



What's New In Biological Control Of Weeds?

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Manaaki Whenua
Landcare Research

Tiny Twosome Tame Tree

In the past people thought trees would be too difficult to target for biocontrol but there are now some good examples to show they can be successfully controlled in this manner, including a recent success in southern Florida. Melaleuca (*Melaleuca quinquenervia*), also known as paperbark, was introduced from Australia because of its attractive flowers and bark, and it was planted widely to dry out what were considered to be “useless” marshes and swamps. It is also fast growing and thrives on neglect, so consequently has spread like wildfire since the late 1800s to now cover more than 500 000 acres in central and southern Florida, including the internationally significant Everglades wetlands.

This weedy tree forms dense stands, excluding native plants and animals. It colonises both wet and dry areas and

can disrupt the natural flow of water. Melaleuca is also a serious fire hazard as the oils in the leaves can create intense fires that spread rapidly. These fires do not usually kill the tree but trigger the release of seeds – each tree can produce millions of these. With an estimated expansion of an incredible 14–15 acres a day, melaleuca had come to pose a serious problem and a biological control programme was initiated.

Researchers decided that it would be too difficult to attempt biomass reduction through biological control so chemical and manual methods of control are used to remove established trees. “Instead biocontrol was aimed at weakening the reproductive capacity of the tree, to prevent regeneration and spread,” explained Paul Pratt of the USDA-ARS Invasive Plant Research Laboratory in Florida. Two biocontrol agents have



The mighty melaleuca weevil.

been released so far with two more waiting in the wings, and three more undergoing further investigation.

The first agent to be released was a weevil (*Oxyops vitiosa*) in 1997. Both the adult and larvae are leaf feeders and attack new growth. The larvae cunningly use melaleuca's defensive chemicals for their own protection against predators. The second was a sap-sucking psyllid (*Boreioglycaspis melaleucae*) in 2002. The psyllid complements the weevil by feeding on older leaves. The nymphs do the most damage killing leaves, stems, and seedlings. They protect themselves by secreting waxy fluff that covers their whole body.

Together the weevil and psyllid are having a major impact on all aspects of melaleuca's life cycle. "These busy insects have already reduced flowering by 90% and halved the number of seed capsules produced per flower," revealed Paul. Seedling mortality has risen by up to 65% and tree density has dropped by a third due to the voracious duo killing many small trees. "The stress they are putting on melaleuca has reduced regrowth on cut stumps by half and decreased leaf biomass in the canopy by a third," adds Paul. These are just the kind of statistics we like to hear!

The pressure on this woody weed is only going to increase with a small fly (*Fergusonina* sp.) and nematode worm (*Fergusobia* sp.) about to be released soon. These two work together to gall melaleuca leaf and flower buds, terminating their growth. In this unusual relationship, the nematode lives in the ovaries of the female fly. When she lays her eggs in a melaleuca bud juvenile worms are also introduced. The nematode causes the bud to swell and the young of both species develop inside the protective gall, feeding on its interior. Other insects being investigated include a sawfly (*Lophyrotoma zonalis*) and moth (*Poliopaschia lithochlora*) that eat foliage, and a flower-feeding weevil (*Haplonyx multicolour*).



Paul Pratt showing off some weevil damage.

Programmes such as this show just how effective a tool biological control of weeds can be and that just about any kind of weed is fair game.

For more information see this website: <http://www.tame.ifas.ufl.edu>

New Information Sheets

After a year's break we have once again produced some new pages for "The Biological Control of Weeds Book". These include colour pages on conflicts of interest and on the social, ethical, economic, and environmental implications of biological control of weeds. This should make a number of school children happy as we have had many requests over the years for this kind

of information for school projects and essays. We have also revised and produced in colour the old black and white pages on the gorse colonial hard shoot moth (*Pempelia genistella*), hieracium gall midge (*Macrolabis pilosellae*), and the impacts of the mist flower fungus (*Entyloma ageratinae*). A new black and white "Who to Contact" page, monitoring forms for the old man's

beard saw fly (*Monophadnus spinolae*) and hieracium gall midge, and a new index have also been prepared. These pages were distributed in August. Any queries should be made to Lynley Hayes (hayesl@landcareresearch.co.nz). The new pages will be made available on our website (www.landcareresearch.co.nz/research/biosecurity/weeds/) in due course.

Hot Gossip

We have a **new PhD student** on board to help conquer **alligator weed** (*Alternanthera philoxeroides*). Quentin Paynter and Jacqueline Beggs (University of Auckland) are supervising **Imogen Bassett** in a project that is jointly funded by Landcare Research and the Australian Co-operative Research Centre for Weed Management (Weeds CRC). Imogen is looking into the factors that make alligator weed such a successful competitor, including the influence of shade, competition with other plants, and how long buried root fragments stay viable, and will seek any other clues as to why the plant is so weedy here. She also hopes to study potential new biocontrol agents in the plant's native range (Argentina) in an attempt to identify those that might be best suited to our climate. Colleagues in **Australia** have recently gained

funding that will enable them to begin host-testing some of the potential new alligator weed agents that have already been identified. The National Biocontrol of Weeds Collective (regional councils plus the Department of Conservation) is making a contribution to this programme to ensure that species of relevance to New Zealand are tested. Those species most likely to be tested first up include a **flea beetle** (*Disonycha argentinensis*), which was released in both countries during the 1980s never to be seen again, and a species of **thrips** (*Amynothrips andersoni*).

A **one-day workshop on current weed research** is planned for **Hamilton** in March next year. The workshop will be free of charge and open to anyone who is interested. It will feature a range of topics presented by researchers working in this field. If you do not already receive notifications about our

workshops and would like to know more about this one, please contact Hugh Gourlay (gourlayh@landcareresearch.co.nz, Ph 03 325 6701 ext 3748). Likewise, if there is sufficient interest, we will run a 2-day **advanced biocontrol of weeds workshop** at Lincoln or Auckland next March/April. This course is ideally suited for people who have previously completed a basic workshop or who have had significant previous experience in biological control of weeds. If you haven't already registered your interest in attending this advanced course then please contact Lynley Hayes (hayesl@landcareresearch.co.nz, Ph 03 325 6701 ext 3808).

The Name Game

Finally after years of confusion, we have managed to sort out the tangle of names and descriptions of fungi that attack *Passiflora* species in New Zealand and Hawai'i (see *Passion Leads to Frustration*, Issue 25). Biological control of banana passionfruit here would involve the importation of a novel species. Our research has confirmed that the species recorded in New Zealand on black passionfruit (*P. edulis*) and a weedy species, *P. tripartita* var. *mollissima*, was correctly identified as *Septoria passifloricola*. The Hawaiian species, which had been called *Septoria passiflorae* but bore more than a passing resemblance to *S. passifloricola*, has turned out to be neither. "The fungus that was released as a biocontrol agent in Hawai'i is new to science and has not been described or named before," revealed Jane Barton. Doing that is a job we will still have to tackle if host-testing trials currently underway suggest we should import this fungus.

The New Zealand and Hawaiian fungi differ in host range. *Septoria passifloricola* attacks black passionfruit (*Passiflora edulis*) and is occasionally found on weedy passionfruit species. By comparison, the Hawaiian species does not attack black passionfruit and is doing a good job on banana poka (*P. tarminiana*). "We tried to get it to infect black passionfruit sourced from New Zealand and were totally unsuccessful. This is good news for commercial growers," enthused Jane.

Jane Barton is a subcontractor to Landcare Research.



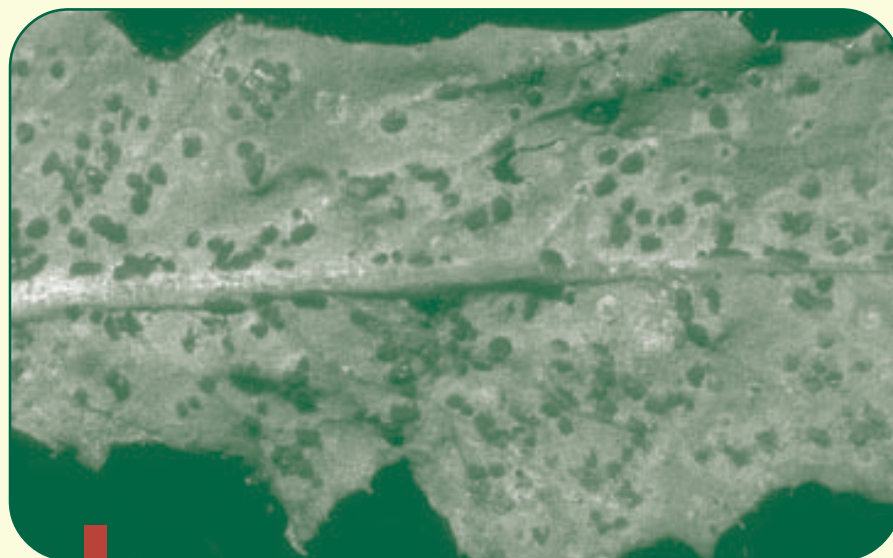
Imogen Bassett at Whale Bay, Raglan.

Pathological Fears Prove Unfounded

Given the misery that plant diseases can cause, e.g. the Irish potato famine, it's not surprising that some people get nervous about introducing plant pathogens for weed biocontrol. However, it is this ability to cause devastating disease outbreaks that gives microscopic fungi so much potential as biocontrol agents. The trick is to weigh up the risks of harming a non-target species against the benefits of controlling the target weed, and this is largely done during host-range testing. But how well can these tests, which are usually undertaken in a glasshouse, predict the behaviour of micro-organisms outdoors in a new environment? And is it possible that a pathogen that is shown to be safe in such tests could later evolve to attack new hosts?

To answer these questions Jane Barton has recently gathered information about all the plant pathogens that have been released as classical biocontrol agents for weeds worldwide. She has looked at the predictions made about these fungi, on the basis of pre-release host-range testing, and compared them to what actually happened after the fungi were released. "The good news is that none of the 26 pathogens released to date have misbehaved at all," enthused Jane.

Excluding results from a couple of host-range tests that were conducted outdoors, there is only one report of a pathogen released for biological control of weeds infecting a non-target species in the field. When the acacia gall rust (*Uromycladium tepperianum*) was introduced to South Africa to control Port Jackson willow (*Acacia saligna*) a few galls also formed on *Acacia cyclops*. This had been



Skeleton weed rust (Puccinia chondrillina), the first micro-organism to be released as a classical biocontrol agent (Australia 1971).

Gary L. Piper, Washington State University, www.forestryimages.org

predicted from host-range testing and a decision was made that minor damage to another introduced species would be a small price to pay for bringing its highly invasive relative into line. The gall rust has worked so well against *A. saligna* that there has been no cause to regret this decision.

Many of the pathogens used for biological control had, like the acacia gall rust, shown potential to damage a non-target plant or plants during host-range tests. Interestingly, once out in the field, these pathogens did not actually do this. The glasshouse tests apparently overestimated the likelihood of attack and there are probably two explanations for this. "Host-range tests are conducted under optimal conditions for infection and disease development, which rarely occur in the field, and plants grown in a glasshouse seem to be more susceptible to infection," outlined Jane.

The study also shows that fears of pathogens evolving to attack susceptible non-target species, or to

"jump" to a new host, are unfounded. In fact, the first pathogen released as a biocontrol agent, *Puccinia chondrillina*, appears to have lost the ability to harm more than one form of its target, skeleton weed (*Chondrilla juncea*). Its host range has actually become narrower since release. This illustrates an important point: the chances of a pathogen evolving to become less fussy are no greater than the chances of it becoming more fussy. Likewise, the chances of an exotic pathogen jumping to a new host are no greater than those of a native pathogen doing the same. It would seem that target weeds are the only ones that should have a pathological fear of our smallest biocontrol allies.

Jane Barton is a subcontractor to Landcare Research. For a full copy of her review see: Barton (née Fröhlich), J. 2004: How good are we at predicting the field host-range of fungal pathogens used for classical biological control of weeds? Biological Control 31: 99–122.

Where the Wild Things Are

Hawaiian ginger expert Rob Anderson (Pacific Island Ecosystem Research Centre) visited last November and told people up and down the country about his "Kahili"make" project. This created much interest and the question on many people's lips was could we possibly use the bacterium (*Ralstonia solanacearum*) against wild ginger (*Hedychium gardnerianum*) here too? Two important questions needed to be answered: Are New Zealand populations susceptible? and would conditions here suit? Having ascertained the answer to the first question was yes, we set about exploring the second.

In Hawai'i this rhizome-rotting disease is working well in experimental plots at Volcano. At an elevation of 1200 m, Volcano is not one of the hottest places

in Hawai'i, with a mean annual temperature of 17°C and around 3000 mm of rain a year. Initially we intended to find out if there are any places here with a comparable mean annual temperature. However, this turned out to be a difficult task. While temperatures in both places vary between day and night, there is much more seasonal variation in temperature in New Zealand, and as a result we have much lower mean annual temperatures. "To overcome this problem we used environmental measures based on growing season, which occurs over the warmer months of the year here," explained Alison Gianotti.

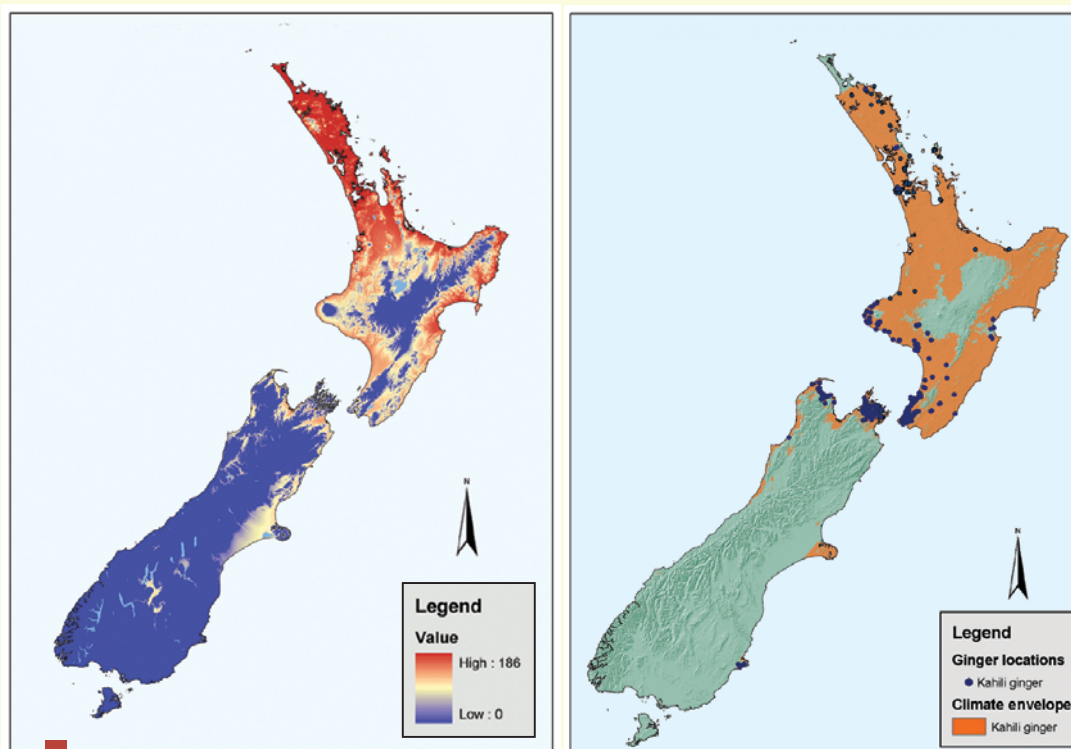
Our Hamilton-based colleagues, John Leathwick and Craig Briggs, produced a map showing the number of days

during the growing season that an area experienced conditions similar to those found at Volcano (Map 1). Based on the Volcano experience, areas shaded yellow/orange/red should have favourable temperature conditions for rhizome infection by the bacterium. We also prepared a map showing areas where wild ginger is currently ensconced and where it could grow given half a chance, as shown by the orange shading (Map 2). Luckily what this seems to indicate is that, although not a match made in heaven, there is considerable overlap between the places wild ginger occurs (or could occur) and the areas where the bacterium should be able to infect it based on temperature comparisons.

As a next step, Rob will be helping us find out how well the bacterium copes with the cooler temperatures it would experience during winter here. If he is

able to give us good news on this front then the next task is likely to be a comparison of the Hawaiian strain with strains of the bacterium that occur here.

Thanks to staff from the Northland, Auckland, Taranaki, Horizons, Hawke's Bay, Otago, and Greater Wellington regional councils, North Shore City Council, Tasman District Council, and the Department of Conservation for providing data. We also gratefully acknowledge the use of data obtained from the Auckland Museum Herbarium and Landcare Research Allan Herbarium.



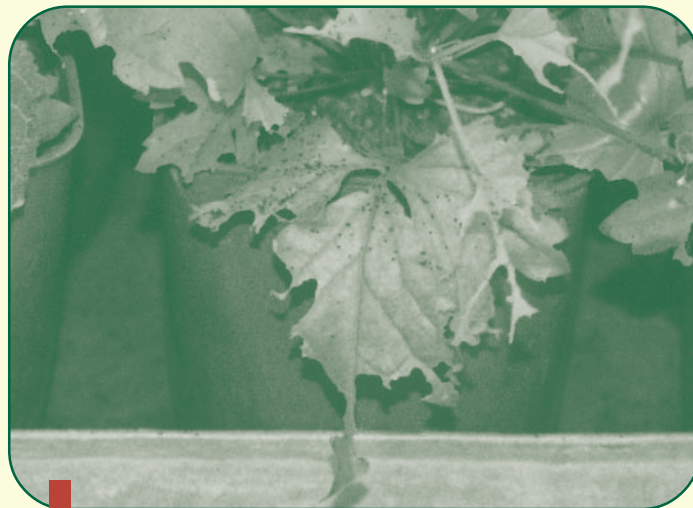
Map 1: The number of days during the growing season that areas in New Zealand experience conditions similar to that found at Volcano, Hawai'i. Map 2: Areas where wild ginger currently grows or could grow.

Things To Do This Summer

I know you will all be looking forward to a nice holiday this summer but many biocontrol agents will be at their busiest so you might need to also plan for some of these activities:

- Checking old man's beard sawfly (*Monophadnus spinolae*) release sites – we have not had a confirmed sighting of these in the field yet so keep your eyes peeled and let us know if you find anything suspicious. Look for leaves that have semicircular incisions along the margin or that have been completely skeletonised by the white caterpillar-like larvae. Black balls of frass may also be visible where larvae have been feeding. Our colleagues overseas tell us that the adults are hard to spot, but sometimes you can see females sitting underneath the leaves or males swarming around looking for females to mate with.
- Checking gorse colonial hard shoot moth (*Pempelia genistella*) release sites – the best time to look for this agent is in late spring when the green-and-brown striped caterpillars and the webs they live in are at their largest. Check near the release site for feeding damage and webbing containing balls of frass, preferably before the plants start to put on new growth. Don't be too disappointed if you don't find anything as it can take several years before they become numerous enough to be easily detectable.
- Checking any gorse soft shoot moth (*Agonopterix ulicetella*) release sites that have previously shown positive results from pheromone trapping. The best time to look is early December when the

caterpillars are quite large but have not yet pupated. Look for webbed or deformed growing tips and if you can find a dark brown or greyish-green caterpillar (they change colour as they age) inside then you are in luck – leafroller



Typical old man's beard sawfly damage.

caterpillars are quite common on gorse but are generally brighter green and smaller than soft shoot moth caterpillars.

- Checking Portuguese gorse thrips (*Sericothrips staphylinus*) release sites – gorse thrips can be confused with flower thrips (*Thrips obscuratus*) so the best time to check for them is when the gorse isn't flowering. Check areas of new growth in particular and, as thrips are pretty tiny, a hand lens may be helpful. If you can't see any try gently beating some foliage over a piece of white cardboard – but don't disturb the bush any more than necessary.
- Checking on hieracium gall midge (*Macrolabis pilosellae*) release sites – you will be very unlikely to find adults so instead check release sites for plants with the swollen and deformed leaves caused by larval feeding.
- Harvesting broom seed beetles (*Bruchidius villosus*) – beetles can be redistributed while still inside the pods but keep an eye on pod development. Harvest pods when they are brown and mature, otherwise the beetles inside may not be completely developed. Be aware that a spell of hot weather can cause the pods to ripen rapidly so don't delay once the first pods have begun to burst.
- Harvesting cinnabar moth (*Tyria jacobaeae*) – cinnabar moth is now becoming harvestable in some parts of New Zealand where previously it has been rare. It can be difficult to establish this insect in some areas and the reason why is not always obvious. If you have been unsuccessful in a particular area in the past then it's probably best to try releasing caterpillars somewhere else. As part of our non-target survey work we would like to know if you come across any good cinnabar moth outbreaks. Please contact Quentin Paynter paynterq@landcareresearch.co.nz, Ph 09 574 4123).

Remember to read up the relevant pages in "The Biological Control of Weeds Book" before embarking on any of these activities, and let us know how you get on!

Why Do Faunal Surveys?

We are often asked why we need to spend so much time and effort finding out what's living on exotic weeds here? The reality is that a thorough faunal survey early on is a necessary part of any biological control programme as it can enhance success and save time and money further down the track.

One useful piece of information that such surveys can provide is confirmation of the identity of target weeds. For example, boneseed (*Chrysanthemoides monilifera* ssp. *monilifera*) is closely related to bitou bush (*C. monilifera* ssp. *rotundata*) and they are similar in appearance. "Both are weeds in Australia and since potential agents may be specific to subspecies level we needed to double-check that we only had the one offender here before pursuing a biological control programme," revealed Chris Winks.

The main reason for conducting faunal surveys, however, is to establish what species occur on weeds here.

Although it is fairly uncommon to find specialist biocontrol agents, occasionally we do – the broom twig miner (*Leucoptera spartifoliella*) being the best-known example. It would be a huge waste of resources to go down the track of importing an organism that had already arrived under its own steam; a situation that has occurred elsewhere.

A key part of these surveys is to assess what parts of the plant are being attacked and how severely. We need this base-line data in order to make the best possible decisions about potential agents. "We always look for agents that might best complement any existing organisms rather than compete with them, and fit niches not already being utilised on the weed," explained Simon Fowler. We usually find a large number of generalist species that are having minimal impact, which strengthens the case for a classical biological control approach. It is also common to find a range of naturally occurring fungi that we can

assess for their mycoherbicide potential.

Faunal surveys also help us to identify predatory or parasitic species that may hinder the establishment or impact of introduced agents. For example, during the boneseed survey Argentine ants were found in high numbers at three locations. This discovery could be significant because aggressive ant species are believed to have hindered the establishment of boneseed agents in Australia. If the target weed is already host to something that might compete or interfere with a particular biocontrol agent, we might need to rethink our choice of agents. For example, we may choose an internal feeding-agent, such as a galling insect, over an external feeding one. Or we may need to rethink our release strategy in order to minimise any interference.

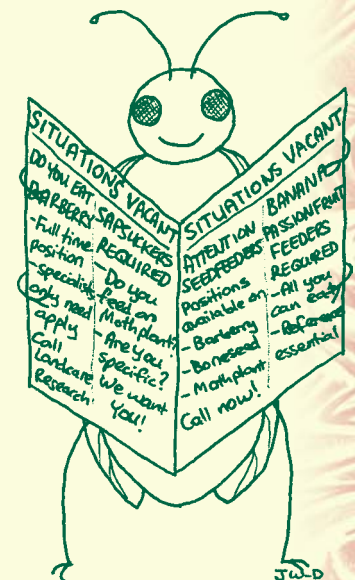
Recently we have undertaken two such faunal surveys and we share the results below.

Not Much Menacing Moth Plant

We found the usual scenario on moth plant (*Araujia sericifera*), with a wide range of native and exotic invertebrates feeding on it but none actually causing much damage. Leaf-feeding species, for example, caused less than 2% damage overall. "We identified 46 species of generalist herbivores but no specialist moth plant feeders, and none of the available niches are being exploited well," concluded Chris Winks. The only species classed as "abundant" was the good old generalist passionvine

hopper (*Scolypopa australis*). Another sap-sucker, the oleander aphid (*Aphis nerii*), was found in very high numbers at one site. This is of interest because aphids can transmit viruses that may have potential as biocontrol agents for this weed.

Sixteen fungal species were found on moth plant, but most do not appear to show any promise as biocontrol agents due to low virulence or a lack of host-specificity. However, three species, *Colletotrichum gloeosporioides*, *Microsphaeropsis* sp. and *Phomopsis* sp., do warrant further investigation. Species of



Colletotrichum have already been used as inundative mycoherbicides and classical biological control agents in other countries, and strains of the other two species are presently being developed for weed control overseas.

Overall moth plant appears to be getting off lightly in New Zealand. No species were found that would appear to rule out attempting a biological control programme, so it seems appropriate to continue down this track. Potential biocontrol agents are currently being sought in South America.



The oleander aphid.

Potential Pathogens for Barberry

Barberry (*Berberis glaucocarpa*) and Darwin's barberry (*B. darwinii*) were the main targets of another recent faunal survey. Again we found lots of little beasts (101 species of herbivorous invertebrates) doing little damage, with leaf-feeding species estimated to be causing less than 5% damage at most sites. There was very little, if any, attack observed on fruit and seeds. "We found one specialist feeder, the sap-sucking barberry aphid (*Liosomaphis berberidis*)," revealed Lindsay Smith. It was classed as "abundant" on barberry, the only herbivore to be accorded this status, and "common" on Darwin's barberry (a new record for this species). Other invertebrates found included 26 fungal-feeding species (such as cryptic beetles and book lice), and 18 predatory groups, but again none of these appear likely to preclude a biological control programme.

"We found a high incidence of fungal infection, 95%, on the leaves, flowers and fruit," summarised Nick Waipara.

Of the 24 fungal species identified only five warrant further investigation, including the two also of interest on moth plant (*Colletotrichum gloeosporioides* and *Phomopsis* sp.) as well as *Colletotrichum acutatum*, *Pestalotiopsis* sp., and *Sclerotinia sclerotiorum*. The latter is currently under development as a mycoherbicide by AgResearch for a range of weeds.

While this survey shows that there is some potential for exploring fungal-based control methods here in New Zealand, if we are to hit barberry really hard we will probably need to look for potential agents in South America and the western Himalaya.

These faunal surveys were funded by a national collective of regional councils and the Department of Conservation. The full reports are available from Lynley Hayes (hayesl@landcareresearch.co.nz).

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