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Manaaki Whenua
Landcare Research

Weed Biocontrol

WHAT'S NEW?



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www.weedbusters.org.nz

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PRISMSS Invigorates Pacific Weed Biocontrol

Invasive species are the leading driver of biodiversity loss in the Pacific, negatively affecting ecosystem resilience, ecosystem services, and future ability to adapt to climate change. In the past the major gap in invasive species management in the Pacific has been adequate, on-the-ground operational action. Now a new initiative has been launched by the Secretariat of the Pacific Regional Environment Programme (SPREP) to address this gap.

"The Pacific Regional Invasive Species Management Support Service, which is known as PRISMSS, will significantly increase both the quantity and scope of management operations in the region," explained David Moverley of SPREP. "PRISMSS will provide management support for on-the-ground invasive species actions, through streamlining and coordinating activities and providing ready access to invasive species management experts who are leaders in their respective fields," he added. PRISMSS has five regional programmes, which are described below.

Protect Our Islands focuses on national and inter-island biosecurity, and the early detection of and rapid response to new incursions. This is critical, since biosecurity is the first line of defence against invasive species arriving and establishing in a new destination. Pacific Biosecurity, based at Victoria University of Wellington, is the lead PRISMSS technical partner for this regional programme, with support from the Pacific Community (SPC), the mandated coordinator for national biosecurity in the Pacific.



War on Weeds targets the management of high-risk, low-distribution weed species, where the objective is eradication or containment. Weeds thrive on disturbance, and so their harmful impacts are exacerbated by tropical cyclones, strong winds, drought and fires, all of which are increasing in severity due to the changing climate. SPREP is the lead PRISMSS technical partner for this regional programme.

Natural Enemies – Natural Solutions deals with widespread weeds, where the only safe, cost-effective and sustainable way of managing them is by utilising their natural enemies (biocontrol). Natural enemies have been established on 25 weed species in 17 countries in the Pacific, and there are many opportunities for spreading existing agents available in the Pacific to new countries, introducing agents available outside the Pacific, as well as developing new options for the Pacific. Manaaki Whenua – Landcare Research is the lead PRISMSS technical partner for this regional programme, with assistance provided by tropical weed biocontrol expert Michael Day (Biosecurity Queensland).

Predator Free Pacific covers the removal of mammalian predators from islands. Sixty Pacific islands have had predators, such as rats, removed. Island Conservation is the lead PRISMSS technical partner for this regional programme, the only charitable organisation solely dedicated to removing invasive species on islands to prevent extinctions. They are supported by BirdLife International, who, with their partners, have eradicated introduced vertebrates from over 30 tropical Pacific islands.

Finally, *Resilient Ecosystems-Resilient Communities* supports the ecological restoration of priority areas. Threatened species and ecosystems in the Pacific often exist within high-value areas on larger islands where invasive animals and invasive plants will continue to

be a threat. A site-led approach to manage multiple invasive species and re-introduce lost native species and ecosystem structure over a longer period of time is therefore needed. SPREP is also the lead PRISMSS technical partner for this regional programme.

PRISMSS was officially launched in July, and during October and November a 5-week Programme Management Course was held at SPREP's headquarters in Apia, Samoa. "This enabled participants from across the Pacific to receive training to plan and manage an invasive species programme of work focused on the regional programmes under PRISMSS," explained David. Lynley Hayes and Michael Day ran a module covering the use of weed biocontrol for 18 participants from 10 countries and five SPREP staff. "In recent decades biocontrol has become somewhat of a forgotten tool in the Pacific. But the tide appears to be turning, with New Zealand enabling recent activity in the Cook Islands, and a project currently underway in Vanuatu, leading to the development of new agents for key weeds in the region," said Lynley.

The workshop participants were surprised to learn about successful weed biocontrol programmes in their countries, of which they had no prior knowledge. Because successful programmes result in weeds becoming low incidence, out of sight can soon become out of mind, and the previous importance of these weeds and the biocontrol intervention taken are forgotten within a generation. This meant that quite a bit of searching was needed to find suitable sites for the field trip component, since the weed targets are now much less common.

Agents were released in Samoa in the 1980s and 1990s against giant sensitive plant (*Mimosa diplotricha*) and lantana (*Lantana camara*), respectively. However, eventually a small patch of the former, and three plants of the latter, were located, and the participants were able to familiarise themselves with the psyllid (*Heteropsylla spinulosa*) on giant sensitive plant and leaf-mining beetle (*Uroplata girardi*) on lantana, which have provided excellent suppression of these weeds. "By the end of the workshop there was considerable excitement and enthusiasm for the prospect of delivering more such successes in the Pacific," said Lynley.

With the training over, the focus now will be on developing new biocontrol programmes in 2020 for Niue, Tonga, Tuvalu, Marshall Islands, and Wallis and Futuna, all of which have secured funding for this work. It is anticipated that funding will also be secured soon to enable additional Pacific Island countries and territories to get new projects underway. At the outset, in-country surveys will be undertaken to assess which weed targets may be suitable for the natural enemies approach and any biocontrol agents already present. Workshops will then be held so that people with knowledge of, or interest in, weeds in-country can consider the relative importance of each species under consideration. This information will be combined with the feasibility of biocontrol and the likelihood

of success for these weeds so the workshop participants can identify and agree on the top priorities for action.

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PRISMSS was established in 2019 with the assistance of the Global Environment Facility (GEF) project "Strengthening national and regional capacities to reduce the impact of invasive alien species on globally significant biodiversity in the Pacific". GEF and the European Union-funded PROTEGE project are funding the development of new national biocontrol projects mentioned above. The New Zealand Department of Conservation is also supporting the development of PRISMSS. The New Zealand Ministry of Foreign Affairs and Trade is funding weed biocontrol projects in the Cook Islands and Vanuatu.



Yellow Flag Iris: Beauty Turned Beast

Yellow flag iris (*Iris pseudacorus*) is a robust, perennial, semi-aquatic iris species with attractive yellow flowers that was once favoured as an ornamental garden plant. However, it is now an unwanted organism under the New Zealand Biosecurity Act 1993, and is listed in the National Plant Pest Accord, prohibiting its sale and distribution. Yellow flag iris is native throughout Europe, the Mediterranean, western Asia and parts of North Africa, and has been introduced to South and North America, Japan, Korea, South Africa, Australia and New Zealand. It was first recorded as growing wild in New Zealand in 1938 in Lower Hutt and has since spread throughout the country. Christchurch's Avon River and the Lower Waikato Catchment are the worst affected by populations of yellow flag iris, which have increased rapidly since the mid- to late 2000s. A helicopter survey along the Waikato River in 2011 recorded a 258 ha infestation of yellow flag iris, which has continued to expand, now threatening the internationally significant Whangamarino wetland.

Yellow flag iris grows along the shores of still water bodies such as lakes and ponds, and along slow-flowing rivers and streams. In its introduced range it forms large, dense rhizome mats that crowd out native species, clog waterways and alter hydrological systems through sediment accumulation. Being well adapted to disturbance, it is often associated with human-modified landscapes and structures such as meadows, wet pastures, ditches and, the banks of irrigation canals.

Yellow flag iris is tolerant of a range of environmental conditions, including high salinity, drought, submersion, low pH, and long-term anoxia (absence of oxygen). It can reproduce asexually (vegetatively) from rhizome fragments or sexually from buoyant seeds, and is easily dispersed along waterways, particularly during flooding. This can lead to encroachment onto farmland, where there is a risk of poisoning cattle due to its toxic properties. The poisonous seeds may also affect native birds.

Mechanical and manual control methods are used to manage yellow flag iris infestations but are seldom effective,

particularly on a large scale. Chemical control is currently the recommended management method, but this requires repeat applications and is costly. Estimated costs of labour and herbicide are as much as \$1,350 per hectare when cover exceeds 40%. However, according to Hamish Hodgson from the Waikato Regional Council, yellow flag iris infestations have become so large in certain parts of the Lower Waikato Catchment that chemical control is not a viable option.

With the growing threat posed by yellow flag iris to New Zealand's wetlands and river catchments, and the difficulty of controlling large infestations with conventional methods, we recently conducted a feasibility study exploring biocontrol options. According to Chris McGrannachan, who did the feasibility study, biocontrol agents for yellow flag iris have not yet been released anywhere in the world. "However, the Centre for Biological Control (CBC) at Rhodes University in South Africa have initiated a programme and are currently testing candidate insect biocontrol agents," said Chris. This is potentially of great benefit to New Zealand, since South Africa is doing much of the groundwork, including native range surveys, re-phasing of agents from the northern to the southern hemisphere, and host specificity testing. "This will significantly cut down on the costs associated with developing a biocontrol programme for yellow flag iris in New Zealand and will greatly improve the chances of selecting host-specific and damaging agents, if a programme against this target is to go ahead here," said Chris.

Collaborators in South Africa are willing to assist and are already conducting research on the genetic diversity of yellow flag iris populations in New Zealand. These will be compared with other invasive populations of yellow flag iris in the southern hemisphere (i.e. South Africa and Argentina) as well as populations in the native range of Europe. This research could pinpoint the origin of the New Zealand populations and could assist biocontrol programmes worldwide.

Professor Julie Coetzee, Deputy Director of the CBC, said efforts to begin a biocontrol programme against yellow flag



Iris seed weevil



Iris flea beetle adults and damage

iris in South Africa are timely. “I was in Argentina in October last year and the yellow flag iris invasion there was like nothing I have ever seen. This has served as a very loud warning to us in South Africa to get control of this weed as soon as possible,” said Julie. Julie explained that preliminary surveys in the native range identified two potential insect biocontrol agents: the iris flea beetle [*Aphthona nonstriata*] and the iris seed weevil [*Mononychus punctumalbum*]. Adults of both species feed on the foliage of yellow flag iris, while larvae of the flea beetle mine the leaves, and larvae of the weevil attack the seeds.

The CBC currently have the flea beetle in containment and have started host-specificity tests looking at native species in the genus *Dietes*, the most closely related genus to the *Iris* genus in South Africa. According to Julie the results are encouraging. “So far we have had no development of the iris flea beetle on non-target plants, and we are looking at importing the iris seed weevil into containment this coming summer for testing.”

“Like South Africa, New Zealand does not have any native *Iris* species. Several ornamental *Iris* species of commercial and aesthetic value are cultivated in New Zealand, and these would need to be considered in a biocontrol programme targeting yellow flag iris,” said Chris. “Our closest native relatives are in the genus *Libertia* [nine of which are endemic], and these would also need to be tested, but are unlikely to be at risk of attack by insects with a narrow host range as they are quite distantly related to yellow flag iris,” explained Chris.



Yellow flag iris seed pods

After a thorough desk-top study and consultation with the CBC in South Africa, Chris regards the iris seed weevil and the iris flea beetle as the most promising candidate agents for yellow flag iris in New Zealand. Is it time we heed the warnings from South Africa and Argentina that our problems with yellow flag iris might only have just begun?

This project was funded by the Waikato Regional Council.

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Booting Aquatics with Biocontrol

New Zealand has a serious problem with invasive alien aquatic weeds, including rooted, submerged macrophytes such as lagarosiphon [*Lagarosiphon major*], hornwort [*Ceratophyllum demersum*] and Brazilian waterweed [*Egeria densa*].

Aquatic and wetland weeds are one of the worst groups of invasive species because they negatively affect the quality, quantity and accessibility of irrigation and potable water, and they are easily spread by water birds and downstream flows to new, uninvaded areas. They are typically characterised by rapid vegetative growth and the ability to easily regenerate via fragmentation [the production of new plants from small broken segments] and dormant vegetative organs such as tubers or turions. Aquatic and wetland weeds critically threaten the unique and sensitive biota associated with these ecosystems, and they negatively affect farming and hydro-electric operations and recreational water use, usually with high costs of control. In freshwater systems, the negative impacts of these weeds are often enhanced by other drivers, such as nutrient enrichment, which further degrade these systems and the ecosystem services they provide.

While several control methods are routinely used to help manage aquatic and wetland weeds, they are costly,

particularly once a weed has established widely. They are usually non-selective and can lead to other unwanted, non-target impacts. For example, manual and mechanical control causes plant fragmentation, which can worsen the problem by establishing new infestations in previously uninvaded areas. If misused, chemical control using herbicides can be toxic to non-target native fauna and flora, and the rapid decay of large amounts of plant biomass can lead to anoxic [low oxygen] conditions in the water, or algal blooms from the release of plant nutrients.

For this reason, biological control, which has the advantage of being selective, self-sustaining and of low environmental risk, is a viable option for helping to managing aquatic plant problems. “Biocontrol of floating, emergent and submerged aquatic weeds has been studied and applied worldwide since the 1960s, often with great success,” said Angela Bownes. “With the expanding threat of aquatic and wetland weeds to our freshwater ecosystems, we need another weapon in our arsenal to help reduce the negative ecological and economic impacts of these weeds. We see this is an important new focus area for weed biocontrol in New Zealand,” said Angela.

Lagarosiphon, which is widely distributed throughout the North and South Islands and is considered a major pest by



stakeholders managing New Zealand lakes, was identified as the most promising first target. Lagarosiphon, or oxygen weed, is native to South Africa and is also highly invasive in several parts of Europe. Biocontrol options for lagarosiphon were well studied in Ireland in the early 2010s, with two candidate biocontrol agents – a leaf-mining fly (*Hydrellia lagarosiphon*) and a shoot-mining midge (*Polypedilum tuburcinatum*) – prioritised based on their narrow host range and their damage potential. Host specificity testing of the leaf-mining fly was opportunistically done while collaborators from the University of Dublin were working on the fly. Their research included key native aquatic plants in New Zealand and showed that the fly is sufficiently host specific for release here.

The host range of the shoot-mining midge in a New Zealand context is currently being researched on our behalf by Ben Miller from the Centre for Biological Control (CBC) at Rhodes University in South Africa. Aquatic plant species in the Hydrocharitaceae and native aquatic plants in the order Alismatales will be tested in South Africa to assess the midge's host range and safety for release.

However, before embarking on any new application to release a weed biocontrol agent, it is important to conduct pre-release research to guide the programme and maximise the chances of success. "This is essential baseline research to ensure the candidate agents are not already present on the target weed, and to assess the risk of parasitism of the agents, which could affect their establishment and efficacy," said Quentin Paynter who conducted a feasibility study on biocontrol options for lagarosiphon in New Zealand.

"Equally important for this particular programme is to conduct further underpinning research to assess whether biological control is likely to be an effective management approach for lagarosiphon. Biocontrol of a similar submerged aquatic macrophyte, hydrilla [*Hydrilla verticillata*] in the USA had variable success, so we need to assess quantitative scientific data to help us predict an outcome for a biocontrol programme against lagarosiphon," said Quentin.

This will be done by comparing plant biomass and growth

rates of lagarosiphon in the native range of South Africa, where the candidate biocontrol agents are present, and in New Zealand, where lagarosiphon [to our knowledge] does not have any significant natural enemies. "This will test the hypothesis that lagarosiphon is a serious weed here because of a lack of natural enemies to keep it in check, and that this can be reversed using biocontrol," said Quentin. This work will be done in collaboration with aquatic weed experts at the CBC in South Africa and is planned to commence this coming summer.

Although there is much work to be done prior to proceeding with an application to release any biocontrol agents for lagarosiphon, early indications are that it will be a valuable tool to help manage the weed. Angela explains that "the fact that we don't have any native plants in the same plant family [Hydrocharitaceae] as lagarosiphon greatly improves our chances of finding host-specific natural enemies, and since the invasive biotype in New Zealand is dioecious [having male and female flowers on separate plants], and we only have female plants, there is no seed bank to contribute to reinvasion. Also, since lagarosiphon typically occurs in the high-lying areas of South Africa, the agents should be cold-tolerant enough to thrive in the New Zealand climate.

Although biocontrol can be a highly effective control method, it is not expected to cause rapid, large-scale declines of lagarosiphon populations that could jeopardise the integrity of our aquatic ecosystems. "In fact, we expect that an integrated approach, using different control methods at different times and locations, will be necessary to provide a long-term, environmentally sound solution to the management of lagarosiphon and other aquatic and wetland weeds in New Zealand," said Angela.

This project is currently supported with funding from the Ministry of Business, Innovation and Employment as part of Manaaki Whenua – Landcare Research's Beating Weeds programme.

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Melissa Kirk's PhD Work

We are delighted to introduce a PhD student, Melissa Kirk, who is registered at Auckland University and is based both at the university and at our Tamaki office. Melissa is originally from England and moved to New Zealand when she was 12 years old. She has since lived in Christchurch, Blenheim and Dunedin, and is currently living in Auckland. Melissa's PhD study is investigating the co-evolution of plants and insects in exotic ecosystems in order to gain a better understanding of the successes, and the risks, associated with weed biocontrol programmes.

Depending on their origins and the time since their separation, genetics play a key role in weed biocontrol programmes in three main ways.

- A match or a mismatch may occur between the target weed and the weed biocontrol agents.
- Genetic imbalances may occur between the target weed and the agent, where, for example, low genetic diversity of an agent may reduce its ability to adapt over time.
- There is often adaptation to novel environments and stressors over time, resulting in genetic differences in the plants and/or the biocontrol agents compared to their source origin.

Melissa will use long-established weed biocontrol systems in New Zealand as case studies. "The aim of my research is to investigate how multiple factors, such as genetic diversity, genetic processes (e.g. maternal priming, epigenetic changes), time since separation, phenotypic/genotypic matching, and rapid adaptation can all influence the outcome of biocontrol programmes."

The first case study will be on nodding thistle (*Carduus nutans*) and its three insect biocontrol agents: the gall fly (*Urophora solstitialis*), the crown weevil (*Trichosirocalus horridus*), and the receptacle weevil (*Rhinocyllus conicus*). By using common garden experiments and molecular techniques, Melissa will determine if imbalances occur between native and introduced populations of nodding thistle and its biocontrol agents. "Firstly, I will explore the life history traits of nodding thistle and the presence and abundance of the biocontrol agents in different parts of New Zealand," said Melissa. "Then I will explore the life history traits and genotypes and phenotypes of nodding thistle from New Zealand, Australia and the United Kingdom [conducted at Sheffield University]". Melissa explains that these nodding thistle populations have had different relationships with their natural enemies over time.

Native nodding thistle populations in Europe have had continuous exposure to these natural enemies, and they have other insect natural enemies that are not present in the introduced range. The New Zealand and Australian populations were without any natural enemies for decades until three host-specific biocontrol agents were introduced. "The



Melissa Kirk

native populations of the agents in Europe could potentially have higher genetic diversity compared to the introduced populations in New Zealand and Australia, and it is possible that these populations have diverged because of a lack of gene flow. The same could be true for the plant populations," said Melissa. If differences are found, Melissa also plans to investigate how these traits have evolved. "By understanding which factors influence plant-insect interactions, we can make biological control safer and more effective," Melissa added.

Melissa majored in ecology and statistics for her undergraduate degree and moved into entomology with a focus on invasive species for her Masters, where she investigated the influence of propagule pressure, source variation, and dispersal capabilities on the establishment of exotic insects. Melissa considers herself an entomologist with an interest in developing her expertise in molecular biology. "I find insect biocontrol agents so interesting, so I'm very excited about having a project in weed biocontrol with a focus on genetics," enthused Melissa.

Melissa's PhD project is funded by the Ministry of Business, Innovation and Employment as part of Manaaki Whenua – Landcare Research's Beating Weeds programme, by the University of Auckland, and by the Centre of Biodiversity and Biosecurity (CBB) Project Fund. Melissa is being supervised by Darren Ward, Quentin Paynter and Thomas Buckley [all MWLR].

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Summer Activities

Broom gall mites (*Aceria genistae*)

- Check 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 been observed at some sites.
- Harvesting of galls is best undertaken from late spring to early summer, when predatory mites are less abundant. Aim to shift at least 50 galls to each site and tie them on to plants so the tiny mites can move across.

Green thistle beetles (*Cassida rubiginosa*)

- December is often when green thistle beetle activity is at its peak. Look for adult beetles, which are 6–7.5 mm long and green, so they are well camouflaged. Both the adults and the larvae make windows in the leaves. Larvae have a protective covering of old moulted skins and excrement. You may also see brownish clusters of eggs on the undersides of leaves.
- If you find good numbers, use a garden leaf vacuum machine to shift at least 100 adults to new sites. Be careful to separate the beetles from other material collected, which may include pasture pests. Please let us know if you discover an outbreak of these beetles.

Honshu white admiral (*Limenitis glorifica*)

- Look for the adult butterflies at release sites from late spring. Look also for pale yellow eggs laid singly on the upper and lower surfaces of the leaves, and for the caterpillars. When small, the caterpillars are brown and found at the tips of leaves, where they construct pier-like extensions to the mid-rib. As they grow, the caterpillars turn green with spiky, brown, horn-like protrusions.
- Unless you find lots of caterpillars, don't consider harvesting and redistribution activities. You will need to aim to shift at least 1,000 caterpillars to start new sites. The butterflies are strong fliers and are likely to disperse quite rapidly without any assistance.

Privet lace bug (*Leptoypha hospita*)

- Examine 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, stem and tip beetles (*Neolema ogloblini*, *Lema basicostata*, *N. abbreviata*)

- Look for the distinctive feeding damage and adults. For the leaf and tip beetles, look for the external-feeding larvae, which have a distinctive faecal shield on their backs.
- If you find them in good numbers, aim to collect and shift at least 100–200 beetles using a suction device or a small net. For stem beetles it might be easier to harvest infested material and wedge this into tradescantia at new sites [but make sure you have an exemption from MPI that allows you to do this].

Tradescantia yellow leaf spot (*Kordyana brasiliensis*)

- Although the fungus has only been released for a short

time at many sites, promising signs of likely establishment have been seen at some sites after only a few months, so it is worth taking a look this summer. Look for the distinctive yellow spots on the upper surface of the leaves with corresponding white spots underneath, especially after wet, humid weather. Feel free to take a photo to send to us for confirmation if you are unsure, as occasionally other pathogens do damage tradescantia leaves.

- The fungus is likely to disperse readily via spores on air currents. If human-assisted distribution is needed in the future, again you will need permission from MPI to propagate and transport tradescantia plants. These plants can then be put out at sites where the fungus is present until they show signs of infection, and then planted out at new sites.

Tutsan beetle (*Chrysolina abchasica*)

- It is early days for most tutsan beetle release sites, but the best time to look for this agent is spring through to mid-summer. Look for leaves with notched edges or whole leaves that have been eaten away. The iridescent purple adults are around 10–15 mm in size, but they spend most of the day hiding away so the damage may be easier to spot. Look also for the creamy-coloured larvae, which are often on the undersides of the leaves. They turn bright green just before they pupate.

Tutsan moth (*Lathronympha strigana*)

- We don't yet know if the tutsan moth has established so are keen to hear how it is doing in the field. 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 will be too soon to consider harvesting and redistribution if you do find the moths.

National Assessment Protocol

For those taking part in the National Assessment Protocol, summer 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

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Target	When	Agents
Broom	Dec–April	Gall mite (<i>Aceria genistae</i>)
Privet	Feb–April	Lace bug (<i>Leptoypha hospita</i>)
Tradescantia	Nov–April Anytime	Leaf beetle (<i>Neolema ogloblini</i>) Stem beetle (<i>Lema basicostata</i>) Tip beetle (<i>Neolema abbreviata</i>) Yellow leaf spot fungus (<i>Kordyana brasiliense</i>)
Woolly nightshade	Feb–April	Lace bug (<i>Gargaphia decoris</i>)