefits of the gall mite. Steve Palmer from ECAN was involved in redistributing the mites last year using a helicopter. "Infested stems were dropped from a height of 3 m onto broom plants in a 30-km stretch of the Clarence River bed," said Steve. "We delivered 1382 stems using this method. When the galls dry out, the mites exit them and crawl into developing shoot buds where they feed and initiate new gall formation," said Steve. "Weeds such as broom are a big problem in river beds because they reduce the amount of habitat available to nesting birds such as terns, dotterels and gulls," Steve explained. "We had to gain ministerial approval to introduce the mites onto Department of Conservation estate in December, but when it came time to release them we were surprised to find them already there," he said. "Either we missed seeing them because they were less obvious on our first visit or they had dispersed there since," said Steve. "In any case, there were broom plants that were heavily loaded with galls and others that were completely dead. It was really impressive to see and very encouraging."

Broom in the Waiau River that has succumbed to the combined pressures of gall mite attack and drought.

ECAN Biosecurity Officer, Terry Charles has also reported significant damage to broom plants in the Waiau River, North Canterbury, 3 km downstream of the original 2009 release site made by the Canterbury Broom Group (which formed to tackle the serious broom situation in North Canterbury). "The broom is heavily galled and this, in combination with the dry conditions, has killed large areas of broom. ECAN biosecurity officers have been making strategic releases of this agent in North Canterbury and Kaikoura since 2012. We are increasingly confident that this is going to be a successful agent," said Terry.

The gall mite is part of a suite of complementary broom agents comprising a leaf beetle *(Gonioctena olivacea),* seed beetle *(Bruchidius villosus),* psyllid *(Arytainilla spartiophila),* shoot moth *(Agonopterix assimilella)* and twig miner *(Leucoptera spartifoliella).* As well as being possibly the most damaging, the mites appear to be the most tolerant of shaded conditions. "This will be especially helpful in environments, such as regenerating forests, where broom can reach high densities in the understory," said Quentin.

A video about ECAN's project to deploy the gall mite in the Clarence River is available at: https://youtu.be/nrm676BlCH4. *Trials to measure the impact of broom biocontrol agents in North Canterbury are funded by the Ministry of Business, Innovation and Employment as part of Landcare Research's Beating Weeds programme.*

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News from the 'Rearing' End

The failure of weed biocontrol agents to establish in the field can be costly in terms of resources, but also because of ongoing harm to the environment and productive landscapes. Whether or not we can easily rear biocontrol agents can have a significant bearing on agent establishment and, therefore, on the outcome of weed biocontrol projects. Quentin Paynter has recently led a study to analyse which key factors influence our ability to successfully rear biocontrol agents.

In his analysis Quent compiled a list of agents that had been reared both in and out of containment in New Zealand. He used published records and the Landcare Research release database to classify the resulting 82 species into three categories: species that could be reared easily for several generations; species that could be reared through at least one generation, but only in low numbers, and species that could not be reared at all. Quent then tested whether rearing success was influenced by feeding guild, taxon and novelty (whether the agent had been reared successfully overseas). Quent also explored whether mandatory disease testing, introduced in 1984, had had an impact on the establishment of the 43 species introduced after this time.

Of the 82 agents considered, 13 species could not be reared in containment. Six of these 13 species did not mate and as a result did not produce fertile eggs. Four species didn't reach maturity due to poor host plant quality and the remaining three species failed to emerge from hibernation. Thirteen species were unable to be reared in large numbers, but the reasons for low breeding success were not so easy to identify.

Rearing insects in containment can be especially challenging.

"Generally speaking, we have fewer problems rearing agents that have already been used overseas in other biocontrol programmes as more is known about their lifecycles and preferences. However, if an agent is novel, we have to develop the rearing techniques ourselves, which can require some degree of trial and error," Quent added.

"The feeding strategy of the agents (feeding guild) can also influence our ability to rear them. For example, root and rosette feeders are more difficult to rear than defoliators," explained Quent. "Beetles seem to be generally easier to rear than moths, and sawflies are more difficult again as they are very particular about the conditions they need for hibernation. "Agents such as stem borers, that require mature stems, can be logistically difficult because of the size or maturity of the plants required," he commented.

The containment phase, where all new agents must be housed in a secure facility under artificial conditions for several months, can be especially challenging. This phase is essential to ensure that the correct species has been imported, and that no unwanted hitchhikers have come along for the ride. Often the biggest obstacle is successfully growing the weeds themselves under artificial conditions, along with the added challenge that most of the problem weeds in New Zealand originate from the Northern Hemisphere. Therefore, any insects newly imported into containment from that part of the world will be out of phase with Southern Hemisphere conditions, which may necessitate manipulating their hosts to flower or produce fruit or new growth out of season in containment, which can be tricky. "To get around this problem we can do the host range testing overseas, but at some point insects progressing towards release must be rephased by manipulating light and temperature regimes, and this is easier for some species than others," said Quent.

Some plants sulk when grown in pots, and none do as well under artificial light regimes as in natural sunlight. If host plants are not of sufficient quality the insects will also do poorly and may not survive. Outbreaks of pests, like aphids, can also be a problem since they cannot be controlled in ways that might also harm the biocontrol agents," he added. Other frustrations include agents failing to emerge from winter hibernation since the normal triggers are absent or confused inside containment, and staggered emergence times (a strategy thought to have evolved to avoid parasitism). Sometimes males and females emerge at different times with little overlap, posing an additional complication.

"A recent example, where we had major rearing challenges was with the white admiral butterfly (*Limenitis glorifica*) for Japanese honeysuckle (*Lonicera japonica*). These butterflies need a lot of room to do elaborate courtship displays, which is not possible in containment, and the end result was that we could not get the butterflies to mate. Attempting a hand-pairing technique developed for other related *Limenitis* species, and releasing the white admiral into a spacious butterfly house were also unsuccessful," said Quent. The only remaining option was to release new adults in the field where they could breed naturally. Despite the fact that only a small number could be released, for a variety of logistical reasons, success has been achieved (see article this issue on page 6).

The downside of not being able to mass rear agents and having to rely on natural breeding under field conditions instead, is that it can take longer before widespread releases can begin. Climate-controlled rearing rooms allow colonies to be kept at the optimal temperature and not at the mercy of the weather, predators or parasitoids. It is also obviously easier to keep tabs on them indoors and collect them up when it's time for releases to be made.

"It is pretty well recognised that agent establishment is closely linked to the number of individuals that are released and the number of release sites," said Quent. "This was supported by our analysis, which showed a positive correlation between release size and establishment success. With the sole exception of one unsuccessful Californian thistle agent (*Hadroplontus litura*) back in 1976, all of the establishment failures associated with small release size have occurred since 1984, when disease-testing became mandatory," explained Quent. Prior to 1984, if rearing proved difficult large direct field releases from the country of origin were made instead. For example, around 150 000 gorse seed weevils (*Exapion ulicis*) were directly released. However, this type of activity is no-longer possible. Traditionally, disease screening has required sacrificing a percentage of the population to be released and getting an insect pathologist to examine them in minute detail under a microscope. Such time-consuming and painstaking work is not practical for large samples, and so only relatively small numbers (<400) have been direct field released since 1984. More recently, non-destructive molecular methods have become feasible, such as screening for evidence of disease in the faeces (frass). However, such tests need to be developed on a species by species basis and are not yet widely available.

Due to rearing challenges only a small number of Californian thistle stem miners (*Ceratapion onopordi*) could be field released, and their fate is unknown.

In summary, Quent's analysis demonstrated that difficulties have been experienced with rearing about one-third of all biocontrol agents in New Zealand and c. 16% could not be reared at all. The best predictors of rearing success were novelty (i.e. whether or not an agent had already been reared successfully in another country) and the feeding guild the agent belonged to. Since rearing difficulties have contributed to the establishment failure of five out of 34 agents released between 1985 and 2014 (i.e. about one in seven agents approved for release) this suggests that the cost-effectiveness of weed biocontrol programmes could potentially be enhanced by:

- prioritising (but not discounting) candidate agents based on feeding guilds that are likely to be straightforward to rear and/or doing small direct field releases and then redistributing the agents once establishment has been achieved.
- developing better information pathways between research institutes to improve the techniques used to rear agents in containment and identify the main causes of rearing failure.
- developing improved direct-release methods for agents that are difficult to rear, such as using non-lethal molecular analysis allowing a larger number of individuals to be released.
- releasing agents in more climatically favorable sites first to establish source populations that can be used to support releases in more climatically extreme environments.

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

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White Admiral Butterfly Establishes

One of the highlights of last year was releasing the Honshu white admiral butterfly (*Limenitis glorifica*) in November 2015 and observing that it had successfully reproduced at a location in the Waikato, with subsequent generations emerging in January and again in March 2016.

However, Quentin Paynter, who has been leading the project, noted that "we cannot be certain an agent has successfully established until it has successfully overwintered." "We were concerned that conditions in New Zealand might not be ideal for hibernating larvae because winters here are generally much milder than in Japan," he added. So, it was with a little trepidation that Quent returned to the Waikato release site this spring.

Japanese honeysuckle (*Lonicera japonica*) is now a widespread weed in both the North and South Islands and biological control is the only reasonable option left to reduce the prevalence of this vigorous vine. "We were limited to releasing newly emerged adult butterflies because of the difficulty we had rearing them in containment, where the conditions were not suitable for their courtship flight and mating," said Quentin. "It was a bit of a long shot because we were relying on them finding a mate and producing offspring from relatively small numbers."

Fortunately the larvae did successfully overwinter, as Quent saw several adult butterflies at the Waikato release site last November, despite relatively cool and windy conditions. "November is equivalent to May in Japan, which is when butterflies emerge in lowland sites there, so as it turns out, we released butterflies at just the right time."

Quent and Hugh Gourlay visited the Waikato release site again in December finding eggs and 1st instar larvae. The eggs and larvae were not that hard to find, but they were not abundant enough to consider collecting and redistributing larvae to other sites yet. "They are probably diluted by the vast amount of honeysuckle present at the site," said Quent. "The presence of eggs and larvae several hundred metres from the release site also shows that butterflies have clearly begun dispersing away from the original release site," noted Hugh, adding that "dispersal could be rapid because the adults are strong fliers and there is a vast amount of honeysuckle in the nearby valley." Quent confirmed this to be the case in late January, when he found adult butterflies about 1.3 km from the release site "as the butterfly flies", which was as far as he had time to search. He noted that "they could have gone much further than this as there is suitable habitat for several more kilometres in all directions!" More recent sightings of the butterflies have been made 1.5 km in the opposite direction.

White admiral photographed at the Waikato site in late 2015.

"If the butterflies have dispersed about 1.5 km in all directions, then the population must occupy at least 7 square kilometres and we estimate there must already be several thousand of them. The females lay hundreds of eggs, so we are hopeful that there will be sufficient numbers to be able to begin safely harvesting from this site next spring," said Quent.

The news from the second release site on Waiheke Island is less positive. "I didn't find any signs of establishment last spring," said Quent. "It was a much smaller release, compared to the Waikato one, so failure is not that unlikely, but I'm not giving up hope just yet and folk should still be on the lookout in case there are butterflies present," he added.

Another key step in the Japanese honeysuckle project this year will be to progress work on the longhorn beetle *(Oberea shirahatai),* which attacks the stems. "We have been given approval from the Environmental Protection Authority (EPA) to release them but have not made any actual field releases as yet," confirmed Hugh Gourlay. These beetles are also difficult to mass rear and our best option is probably to take a similar approach to the white admiral and attempt to set up a field population that can eventually be harvested. "We have a small population of late instar larvae in containment presently and they are currently in their hibernation phase, which can last up to a period of 2 years," said Hugh. It is expected that the beetles will emerge from diapause in April this year but we will need to wait until spring before we can release them in the field, rather than plunge them straight into another winter. Hugh will also be heading off to Japan in May to collect additional beetles to boost the population and allow for a larger field release.

This project was funded by the National Biocontrol Collective.

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Autumn Activities

There are a few things you might want to fit in before the wind-down towards winter. We would be very interested to hear about what you find.

Broom gall mites (*Aceria genistae*)

- Check release sites for galls, which look like deformed lumps and range in size from 5 to 30 mm across. Very heavy galling, leading to the death of bushes, has already been observed at some sites.
- Harvesting of galls is best left until spring when predatory mites are less abundant.

Gall-forming agents

- Early autumn is the best time to check release sites for many gall-forming agents. If you find large numbers of galls caused by the mist flower gall fly (*Procecidochares alani*) and hieracium gall wasp (*Aulacidea subterminalis*), you could harvest mature specimens and release them at new sites.
- Do not collect galls caused by the hieracium gall midge (*Macrolabis pilosellae*) as this agent is best redistributed by moving whole plants in the spring.
- At nodding and Scotch thistle gall fly (*Urophora solstitialis* and *U. stylata*) release sites 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 bags on fences, and over winter the galls will rot down, allowing adult flies to emerge in the spring.
- At Californian thistle gall fly (*Urophora cardui*) release sites look 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.

Tradescantia leaf beetle (*Neolema ogloblini*)

- Check release sites, especially older ones. You may see the shiny metallic bronze adults sitting on the foliage, 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. The white, star-shaped pupal cocoons may also be visible on damaged foliage.
- If you can find plenty of beetles then harvesting can begin. Aim to collect and shift 50–100 beetles. Collect the beetles either using a suction device or a small net.

Tradescantia stem beetle (*Lema basicostata*)

- Check release sites, especially older ones. The black knobbly adults tend to drop when disturbed, and can be difficult to see. Look for their feeding damage, which consists of elongated windows in the upper surfaces of leaves or sometimes whole leaves consumed. The larvae inside the stems will also be difficult to spot. Look for stems showing signs of necrosis or collapse and brown frass.
- If you can find widespread damage at the site then you may be able to begin harvesting. We still need to identify the best possible method to do this. If it proves to be too difficult to collect 50–100 adults with a suction device, then another approach to try would be to 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. However, to distribute tradescantia in this manner an exemption from the Ministry for Primary Industries will be required.

Tradescantia tip beetle (*Neolema abbreviata*)

- Check release sites, especially older ones. The adults are mostly black with yellow wing cases, and you may see them sitting about on the foliage. Look also for their feeding damage, which looks like elongated windows in the leaves, similar to the stem beetle. Larvae will also be difficult to see when they are feeding 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 can see find plenty of beetles then harvesting can begin. Aim to collect and shift 50–100 beetles. Collect the beetles using either a suction device or a small net.

Woolly nightshade lace bug (*Gargaphia decoris*)

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

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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 (*Prospodium tuberculatum*) Leaf rust (*Puccinia lantanae*)
Tradescantia	Nov–April	Leaf beetle (*Neolema ogloblini*) Stem beetle (*Lema basicostata*) Tip beetle (*Neolema abbreviata*)
Woolly nightshade	Feb–April	Lace bug (*Gargaphia decoris*)

Online Weed ID now Bigger and Better

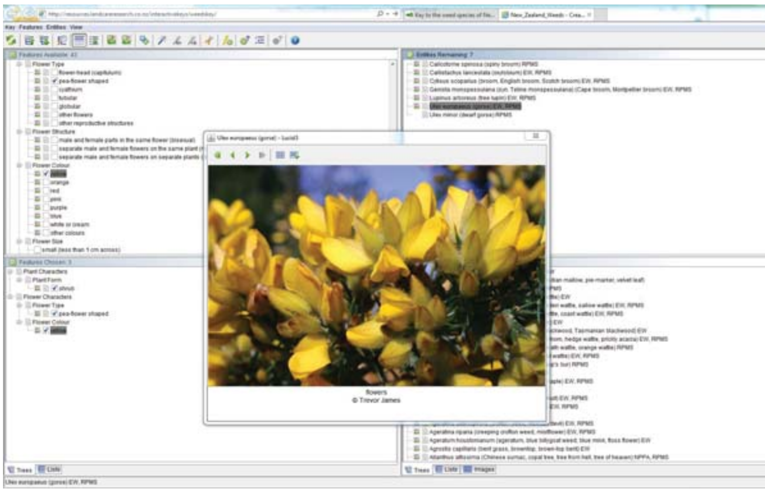
Identification of New Zealand's weeds has just become easier with an expanded online tool. The interactive key to Weed Species of New Zealand is available for use, free of charge, on the Landcare Research website at www.landcareresearch.co.nz/resources/identification/plants/weeds-key. As of January 2016, the key now covers more than 650 species (and subspecies, varieties, hybrids and cultivars) and is even more helpful for people seeking to identify weeds and pest plants from the naturalised flora.

The enlarged Weeds Key is a unique and extensive resource. It is a powerful tool that makes it easy to identify weedy plants without having to learn all the complex botanical terminology. Users choose whichever characters match the weed they are identifying through a process of elimination. If a user needs help to understand what a particular character means, they can bring up an explanation page for it.

Murray Dawson (Landcare Research) is the lead developer of the Weeds Key. Sheldon Navie (Technigro) provided data from similar keys he has developed in Australia. Trevor James (AgResearch) contributed the great majority of images from his outstanding collection. The remaining authors of the key, Peter Heenan (Landcare Research) and Paul Champion (NIWA) provided further images and specialist expertise.

"This key is the most comprehensive online tool there is for identifying New Zealand weeds," said Murray. "It's a perfect companion to the popular book *An Illustrated Guide to Common Weeds of New Zealand* and shares many of the images taken by Trevor James. Carolyn Lewis (Weedbusters), Jonathan Boow (Auckland Council), and others also helped by generously providing their images for the Weeds Key", added Murray. The Weeds Key now contains about 11 000 images showing a range of features for each weed, including plant form, leaf, floral, fruit and seed characteristics. "We would be very happy to receive further images if anyone can improve on the ones we already have, or to fill any gaps. One of the great things about online tools is that you can continually update and improve them, providing funding is available," said Murray.

The Weeds Key began life in 2007 as an identification tool to National Pest Plant Accord (NPPA) species – plants banned from sale, distribution, and propagation in New Zealand. That project was completed in June 2009 with some 150 NPPA species and a similar number of related species and lookalikes included. Thanks mainly to successive funding from the Terrestrial & Freshwater Biodiversity Information System Programme (TFBIS), this resource grew in March 2011 to include all 328 species on the Department of Conservation's consolidated list of environmental weeds. Five year later, the most recent (2016) expansion now covers all 370 Regional Pest Management Strategy (RPMS) species, and many more common weed species. In total, more than $440,000 has been invested in this resource. The Weeds Key includes links at the species level to related weed and pest plant resources – these include the websites of Weedbusters, AgPest, Ministry for Primary Industries, and Flora of NZ online weed profiles.



Screen shot of the expanded key.

The Weeds Key is the most popular interactive plant key hosted by Landcare Research. Other keys available include the flowering plant genera, native and exotic grasses, native orchids, a *Coprosma* and a *Cotoneaster* key. Recently, Murray Dawson led the creation of smartphone versions (Android and iOS) of the online native orchid and *Coprosma* keys. Smartphones have rapidly become the device of choice for New Zealanders and the rest of the world. Their processing power, storage capacity, and portability have come of age, making it possible to run comprehensive productivity apps including identification tools. Uptake of this technology will continue to increase into the foreseeable future.

"Our smartphone ID apps have been very well received", said Murray. "Weed identification apps are definitely the next step in the evolution of these useful resources," he added. "But we need further funding for their development in New Zealand."

This project was funded by the Terrestrial & Freshwater Biodiversity Information System (TFBIS) Programme. The TFBIS Programme is funded by the Government to help to achieve the goals of the New Zealand Biodiversity Strategy, and is administered by the Department of Conservation.

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