What's New In Biological Control Of Weeds?

What's Inside:

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Manaaki Whenua
Landcare Research

Catching up with the Ginger Bug Man

Last November a leading expert on biological control of kahili ginger (*Hedychium gardnerianum*), Rob Anderson, came over from Hawai'i to share some of his expertise with us. Field days were organised in Whangarei, Auckland, Taupo, Wellington and Nelson so as many people as possible could hear what Rob had to say. "I have called my project "Kahili'make", which in Hawai'ian literally means kahili death," explained Rob. Although wild ginger species can be controlled successfully with herbicide, this is only cost-effective and environmentally safe for small infestations. If follow-up is not done religiously for many years to come, regeneration can take you right back to square one.

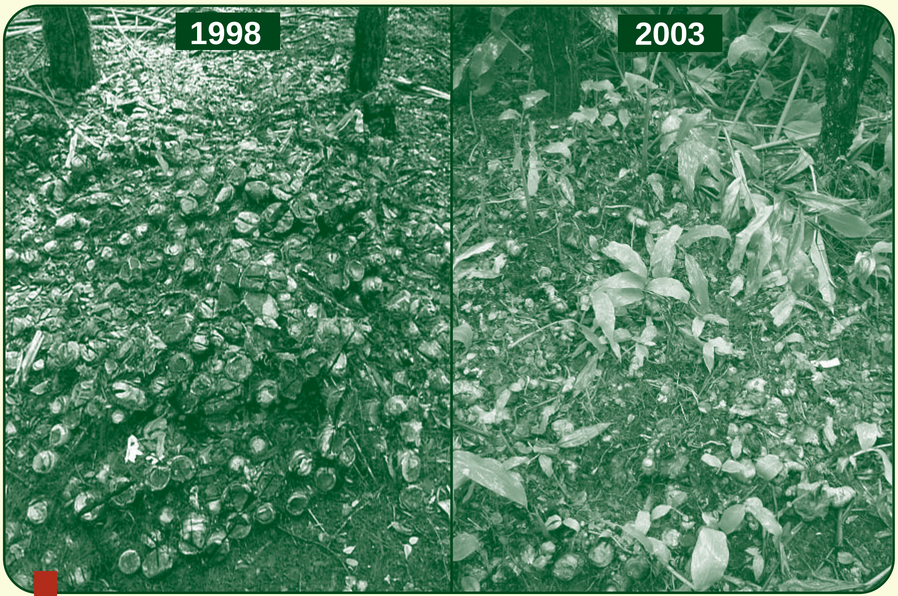
Rob isolated a bacterium (*Ralstonia solanacearum*) from diseased edible ginger (*Zingiber officinale*) rhizomes in Hawai'i back in 1995. This "ginger strain" appears to have a narrow host-range, and even other closely related ginger species such as yellow ginger (*Hedychium flavescens*) are not attacked. This pathogen lives in the soil and gets into the plant either through wounds or root absorption. Once inside the host, the pathogen will cause severe wilting of ginger stems and eventually kill the entire plant. Individual rhizomes will rot and decay within 6–8 weeks of infection, with entire mounds taking anywhere from 1 to 2 years to completely decay away, depending on size. As the rhizomes degrade away, the bacterium is released

Rob Anderson endorses the sentiment expressed on this Whangarei billboard.

into the soil. "One of the advantages this bacterium has over herbicides is that it remains in the soil ready to attack any new ginger seedlings that attempt to recolonise the area," explained Rob.

Rob has been experimenting with various ways of deliberately infecting kahili ginger plants. He started off by injecting inoculum into young stems but this method was not practical for large areas. Next he tried chopping up rotting rhizomes, mixing them with water and incubating the mixture for a fortnight, before spraying it on to ginger that had been slashed to remove the tops and injure the rhizomes. "It wasn't absolutely necessary to slash the ginger beforehand but it did allow results to be obtained more quickly," revealed Rob. More recently Rob has been working on better mass-production methods and has developed a process that encapsulates the bacterium inside alginate beads. As well as being easy and cheap to produce, the beads are easy to store and carry. The bacteria are also protected from environmental stress because they are encapsulated.

Some of Rob's field trials have been underway now for 5 years and this devastating wilt disease appears to be providing excellent long-term control. Initially the only downside appeared to be that the disease was slow to spread (e.g. 75 cm^2/month). Last year Rob noticed infections were spreading much more rapidly and he discovered that small drosophilid flies are acting as vectors. "These flies are attracted to the lesions on diseased ginger and are helping to spread the disease around," said Rob. "This was an unexpected bonus!" Another bit of good news was that Rob has tested the bacterium on New Zealand kahili ginger we sent over to him and found it to be susceptible.



Rob Andeson

Field trials where the bacterium was applied in 1998 and the ginger is still supressed 5 years later. The weak regrowth shown in 2003 is infected and will not persist.

A few questions still remain to be answered before we decide to launch into this project full steam ahead. We do not know what climatic conditions the bacteria need for optimal functioning and whether it would be warm enough here. In Hawai'i the disease is working well at Volcano, which is comparable climatically with Auckland, so it seems promising that conditions here might be suitable. We also don't know if we have any potentially suitable vectors that could spread the disease around. We hope to know more later this year and are grateful that Rob has agreed to assist us further. Thanks Rob!

Thanks also to all the staff at the Northland, Auckland and Horizons regional councils, Environments Waikato and Bay of Plenty, Greater Wellington, and Tasman and Marlborough district councils who helped make all the necessary arrangements that allowed this exchange visit to go off smoothly, and/or provided ginger rhizomes for us to send to Rob for testing.

Rob's visit was funded by Landcare Research and the Secretariat for Conservation Biology, Hawai'i, as part of the Hawai'i – New Zealand Exchange Programme. Rob works for the United States Geological Survey – Biological Resources Discipline based at the Pacific Island Ecosystems Research Center in Honolulu. Kahili ginger is also invasive in the Azores and Canary Islands, Mauritius and La Réunion, French Polynesia, Pohnpei, and Jamaica.

Oliver Retires

Christmas saw the retirement of a biocontrol stalwart after a long career in science. **Oliver Sutherland** was involved in the biocontrol of **alligator weed** (*Alternanthera philoxeroides*) programme during the 1980s. Later he was for many years the manager responsible for biocontrol of weeds staff at Landcare Research. We wish him all the best for his retirement and warn all pests in the Marlborough Sounds to watch out.

Confirming Our Suspicions

We recently had word from Australia about the identity of the strain(s) of blackberry rust (*Phragmidium violaceum*) we have in New Zealand. The rust was first noticed here in 1990 and was believed to have blown over from Australia. The rust quickly became widespread, but has been variable in its impact as not all of the 18 species we commonly refer to as "blackberry" under the aggregate name *Rubus fruticosus* are susceptible to it.

At least two strains of the rust have been released in Australia. An illegal release of one or more strains was made in 1984. Then there was a second, official, release in the early 1990s of what was believed to be a better, more damaging "F15" strain. The quest to identify the strain(s) of the rust present in New Zealand has been a real team effort. First Shaun Pennycook scoured the country for rust-infected blackberry and collected samples from many sites. Then back at the Mt Albert Research Centre, Paula Wilkie "bulked up" the rust from seven of these samples, and Duckchul Park extracted the DNA and sent it across the Tasman for analysis by Don Gomez.

The results now in show the New Zealand rust isolates are very closely related to each other, and also share a high percentage of similarity with Australian isolates. "This supports the hypothesis that the rust we see in New Zealand originated from the illegal release made in Australia and not through some accidental introduction from Europe," explained Jane Barton, who has been overseeing this project. The legally introduced F15 strain has probably not yet reached New Zealand, but it is possible it is just not common or widespread enough to have been collected during this study.

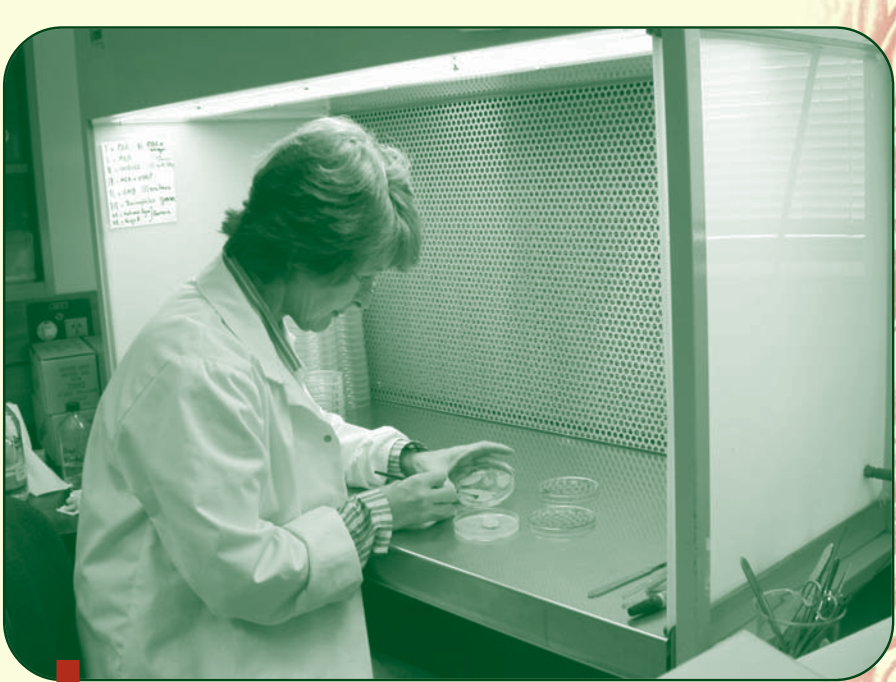
The most obvious implication of these results is that blackberry control in New Zealand might be improved by the introduction of strains of the rust that will attack plants that aren't harmed at present. "It might be worth considering importing the F15 strain which was selected for its virulence and reproductive fitness under controlled-environment conditions, although there is some concern about its ability to spread and persist in the field," cautioned Jane. Our colleagues in Australia are seeking additional strains of the rust to improve levels of control there, so it's possible we may have even more options for improving blackberry control in years to come.

"The rust we see in New Zealand originated from the illegal release made in Australia"

The Forest Health Collaborative and Environment BOP provided the funding for this work. Jane Barton is a contractor to Landcare Research. Shaun Pennycook, Paula Wilke and Duckchul Park all work for Landcare Research at our Auckland office. Don Gomez is with the Co-operative Research Centre for Australian Weed Management based at the University of Adelaide.

Advanced Biocontrol Workshop

A 2-day advanced biocontrol workshop will be held at Lincoln towards the end of April. This course is ideally suited to people who have completed a basic course a couple of years ago or who have had considerable experience with biocontrol in the field. If you are interested in attending this workshop then contact Lynley Hayes (hayesl@landcareresearch.co.nz).



Paula Wilke bulking up the rust.

Clarifying a Grey Area

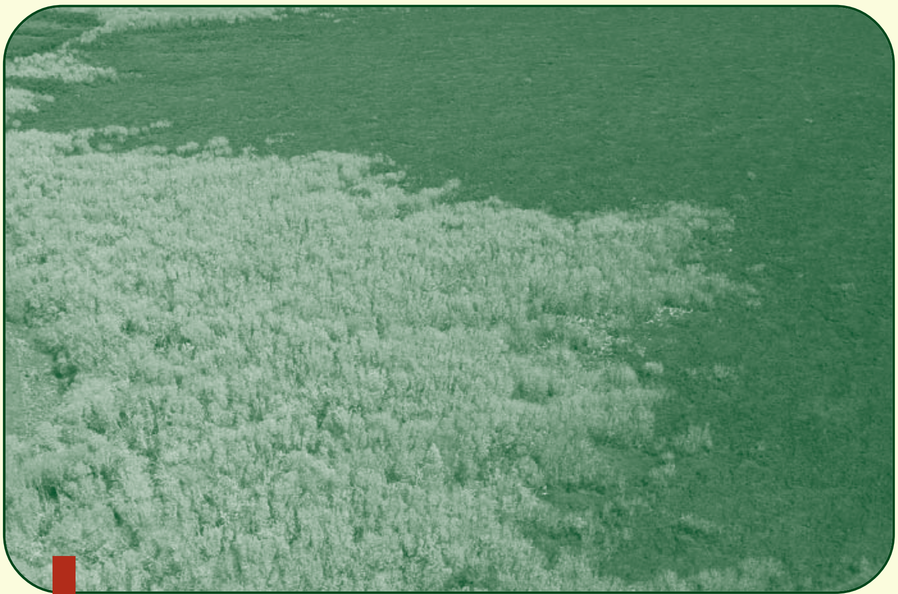
Recently we were asked by the Department of Conservation (DOC) to review the feasibility of biological control of grey willow (*Salix cinerea*), and Helen Harman undertook this task. Many species of willows (both tree and shrub) have been introduced to New Zealand and are used for soil stabilisation, riverbank protection, as shelter belts and for aesthetic reasons. Most *Salix* species are fast growing and easy to propagate, which has allowed them to quickly become widespread. At least 11 species of *Salix* and five hybrids are naturalised here. Grey willow is considered to be one of the weediest, threatening many wetland and riparian areas. Seven DOC conservancies regard it as one of their top 10 environmental weeds. Reproduction is almost exclusively by seeds that are capable of dispersing widely. Introduced willow species are also spreading in other countries including Australia, South Africa and Canada.

While a number of willow species are valued, grey willow does not appear to fall into this category. A biocontrol programme against grey willow in New Zealand could, however, potentially be complicated by hybridisation between grey willow and other *Salix* species. "The extent to which natural hybridisation occurs is unknown, but if hybrids have the potential to be as weedy as grey willow, then a biocontrol agent would also need to be effective against these," explained Helen. If an agent is effective against naturally occurring hybrids, then "desirable" hybrids involving grey willow, such as *S. ×reichardtii* and *S. ×calodendron*, may also be damaged. This may not be a problem though as these hybrids are not widely used, and other species could be used instead. Vulnerable plants could gradually be phased out if a biocontrol programme were implemented.

There are no native plants closely related to grey willow in New Zealand. Grey willow is also in a different subgenus to tree willows, which improves the prospects of finding species that do not attack these commercially valuable species. "Damage to any willow species used commercially is unlikely to be accepted, except perhaps damage caused by seed feeders that would not affect existing plants," explained Helen. "If seed production of non-target willow species was reduced, this could even be regarded as a bonus."

In New Zealand, a number of invertebrates, mostly generalists, have been recorded feeding on *Salix* species. Two specialised willow-feeding species have also found their way here. The willow gall sawfly (*Pontania proxima*) is responsible for the reddish galls that you see on leaves of *Salix* species. It has been here for more than 70 years but its damage appears to be largely cosmetic. A more recently introduced sawfly (*Nematus oligospilus*) feeds on the leaves of many *Salix* species (including grey willow) and is capable of defoliating and killing tree willows.

An extensive fauna has been recorded on *Salix* species in the Northern Hemisphere (grey willow originates from Europe, western Asia and northern Africa). Leaf-feeding beetles are among the most damaging pests of willows in the UK but their host ranges are likely to be too broad for use here. Nematine gall-forming sawflies look worthy of further study as gall-formers are known to often form close relationships with their host plants. "A species that galls flower buds (*Euura gemmacinerae*) and one that galls stems (*E. cinereae*) of grey



Dave Campbell, Waikato University.

Grey willow invading Opuatia peat bog.

willow in Europe look quite promising as potential biocontrol agents," revealed Helen. It also may turn out that some other *Euura* species that have been regarded as polyphagous (having a wide host range) may turn out to be complexes of host-associated sibling species. For example, a shoot-galling sawfly (*Euura atra*) that was considered to be extremely polyphagous has recently been found to consist of four behaviourally different races.

Willow sawfly (Nematus oligospilus).

Other invertebrate groups recorded on *Salix* species may also contain some suitably specific potential agents. Agents with a wider host range that only damage flowers or seeds may also be acceptable. Some weevils that feed on grey willow have been described as catkin-living species; there are bud-galling sawflies thought to only attack new flower buds; and a number of psyllids have been recorded primarily from catkins of other *Salix* species.

A number of diseases attack willows in New Zealand and Australia, but they seem to have little impact on weedy species. Many other diseases have been recorded on *Salix* species in the Northern Hemisphere. *Melampsora* rusts have received much attention because they can devastate valued species, but the *Melampsora* species already in New Zealand do not appear to be very damaging. Other *Melampsora* species may prove more useful, as may *Massonina* species. Surveys in the native range may reveal other useful pathogens too. However, because pathogens are often highly host specific, the hybridisation issue could rule out their effective use as classical biocontrol agents in New Zealand. But a mycoherbicide approach using pathogens with wider host ranges could still be feasible. A wound pathogen (*Chondrostereum purpureum*) is currently being developed as a mycoherbicide for other woody weeds and could prove to be suitable for use against willows too.

Although biological control of grey willow in New Zealand could be a difficult and complicated project, this should be weighed against the extreme weediness of the plant. There are prospects for suitable biocontrol agents, particularly amongst gall-forming insects such as nematine sawflies. Other invasive tree and shrub species have been effectively controlled by gall-forming agents. For example, three gall-formers (*Trichilogaster acaciaelongifoliae, Trichilogaster* sp., and *Uromycladium tepperianum*) are proving very effective agents against *Acacia* species in South Africa. "A biological control programme is therefore worth pursuing," recommends Helen. It is often only necessary to find one or two really effective agents for a biocontrol programme to be successful, and because the natural distribution of grey willow is wide (Europe, western Asia and North Africa), the chances of doing so are increased.

Six willow species, including grey willow, have been declared Weeds of National Significance in Australia, and only three willow species (*S. babylonica*, *S. ×calodendron*, and *S. ×reichardtii*) are seen as desirable. A biological control programme looks likely to go ahead there. The host ranges of any biocontrol agents introduced into Australia may be much broader than for those that might be introduced into New Zealand, but there may still be a possibility of some useful collaboration.

Helen recommends that if funding can be found here then "populations of grey willow throughout the species' known range in New Zealand should be surveyed in different seasons to find out what invertebrates and diseases are currently associated with them." Grey willow should also be surveyed in its native range to identify prospective biocontrol agents. Preliminary host-range tests with the gall-forming species that the literature suggests may be host-specific should also be undertaken. Although no trees have been tackled as biocontrol targets in New Zealand to date, there appears to be nothing preventing us from branching out!

This feasibility study was funded by the Department of Conservation.

Coping under Stress

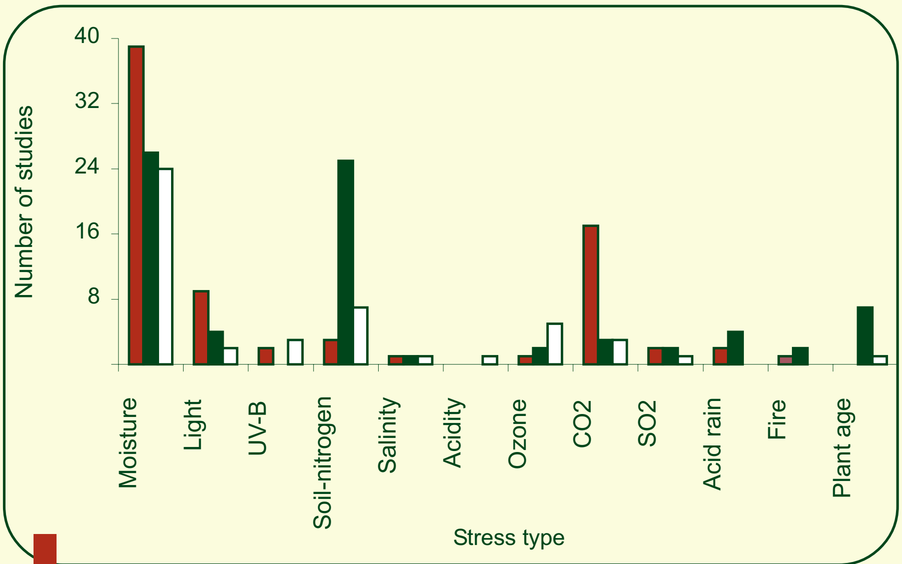
This summer many parts of New Zealand have experienced sweltering temperatures and little or no rain. At the time of writing there is some talk of possibly "the worst drought on record for the South Island". You may have wondered what effect these extreme conditions might be having on our biocontrol agents? As it turns out Kylie Galway has nearly completed a doctoral study of what happens to plant-feeding insects when their host plants become stressed, and she presented some of her findings at the XI International Symposium in Canberra last year. "If we are to improve the efficacy of biocontrol programmes we really need to gain a better understanding of how biocontrol agents perform when their hosts are under stress," explained Kylie. This kind of information could help biocontrol practitioners make better choices about which agents to release in a range of environments.

It is a fact of life that all plants encounter stress at some stage due to variations or fluctuations in environmental conditions – optimal conditions are the exception rather than the rule. Morphological and physiological changes may occur in plants under stress. For example, when water is in short supply many plants have reduced levels of water, starch and carbohydrates and increased levels of nitrogen and soluble sugars in their leaves. Low light levels can lead to reduced levels of soluble sugars, and increased levels of nitrogen and water in the leaves.

"There are three different hypotheses," explained Kylie. One hypothesis predicts insects will do better on stressed plants due to increased levels of nitrogen. Another suggests insects that have close associations with their host (like gall-formers) do best on vigorously growing, non-stressed hosts. The third hypothesis has a foot in both camps. It claims that wood-feeders, sap-feeders and miners will perform better on stressed hosts, while leaf-feeders and gall-formers will perform better on non-stressed hosts.

Some scientists have reported that stress type, not insect feeding type, is the most important determinant of insect performance, while others have claimed the opposite! "During my review I found insect response to host-plant stress can vary greatly according to the feeding-guild the insect belongs to (e.g. wood feeder, sap feeder, leaf feeder etc.) and the type of stress encountered by the host plant," revealed Kylie. As a general rule insect performance improved when hosts were suffering from a lack of water, and decreased when nutrients were in short supply (see graph). Insect performance also improved when light and carbon dioxide levels were reduced, when soil nitrogen was increased, and on younger host plants. Sap-feeding and leaf-feeding insects generally performed better when host-plants were stressed, while mining and galling insects generally performed better on vigorously growing host plants.

Kylie concluded: "if we are to accurately predict insect performance, both insect feeding-guild and stress type must be considered." We also need to know how plants respond to a stress before we can figure out how insect performance might be affected. The current plant-stress/insect-herbivory hypotheses do not adequately predict insect performance on stressed and unstressed plants. Although these hypotheses are too



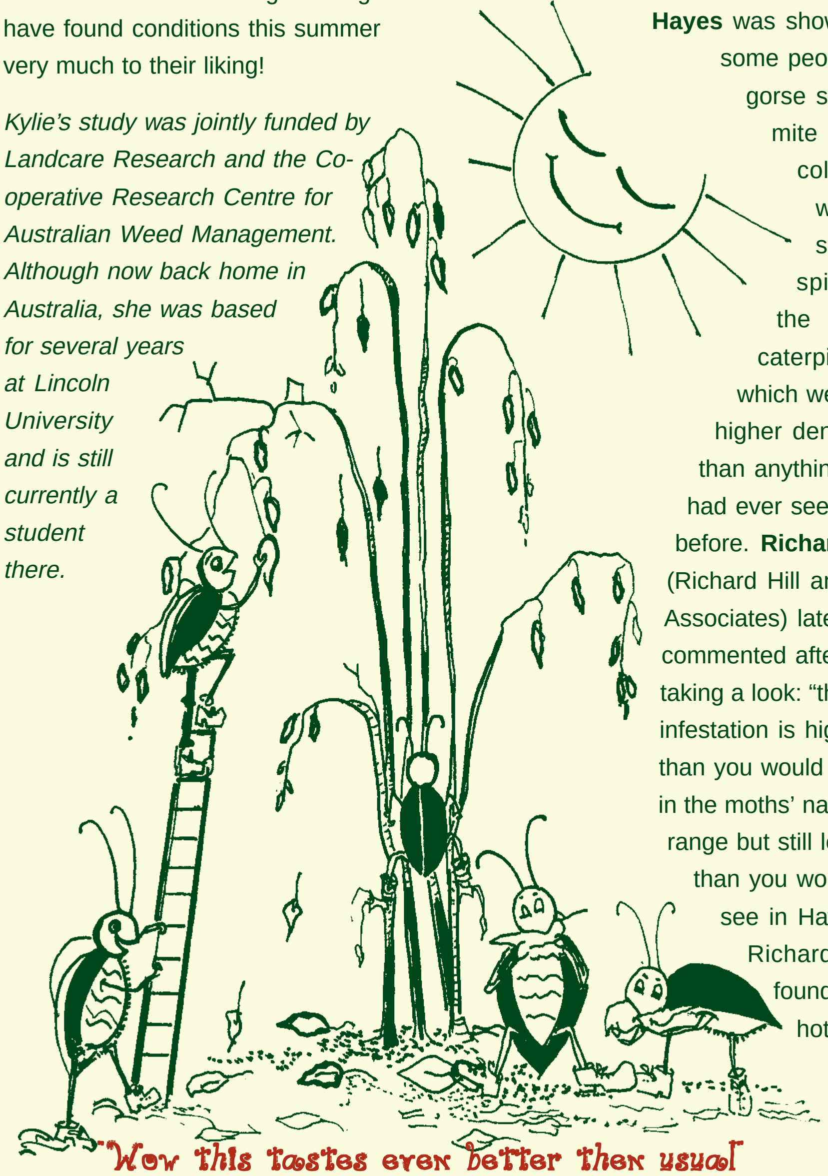
Number of studies where insect performance improved on stressed hosts (red bars), improved on non-stressed hosts (dark-green bars), or showed no relationship with host-plant stress (white bars), for 12 stress types.

Hot Gossip

generalised at this stage to be helpful for improving weed biocontrol strategies, Kylie's work does provide some useful pointers. For example, there is some evidence to suggest that leaf-feeding insects might perform better on host-plants growing under drought-stressed conditions, in shade, or with high soil nitrogen levels, while miners might do better in environments where host plants are receiving high moisture and soil nitrogen. So at this stage we will just have to hope at least some of our biocontrol agents might have found conditions this summer very much to their liking!

Kylie's study was jointly funded by Landcare Research and the Co-operative Research Centre for Australian Weed Management. Although now back home in Australia, she was based for several years at Lincoln University and is still currently a student there.

The **gorse soft shoot moth** (*Agonopterix ulicetella*) might be finally about to show some promise! We know from pheromone trapping of adults that this agent is established at at least 10 sites throughout New Zealand, but until recently it has been hard to actually spot the damaging caterpillar stage. We have been a little disappointed, given that this agent has done extremely well in Hawai'i. Quite by chance a healthy population was spotted on a hedge near Lincoln just before Christmas. **Lynley Hayes** was showing some people a gorse spider mite colony when she spied the caterpillars, which were at higher densities than anything she had ever seen before. **Richard Hill** (Richard Hill and Associates) later commented after taking a look: "this infestation is higher than you would see in the moths' native range but still less than you would see in Hawai'i." Richard found the hot spot extended at least as far away as Ladbrooks, which is about 5 km from the nearest release site at the Canterbury Agriculture and Science Centre. Now that our enthusiasm has keen rekindled we are hoping to do more follow-up next spring. No sign of parasitism was seen in material collected from the hot spot, but we still don't know if parasitism is a limiting factor, or whether the moths have just been a bit slow to get going.

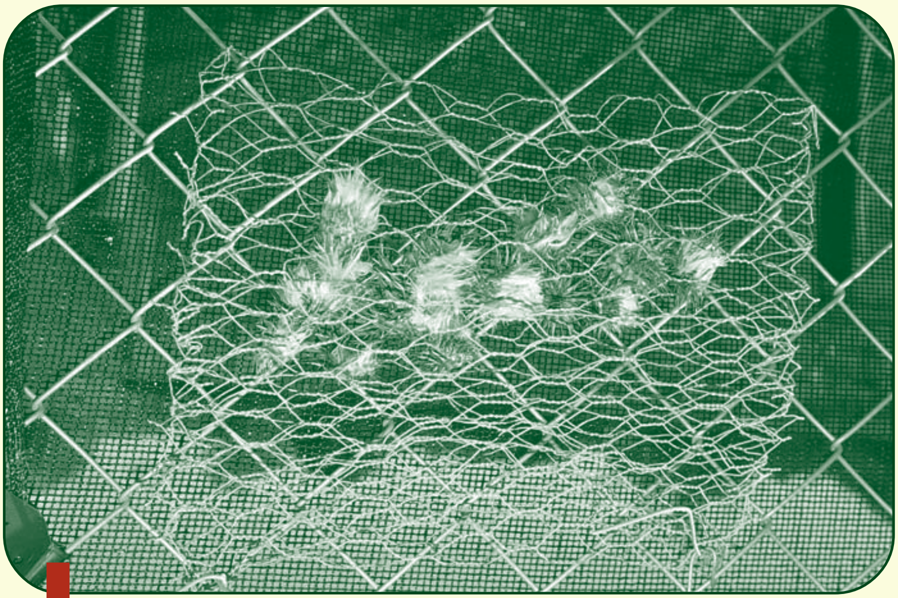


Things to Do This Autumn

Autumn can be a busy time on the biocontrol calendar before things quieten off again over the winter. Some things you might need to plan for include:

- Checking release sites where gall-forming agents, like the hieracium gall wasp (*Aulacidea subterminalis*), hieracium gall midge (*Macrolabis pilosellae*), mist flower gall fly (*Procecidochares alani*), and Californian thistle gall fly (*Urophora cardui*), have been released. The plant deformities (galls) caused by these agents develop over the warmer months and are usually most obvious in early autumn. If galls are present in good numbers, then you can harvest them for release in other areas. However, leave any hieracium gall midge galls alone at this stage – we still need to investigate the best way of harvesting them for redistribution.
- Checking gorse infestations for the presence of gorse pod moth (*Cydia

succedana). We suspect this seed feeder is quietly getting on with the job of dispersing throughout New Zealand, so take some time to check any gorse infestations you come across. You may see the small brown moths fluttering about the gorse, especially on sunny days. They have a characteristic twirling flight and a tendency to suddenly drop down onto plants. Look inside pods for the creamy caterpillars feeding on the seeds or for empty pods where all the seeds have been consumed and the culprit has moved on to greener pastures. The good thing about checking at this time of the year is that there will be no danger of you confusing pod moths with gorse seed weevils (*Exapion ulicis*). If you can find areas of gorse that have not yet been colonised by the moth, then simply harvest infested pod material and wedge it into gorse in these areas.



Infested nodding thistle flowerheads hanging on a fence out of harm's way.

- Harvesting and redistributing ragwort flea beetle (*Longitarsus jacobaeae*) and nodding thistle crown weevil (*Trichosirocalus horridus*). Be careful to avoid sealing up ragwort flea beetles with large quantities of ragwort in non-breathable containers in hot weather as this has proven to be a lethal combination in the past. Also be careful to take the time to sort through any material you collect so that you don't inadvertently spread any pests, like the clover root weevil (*Sitona lepidus*).
- Harvesting and redistributing nodding and Scotch thistle gall flies (*Urophora solstitialis* and *U. stylata*). Look for mature flowerheads that have an unusual fluffy appearance. Carefully squeeze them between your thumb and forefinger to check if they are hard and lumpy (a dead give away that they are infested). You can cut these flowerheads and shift them to new sites, where they will gradually break down over the winter allowing the adult flies to emerge in the spring. It is best to hang them in an onion bag (or similar) on a fence out of harm's way.
- Also keep an eye out for old man's beard fungus (*Phoma clematidina*) damage. This often shows up most strongly in the autumn. Look out for leaves and stems that have a black, slimy appearance.

Remember to read up the relevant pages in "The Biological Control of Weeds Book" before embarking on any of these activities!

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