What's New In Biological Control Of Weeds?

Annual Review

What's Inside:

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Manaaki Whenua
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Introduction

Welcome to the second full-colour 16-page edition of *What's New in Biological Control of Weeds?*, which we produce annually to help you keep your finger on the pulse of biological control of weeds projects in New Zealand. We report on important happenings that have occurred over the past year.

Headlines

- When you are starting a biocontrol project from scratch you never quite know what you are going to find. See why we are quietly optimistic about cutting tradescantia back down to size.
- There is always the worry that if you remove a weed it may be replaced by something even worse. Learn why fortunately that doesn't look to be the case as Mother Nature moves to rapidly fill the void left by mist flower.
- Some breakthroughs have been made this year in our relentless pursuit of agents for banana passionfruit. Check out what was in the parcel sent by our Colombian connections.
- We have been on a mission to uncover whether any of our 20 commonest biocontrol agents have run amok. See just how good our predictions of host specificity have turned out to be.
- Critics of biological control have suggested that safety alone is not enough and that more emphasis needs to be put into selecting control agents that can also make the most difference. Discover whether a little bit of biocontrol could be worse than none at all.

- People always want to know "how good are these bugs going to be?". Catch up on the latest in our quest to uncover how heather beetle stacks up against other more conventional methods, and whether the leaf miner and leaf fungus are causing minor or major damage to old man's beard.
- Sometimes less is more. Find out if this is the case when establishing biocontrol agents and the implications for keeping out unwanted invaders too.
- All that glitters is not gold. Learn why an initially promising unexpected find has not turned out to be Californian thistle's nemesis.
- Ragwort flea beetle has knocked ragwort for a six throughout most of New Zealand but hasn't managed to come up trumps on the West Coast of the South Island. Read about our efforts to find out why and about the other agents we are investigating in case they are needed.
- Finally peruse our summary of who's who in biological control of weeds with the most important vital statistics you need to have at your fingertips, plus some tips for further reading.

Biocontrol training workshop, December 2003 – getting to grips with gorse agents.

Control Agents Released in 2003/04

Species	Releases made
Gorse colonial hard shoot moth (*Pempelia genistella*)	1
Gorse thrips (*Sericothrips staphylinus*), Portuguese strain	25
Hieracium gall wasp (*Aulacidea subterminalis*)	20
Hieracium gall midge (*Macrolabis pilosellae*)	53
Old man's beard sawfly (*Monophadnus spinolae*)	3
Total	**102**

Can We Outsmart Weeds?

Recently a new joint venture between AgResearch, Landcare Research, and Canterbury and Massey universities has begun, that aims to improve the management of pasture weeds in New Zealand. The programme is funded by the Foundation for Research, Science and Technology and aims to develop population models for selected pasture weeds, and use these to target weak points in their life histories with more cleverly focussed control methods. As well as the use of herbicides and mechanical control, there will be a strong emphasis on biological control.

Traditionally in biocontrol there has been an emphasis on releasing only host-specific biocontrol agents that ideally attack just one target weed species. However, in many cases a number of closely related plant species such as thistles (in genera like *Carduus* and *Cirsium*) are all weeds. In New Zealand, many of these "weed complexes" are not closely related to any of our native plants so we have the opportunity to "take off the gloves" and seek some "multi-tasking" agents. As well as improving the prospects for effective control of existing major and minor weeds these multipurpose agents could even help to prevent any sleeper weeds or new invaders from ever becoming problems in the future, and allow biocontrol to be more proactive.

Ecological studies around this topic will form the core of a PhD programme at Landcare Research and the University of Canterbury. Dave Kelly (University of Canterbury), Graeme Bourdôt (AgResearch) and Simon Fowler recently interviewed several good candidates for this position, and it has been offered to Ronny Groenteman who will be joining us from Israel in a couple of months time.

Tradescantia Beware

The natural enemies of tradescantia (*Tradescantia fluminensis*) have not been well studied in its country of origin, Brazil, so we have been setting about putting this to rights. Fortunately we have been able to develop strong linkages with two universities there (Universidade Federal do Paraná and Universidade Federal de Viçosa) that are lending a helping hand. It is clear that tradescantia gets a much harder time in its native range than it does here. "Tradescantia is quite common in certain areas but it does not form dense smothering carpets like it does in New Zealand," observed Simon Fowler. "We have calculated the biomass of the lushest patch in Brazil to be 200 gm/m^2 whereas in New Zealand the biomass of the plant in problem areas is a hefty 800–900 gm/m^2". The survey has already turned up a number of possible suspects that may account for this difference.

One of the leading contenders (Buckibrotica cinctipennis) *and some typical damage.*

Tradescantia gets a much harder time in its native range than it does here.

At least three species look capable of causing significant damage. The most promising is a shiny green beetle (tentatively identified as *Buckibrotica cinctipennis*). This leaf-feeding beetle causes obvious damage and the results of preliminary host-range testing of the adults look good. We have not collected any larvae yet and we suspect they feed on the roots. Another possible agent is a bacterium (identified provisionally as *Burkholderia andropogonis*) that causes lesions on the leaves, and we have started investigating how specific and infectious it is. A fungal pathogen (provisionally identified as *Kordyana* sp.) that damages the foliage also looks promising. None of these beasties have been officially identified before which is why their names are still provisional. The search for more prospective agents is continuing in other parts of Brazil.

We have prepared a list of the plants that are most likely to be at risk of non-target attack and will need to be included in any host-range testing. Luckily we don't have any native or economically important plants in New Zealand that are closely related to tradescantia, which is a huge plus. However, there are a number of native Australian plants in the same family as the weed, and it is possible that pathogens released in New Zealand could accidentally cross the Tasman. "Given this possibility it is important that, as responsible neighbours, we include representatives of these plants in any host-range testing," explained Simon.

We are also in the process of examining the genetic diversity of tradescantia in New Zealand. It is well known that tradescantia spreads by vegetative reproduction here. Even small pieces of broken stem can grow into a new plant, and it appears that all tradescantia plants in New Zealand are clones. "If we can identify the original clone or clones and match them to where they came from in Brazil, we can search for the best possible agents for the material we have here," revealed Helen Harman. This level of specificity can be particularly important when wanting to get the most out of some disease-causing organisms.

All in all at this early stage we are quietly optimistic about the prospects for cutting tradescantia back down to size.

This project is funded by a national collective of regional councils plus the Department of Conservation.

Do All Vacuums Suck?

There is absolutely no doubt that mist flower (*Ageratina riparia*) has declined dramatically since the mist flower fungus (*Entyloma ageratinae*) was introduced in late 1998. Mother Nature, like many women, dislikes a vacuum and has moved quickly to fill the gap. We have been studying her handiwork in Auckland's Waitakere Ranges and with 5 years of data now under our belts an interesting and complex story is unfolding.

By last summer the average percentage cover of mist flower in infested plots had plummeted from 73.5% to just 1.5%. The average height of the tallest mist flower plants had also shrunk from 74 cm to 31 cm. "While the fungus deserves most of the credit for the reduction in cover, the mist flower gall fly (*Procecidochares alani*) is probably contributing to the stunting effect," explained Jane Barton.

So does this mean that areas previously infested with mist flower now look pretty much the same as those that weren't? "The answer seems to be 'yes' in terms of the numbers of species present," said Maarten de Beurs. At the beginning areas choked with mist flower had about 7–8 fewer native species but the gap has closed now to less than 3. The number of exotic species in both plot types has remained the same. "The answer in terms of percentage cover seems to be 'not completely', or perhaps 'not yet'." As mist flower retreated native species increased just as quickly as exotic species. However, since areas infested with mist flower were weedier at the outset (perhaps because mist flower and other weeds facilitate each other's growth) they are still weedier today. Natives would have to increase in cover faster than exotics to overcome this problem, and that hasn't happened yet. Encouragingly 9 out of 11 species that have benefited most from the reduction in mist flower (in terms of percentage cover) are natives: lacebark (*Hoheria populnea*), centella (*Centella uniflora*), native sedges (*Carex* spp.), rewarewa (*Knightia excelsa*), māpou (*Myrsine australis*), hangehange (*Geniostoma rupestre*), nīkau (*Rhopalostylis sapida*), kahikatea (*Dacrycarpus dacrydioides*), and a native grass (*Oplismenus hirtellus* subsp. *imbecillis*). Surprisingly kiokio (*Blechnum novae-zealandiae*) and karamū (*Coprosma grandifolia*) declined in cover during the study. Perhaps they were relatively tolerant of competition with mist flower and have suffered more at the hands of replacement species. Two exotic species, self-heal (*Prunella vulgaris*) and African club moss (*Selaginella kraussiana*), appear to have benefited from the decline in the weed. "It would be wise to keep an eye on these two and perhaps also Mexican daisy (*Erigeron karvinskianus*)," cautioned Jane.

The dramatic decline in mist flower cover has allowed other vegetation to take its place. "While this vegetation is not identical in composition to areas which have not had a mist flower problem, there has not been a stampede of other alien species to fill the gaps," concluded Jane. It would seem that when it comes to coping with a vacuum Mother Nature indeed knows how to handle it best.

Jane Barton is a subcontractor to Landcare Research. The University of Auckland helped make this project possible through their "Summer Studentship" programme with Maarten de Beurs, Jonathan Boow, Krystian Ragiel and Kate Edenborough collecting and analysing the data. Kathryn Whaley, Sarah Gibbs and Jessica Beever helped to identify plants. Funding for this project was provided by the Auckland Regional Council and the Foundation for Research, Science and Technology.

A plot choked with mist flower during summer 2000/01 (left) and the difference 3 years later after biocontrol kicked in (right).

Bring On the Passion Killers

The banana passionfruit (*Passiflora* spp.) project has been beset by difficulties (see *Passion Leads to Frustration*, Issue 25). However, things were starting to look up when a shipment of a foliage-, flower- and fruit-feeding moth (*Pyrausta perelegans*) arrived from South America in February. Knowing that it was likely to be a long and arduous trip Victoria Barney, of the Centro Internacional de Agricultura Tropical in Colombia, sent us the most robust life stage. By the time they arrived here the pupae had clocked up an impressive world tour. "United States Customs Officers, suspicious of packages from that part of the world, had thoroughly checked its contents right down to slicing open the freezer pads which were then left to leak inside the package," explained a philosophical but disappointed Hugh Gourlay. This rough treatment is thought to be the reason why only 14 moths emerged from the 170 pupae sent. Fortunately five were females which came to the party and laid some eggs allowing some initial host-range testing to be carried out. These preliminary results suggest that this moth is unlikely to attack our native passionfruit (*Passiflora tetrandra*) or commercially grown passionfruit (*Passiflora edulis*).

> "I'm expecting to have to brave another trip to South America at some stage."

A way of shipping potential agents more directly from South America has now been found and a second shipment of pupae is expected towards the end of June. We are also expecting a shipment this year of an attractive blue moth (*Cyanotricha necyria*), which feeds on the foliage. "I'm expecting to have to brave another trip to South America at some stage," revealed Hugh. "I need to talk to our collaborators about other potential control agents including two fruit flies. One (*Zapriothrica* nr *nudesita*) is yet to be identified properly and the other (*Dasiops caustonae*) may prove difficult to rear in captivity as it mates in tree tops about 30 m above the ground, a situation somewhat challenging to replicate in a containment facility." We need to find out if it is possible to rear this fly indoors before we go any further down that track.


Foliage, flower and fruit feeding moth caterpillar.


Two of the 14 precious moths that emerged in quarantine.

Fortunately good progress on the pathogen side of things has been made this year. Jane Barton travelled to Hawai'i in November to begin preliminary host-testing of the leaf spot fungus (*Septoria* sp.). The fungus passed a critical test by not attacking our native or commercially grown passionfruit allowing more comprehensive testing to get underway over the winter. Watch out for the results in the November issue of this newsletter.

This project is funded by a national collective of regional councils and the Department of Conservation. Jane Barton is a subcontractor to Landcare Research. The leaf spot fungus testing would not have been possible without the generous assistance of Eloise Killgore of the Hawai'i Department of Agriculture.

Staying on Target

Last year we took a good hard look at the quality of host-specificity testing that had been carried out on weed biocontrol agents prior to their release in New Zealand (see *In Retrospect – Looking for Skeletons in the Closet*, Issue 25). This year our team went out into the big wide world to search for any agents that might be misbehaving themselves. "The aim of this work is to improve our ability to predict the likelihood of non-target impacts, so we are better able to assess risk when making decisions about the suitability of new biological control agents," explained Quentin Paynter. We looked in detail at the specificity of 20 well-established insect and mite agents. We did not include recently released agents, those that are still rare, or pathogens at this stage.

The survey has proven to be a major undertaking. Sometimes just finding the necessary plants was a challenge. Some were very cryptic, for example *Clematis quadribracteolata*, a native climbing plant with very small leaves that we wanted to ensure was not being attacked by the old mans' beard leaf miner (*Phytomyza vitalbae*). Others were quite rare, such as another native species, *Hypericum gramineum,* which we wanted to check wasn't being harmed by St John's wort beetles (*Chrysolina* spp.). However, others such as globe artichoke (*Cynara scolymus*) were easy to find and quite enjoyable to inspect. "After cutting them open to look for nodding thistle receptacle weevil (*Rhinocyllus conicus*) larvae, we ate them," confided Quentin. In addition to examining plants we collected thousands of specimens, mainly seed pods and leaves, and identified the insects that emerged from them.

Half of the agents we followed up on had been well tested by modern standards so we were not expecting to find any unexpected non-target attack. Happily this prediction proved to be true. Four agents were predicted to have a risk of minor non-target attack. However, predictions for the heather beetle (*Lochmaea suturalis*), gorse spider mite (*Tetranychus lintearius*), and ragwort flea beetle (*Longitarsus jacobaeae*) had erred on the side of caution and nothing untoward was found. Results from the host-testing of the fourth, the old man's beard leaf miner, predicted that minor attack on a native plant, *Clematis foetida,* was possible. In the field this attack appears to be extremely rare and was only found at one site on Banks Peninsula, where the amount of mining was low and not considered to be affecting the plant. "No non-target attack was found at any other sites, including one where the leaf miner was abundant and old mans' beard (*C. vitalba*) and *Clematis foetida* were growing entwined!" exclaimed Quentin.

No non-target attack was predicted for another four agents but their host-specificity testing was considered flawed by today's standards. Field surveys found no problems with the alligator weed beetle (*Agasicles hygrophila*) or ragwort seedfly (*Botanophila jacobaeae*). However, as we have reported previously the broom seed beetle (*Bruchidius villosus*) and gorse pod moth (*Cydia succedana*) have gone astray. Lincoln PhD student Melanie Haines has looked closely at broom seed beetle host-testing procedures and found that attack on tree lucerne (*Chamaecytisus palmensis*) could have been predicted if no-choice tests had been carried out or choice tests had been better replicated. In New Zealand tree lucerne starts flowering and producing pods earlier than broom so earlyemerging beetles will be exposed to a no-choice situation in which there are no broom pods to lay on but plenty of tempting tree lucerne ones.

Spot the difference: old man's beard leaf miner (left) and native leaf miner (right) – the colour of the third antennal segment is different!

Our field surveys have turned up gorse pod moth attacking Scotch broom (*Cytisus scoparius*), Spanish broom (*Spartium junceum*), Montpellier broom (*Genista monspessulana),* tree lupin (*Lupinus arboreus*), Russell lupin (*Lupinus polyphyllus*), and lotus (*Lotus pedunculatus*). The reasons for this unexpected non-target attack appear to be complex. It may be that the pod moths emerge at times when there is no suitable gorse (*Ulex europaeus*) material for them to lay on and that they are also faced with a no-choice situation. However, taxonomists have also recently split the pod moth into two species: *C. succedana* and *C. ulicetana*. Our moths originate from England and Portugal. English pod moths are believed to be *C. ulicetana* but we do not know yet the identity of the moths we got from Portugal. "We have collected forms similar to both species in our field surveys and if they prove to be different species this may account for the unexpected non-target attack," explained Quentin.

Minor non-target damage was predicted for two agents because the host-specificity testing was considered flawed. The alligator weed moth (*Arcola malloi*) does not appear to have strayed but cinnabar moth (*Tyria jacobaeae*) caterpillars do occasionally feed on native fireweeds (*Senecio minimus* and *S. biserratus)*. The host-specificity testing for cinnabar moth did include native *Senecio* species, which was unusual for weed biocontrol programmes in the 1920s. However, *S. minimus* and *S. biserratus* were at that time classified in a different genus (*Erechtites)* and were therefore not tested. Our field surveys indicate that cinnabar moths do not lay eggs on these fireweeds and attack only occurs when hungry caterpillars have defoliated their normal host-plant ragwort (*Senecio jacobaea*), and are forced to search for food.

A high risk of non-target attack was predicted for St John's wort (*Hypericum perforatum*) agents as testing did not include two native species, *H. japonicum* and *H. gramineum,* that are very closely related to St John's wort. No evidence that these agents are harming these plants has been found to date but it may be that they don't often cross paths. Since these natives are rare we have only managed to track down a few populations and ideally we would like to check more before we conclude that there is no non-target attack by St John's wort agents.

This survey has raised some important issues to consider in relation to safety testing weed biocontrol agents. Unexpected non-target attack by the broom seed beetle on tree lucerne has highlighted the value of no-choice tests. Although such strict tests often overestimate the true range of an agent, they are particularly important where the target weed and close-relatives flower or set seed at different times. If our investigation into the gorse pod moth finds that we do have more than one species in New Zealand, we may need to routinely check the identification of new agents using molecular techniques to reduce the chances of inadvertently introducing different sister species or races. While biological control is a low-risk activity, and much less dangerous than not controlling weeds at all, we must constantly strive to improve safety testing and risk assessment procedures to ensure that the copybook is never seriously blotted.

This work was funded by the Foundation for Research, Science and Technology.

Could a Little Biocontrol Be a Bad Thing?

Some ecologists in the USA have recently been jumping up and down about biological control of weeds. They have claimed that biocontrol agents are selected using a "lottery approach", i.e. researchers keep releasing agents until something works. It is true that agent selection has proved something of a "holy grail" – we always want to release only the best agents, but sorting the sheep from the goats has been a frustrating and challenging business. In New Zealand it appears that when it comes to effectiveness we have done no better or worse than anyone else, although good assessment data are about as rare as hen's teeth. It seems that less than 50% of weed biocontrol agents released here have so far ended up contributing to the suppression of their target weed. If we could improve on this statistic it would obviously pay huge dividends.

> We have done no better or worse than anyone else.

Releasing ineffective agents is not only a waste of resources but could actually be harmful since every release of a new species entails some risk. We do everything we can to minimise risk with our rigorous safety testing procedures and detailed studies beforehand, and overall our safety record in this regard seems good (see *Staying on Target* p. 6). However, ecologists have pointed out that there could be indirect or knock-on effects in food webs. For example, In Montana, USA, gall flies introduced to attack knapweeds (*Centaurea* spp.) don't seem to be controlling these weeds at all, but deer mice populations have increased as a result of feeding on the nutritious galls. It has been speculated that a knock-on effect from increasing deer mice populations could be a corresponding rise in the prevalence of a wildlife disease that has the potential to affect humans. "Although we suspect that this example is merely a piece of speculative ecological scare-mongering, the proponents do highlight at least one important issue," summed up Simon Fowler. "Agents that become abundant without controlling their host plant may pose the greatest risk of unwanted, indirect non-target effects occurring." Or to put it another way a little biological control could be a dangerous thing!

So what are we doing to silence the critics? We are collaborating with researchers in other countries to find ways of improving agent selection. Staff at Landcare Research and Forest Research are also working together to review just how good agent selection has been in the past here. "We are looking at what information was available to researchers regarding how damaging any prospective agents might be and whether agents were rejected on the strength of that," explained Karina Potter. We suspect that past programmes were in general quite choosy, but that most of this information is tucked away in reports ("grey literature"), or in the memories of the researchers who did the original surveys.

Along with biocontrol researchers worldwide we are still seeking the ultimate goal of achieving perfect agent selection. Although, given the complexity of nature we are unlikely to ever achieve this, we are convinced that there is still some room for improvement.

This research is funded by the Foundation for Research, Science and Technology. Karina Potter works for Forest Research.

Performance Review

As we explained in the previous story good information about how well biocontrol agents are performing in the field is hard to come by. Below we describe our mixed fortunes when attempting to assess the usefulness of heather (*Calluna vulgaris*) and old man's beard (*Clematis vitalba*) agents.

Heather beetle vs herbicide

The New Zealand Army sprays heather every other year to prevent it from taking over the Waiouru Military Training Area. This is an expensive exercise, soaking up about 3000 litres of the active ingredient of Pasture Kleen® (2,4-Dester) alone. Since 2002 we have had an experiment set up near Waiouru to compare the effectiveness of this approach with biological control using the heather beetle (*Lochmaea suturalis*). The beetle is established in the area but remains at low levels and unfortunately hasn't been sighted in any of our experimental plots to date.

However, not all has been lost with some other useful data collected along the way. "The one aerial spray application undertaken so far appears to have reduced heather cover by 20%, while heather in unsprayed areas has expanded by a similar amount," revealed Paul Peterson. Another bad weed, mouse-ear hawkweed (*Hieracium pilosella*), is becoming less common as a consequence of the spraying, while exotic grasses such as sweet vernal (*Anthoxanthum odoratum*) and brown top (*Agrostis capillaris*) appear to be benefiting. Previous work has suggested that some native plants may suffer at the hands of similar herbicides. "It does look like *Coprosma cheesemanii* might be adversely affected by Pasture Kleen® and we need to do further work to properly assess the impact of repeat applications on this and other native species." It also looks like we need to have another go at getting the heather beetles established in our trial plots!

Our Mangaweka study site after the storm.

This assessment trial is funded by the New Zealand Army, the Department of Conservation, and the Foundation for Research, Science and Technology.

Old man's beard has last laugh

Over the past year we have been hard on the heels of the old man's beard leaf miner (*Phytomyza vitalbae*) and leaf fungus (*Phoma clematidina*). We set up study sites in the Manawatu at Mangaweka and in Marlborough at Blenheim. As both agents are now widespread we had to use fungicide and insecticide to remove them from some of our plots.

While the Blenheim site avoided the worst of the severe storms in February, the 100-year flooding in the Manawatu completely obliterated the Mangaweka site.

Up until that time old man's beard growth rates over the spring and summer at both site had not been affected by the control agents, whether attacking plants individually or in combination. Both agents tend to build up higher levels as the season goes on but results from Blenheim showed that the agents were not having a significant impact in the autumn either. "It is not clear why the leaf miner is not performing as well as hoped but at least four species of parasitoids have been reared from mines collected in the field," revealed Quentin Paynter. We have also discovered that the fungus can exist as a symptomless endophyte in the tissues of both old and young leaves. "This result is a major blow as it shows that either host plant resistance and/or external environmental factors are probably limiting infection and systemic disease progression," explained Nick Waipara.

Although it appears that mature plants may be unstoppable, all is not lost if agents can affect the growth or survival of seedlings. Laboratory studies on small plants suggested that 2–3 mines per leaf alone could reduce growth by 50%. We need to study what happens to seedlings in the field. Damage to mature plants may also have a cumulative effect over a number of years. However, the best course of action seems to be to put more pressure on the plant. We are still waiting for some concrete evidence that the sawfly (*Monophadnus spinolae*) is established, and investigations into a beetle (*Xylocleptes bispinus*) that ring barks the stems are continuing.

This assessment trial was funded by the Foundation for Research, Science and Technology.

From Small Beginnings

Getting agents established is a major hurdle in any biological control programme and it helps to know beforehand what makes success or failure more likely. Unfortunately the underlying ecological factors affecting establishment success are not well understood. There is some evidence to suggest that the larger the initial population released, the greater the likelihood that it will establish and persist. Small populations are thought to be much more vulnerable to chance events, such as extreme weather or predation. In an effort to understand this process better we set up an experiment to look at how release size affects the establishment success of the broom psyllid (*Arytainilla spartiophila*). From a biosecurity point of view it is also really useful to learn more about how insects invade, so this trial has been able to provide useful information over and above its original aims.

Jane Memmott checks that they have got enough food for the trip to Central Otago – actually the chillibins were packed with carefully counted out releases of psyllids!

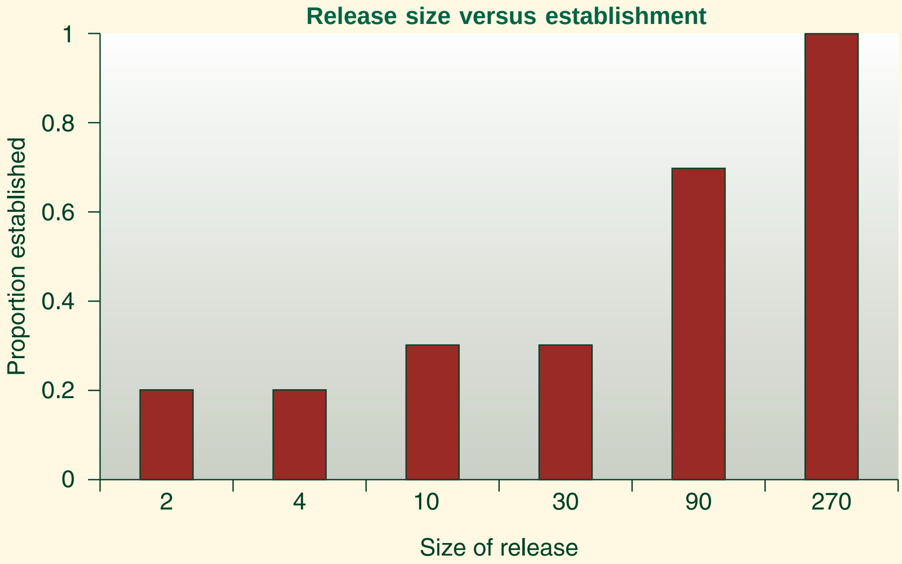
The trial was set up in Otago a decade ago and the results have recently been accepted for publication. Fifty-five nucleus populations were released ranging in size from just two (one of each sex) to 270 individuals. The fate of these was followed for 6 years. All the release sites were visited in late spring, which is the best time to find these little sap suckers feasting on new broom foliage. Since psyllids are extremely hard to spot at low densities we had to flush them out by vigorously beating broom (*Cytisus scoparius*) bushes with a stout stick.

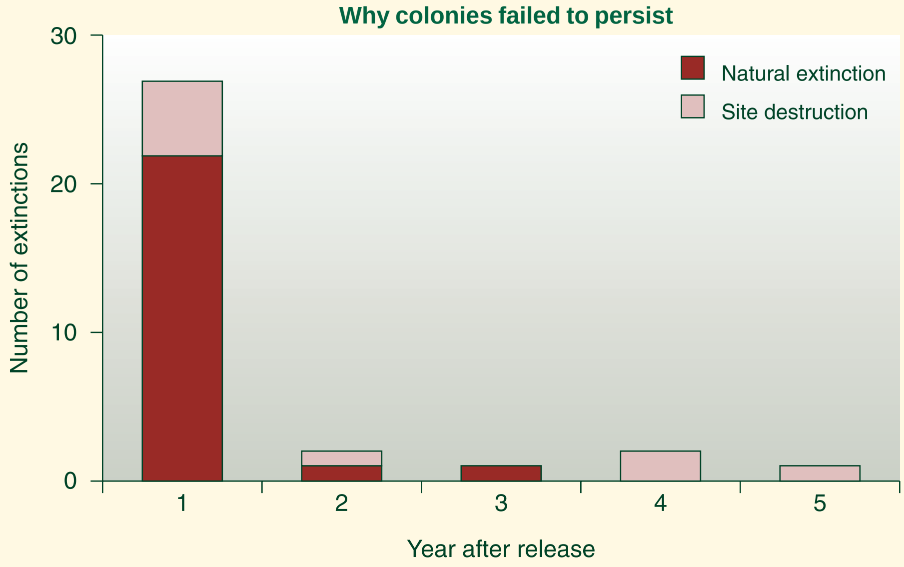
Amazingly some of the smallest release sizes were successful.

"After the first year our results supported the theory," explained Helen Harman. All the large releases established but only a few of the small ones were successful. "However, to our surprise some of the smallest release sizes were successful." On four occasions establishment was achieved by releasing only 2–4 psyllids. The fact that establishment could be achieved with a single mated female (which might be expected to lay at least 90 eggs) was encouraging from a biological control point of view but somewhat of a concern when it comes to biosecurity. If we are to keep unwanted exotic insect pests out of New Zealand we need to be able to detect and destroy any new arrivals before they have a chance to gain a serious foothold. Once an unwanted species has entered an explosive exponential growth phase it becomes much more difficult, and sometimes impossible, to eradicate. While species arriving in large numbers are more likely to establish than those arriving in dribs and drabs, they are also more likely to be detected. Most unwanted arrivals, however, are likely to fall into the second category. While their chances of establishment may be low, our experiment suggests that it is still possible, and they will also be much harder to detect.

Once biocontrol agents are available we want to establish them as widely and as quickly as possible. In the early days agents are inevitably in short supply so a strategy for maximising them must be worked out. While large releases have a higher chance of being successful we all know the risk of putting all our bugs in one basket! A single storm, landslip, or person with a knapsack of herbicide could wipe out the lot in one go. In the case of broom psyllids, the optimum release size seems to be between 90 and 270 individuals (see first graph). Larger releases than this did not significantly increase the probability of establishment, so the extras would be better put towards another release. With less than about 90 individuals the likelihood of establishment fell sharply.

We also studied how well fledgling populations of psyllids persist. "As a general rule psyllid colonies that survived the first year also survived year two and beyond," explained Jane Memmott. The probability of this was 96% regardless of initial population size. Extinctions during the first year





were mainly due to natural processes. After that time any extinctions were mainly due to site destruction, which had a constant influence throughout the experiment (see second graph). A lesson we learnt from this study is that while environmental factors have an important influence on the survival of biocontrol agents, human activities should not be underestimated. The sites we chose were all considered "safe" as landowners had agreed not to use other management methods on the broom while the experiment was in place. Unfortunately, almost half of the sites were sprayed, ploughed, burnt or cut during the 5 years of the experiment. "It appears that the size of the initial population, while important for establishment, does not have a significant influence on its persistence," concluded Jane.

We also looked at population growth. During the critical first year most populations went backwards, decreasing in size regardless of initial release size. This could be due to factors such as the stress of relocation or the need to adjust to local conditions. A lag period was observed before any of the psyllid populations became noticeably abundant. As you might expect, populations originating from small releases generally took longer to become obvious than those from large releases. "After year one all populations started to grow exponentially, with the average rate of population growth similar for all release sizes," explained Helen.

So to recap, release size is positively related to the probability of establishment, but only during the first year after release. If a small release can manage to ride out the ups and downs of the first year then it is just as likely to persist as a larger one. It suggests we are on track with our usual strategy of releasing what we believe to be the optimum number of any particular control agent for establishment, and making as many of these as possible rather than a few giant releases. This is also borne out by the fact that we have a fantastic record when it comes to establishing control agents in New Zealand with just two failures to date (see table, page 14). This work also suggests that if you check a psyllid release site more than a year after the release and find some adults or nymphs, then you can be fairly confident that they are securely established, at least as long as no unforseen mishaps subsequently befall the site! Finally this study reinforces the importance of detecting any unwanted new incursions as soon as possible.

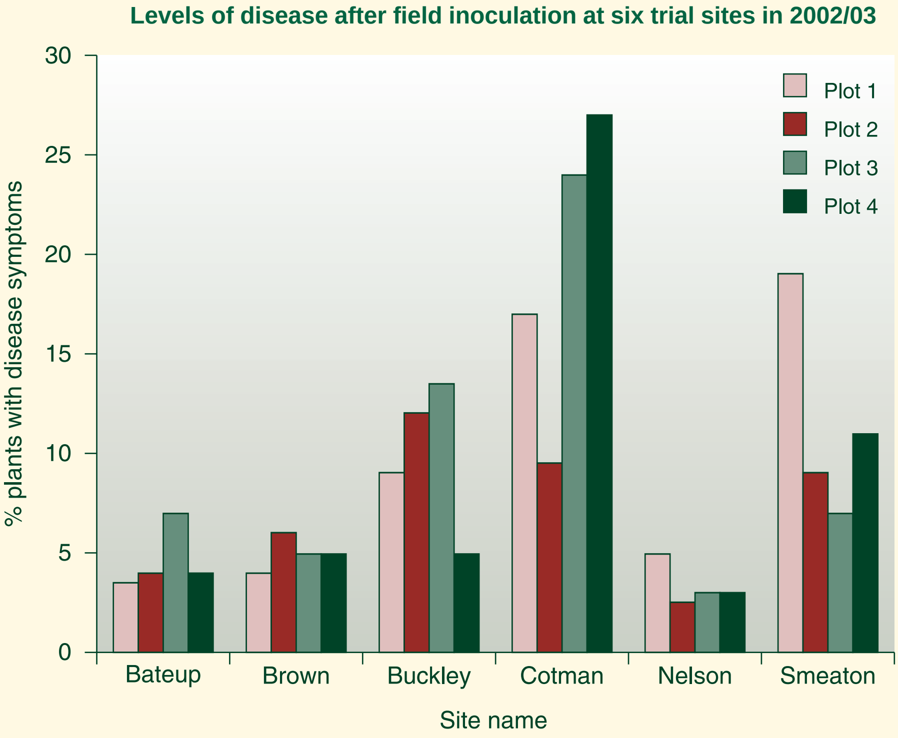
This trial was funded by the Foundation for Research, Science and Technology in New Zealand, and the National Environmental Research Council and Royal Society in the UK – Jane Memmott is a senior lecturer at Bristol University in the UK. Technical assistance was provided by Otago Regional Council staff. See back page for a reference to the full paper.

Thistle Hopes Blighted Again

There was small buzz of excitement following the discovery of some unusually sick looking Californian thistles (*Cirsium arvense*) in the Manawatu in 1999 and the subsequent isolation of the disease-causing organism phoma leaf blight (*Phoma exigua* var. *exigua*). The severity of some of the outbreaks caused people to wonder if this could perhaps be the answer to this perennial prickly problem, and a number of organisations pitched in with some funding to see if anything could be made of this unexpected find.

Nick Waipara has recently completed some trials in the central North Island but the results have been generally disappointing. Although it proved easy enough to infect the thistles with the fungus, the amount of damage it caused was highly variable. "Both disease levels and spread ranged from very low to moderately high both within and between trial site properties," explained Nick (see graph).

Disease development was often slow which meant the host was able to resist systemic disease development and outgrew the initial fungal infection. So at most sites the fungus was unable to inhibit thistle growth and seeding and did not provide effective control of this weed. The best results were achieved by mowing thistle rosettes when they first emerged in the spring and then applying the fungus, but significant variation was still observed. Back in the Manawatu where it all began it seems that the fungus has also been variable in its spread and ability to reduce thistle populations. "Anecdotal evidence suggests that although the fungus has eliminated some thistle infestations, that has tended to be the exception rather than the rule," revealed Nick.



Phoma leaf blight needs splashes of water for its spores to be able to disperse, so it spreads slowly and randomly. To be of any use it would therefore need to be applied inundatively to plants as a bioherbicide-type treatment. From these results, it doesn't appear to be worth putting any further effort into experimenting with the current strains, which appear to be primarily leaf pathogens that infect and cause moderate leaf disease symptoms only. Systemic infection of the entire thistle can occur, but such disease development is by and large rare and dependent on as yet unknown external environmental triggers and biological co-factors (e.g. plant stress and enzymes). However, if a better strain of the fungus could be found then further work may be justified. We would need to gain a much better understanding of the relationship between this pathogen and its host plant to see if we could swing the balance in our favour. "Formulation technologies would also need to be developed specifically for such a strain to ensure reliable and economic delivery to the target," cautioned Nick. Researchers in Germany are currently developing a number of pathogenic *Phoma* species as a mycoherbicide biocontrol product against Californian thistle so we will be following their progress with interest.

It seems sensible that we should be continuing to explore other potential avenues for biocontrol of Californian thistle. A root-feeding weevil (*Apion onopordi)* that has the ability to vector the rust fungus (*Puccinia punctiformis*) is showing potential and it is hoped that sufficient funding can be found to enable further testing of this agent to proceed in the near future.

Funding for this work was provided by the Agricultural Marketing, Research, and Development Trust, Heinz Watties, Horizons Regional Council, Hawke's Bay Regional Council, HortResearch, and Landcare Research. Thanks to the Ohinewai Farmers Group for their support.

Don't Blame the Weather!

The mighty ragwort flea beetle (*Longitarsus jacobaeae*) is doing a sterling job in most parts of the country but the West Coast of the South Island isn't one of them. A community group has formed to tackle the problem and with help from the New Zealand Landcare Trust they were successful in gaining money from the Ministry for Agriculture and Forestry's Sustainable Farming Fund. This funding is allowing an in-depth assessment of ragwort flea beetle performance on the West Coast to be carried out and two potential new agents to be tested.

Ragwort crown-boring adult and larva.

In May 2003 Lindsay Smith visited all 13 sites on the West Coast where ragwort flea beetles had been released over the years and have had ample time to do their stuff. He found large differences in both ragwort (*Senecio jacobaea*) density and flea beetle numbers. Lindsay was able to find adult beetles at five sites, feeding damage only at a further five sites, and nothing at the remainder. "Relatively large numbers of beetles were present at two sites (Pleasant Flat and Tauranga Bay), and good numbers at a third (Porika Hills), but there was still a lot of ragwort there," exclaimed Lindsay. The three "good" sites were all quite different climatically, representing in many ways extreme ends of the spectrum. For example an altitudinal range spanning sand dunes at Tauranga Bay (9 m) to mountain-beech-bordered pastures at Porika Hills (557 m); annual rainfall of 1784 mm at Porika Hills to 4478 mm at Pleasant Flats; mean minimum temperature of –1.6°C at Porika Hills to 3.9°C at Tauranga Bay; and a mean annual temperature range from 9.3°C at Porika Hills to 12°C at Tauranga Bay. "So while this hasn't helped us to put our finger on what the exact problem is here, we are reasonably confident that the poor performance of the flea beetle on the Coast is not just linked to annual rainfall as previously thought," concluded Lindsay. In an attempt to shed further light on this mystery Gaye Rattray is visiting five of the sites on a monthly basis for a year so we can more closely track beetle and ragwort abundance.

> The poor performance of the flea beetle is not just linked to annual rainfall.

Meanwhile permission to import the ragwort plume moth (*Platyptilia isodactyla*) and ragwort crown-boring moth (*Cochylis atricapitana*) into containment has been obtained. Shipments of both moths were received in June and host-specificity testing is now underway. "Both these potential agents have been released in Australia and have established well," reports Hugh Gourlay. The plume moth prefers large rosettes and in glasshouse trials it can kill potted ragwort plants. In the field the plume moths have reduced ragwort density by 60–80% at some sites after only 1–2 years. The crown moth will sometimes kill ragwort plants but more commonly reduces their height, the number of seeds produced and seedling survival. Should it turn out that the ragwort flea beetle has indeed met its Waterloo on the West Coast then one or both of these moths may be called up as reinforcements.

Funding for this project has been provided by the West Coast Regional Council, Westland Conservancy of the Department of Conservation, Westland Milk Products, West Coast Development Trust, and Forest and Bird – a true community effort!

Who's Who in Biological Control of Weeds?

Alligator weed beetle (*Agasicles hygrophila*)	Foliage feeder, common, often provides excellent control on static water bodies.
Alligator weed beetle (*Disonycha argentinensis*)	Foliage feeder, released widely in the early 1980s, failed to establish.
Alligator weed moth (*Arcola malloi*)	Foliage feeder, common in some areas, can provide excellent control on static water bodies.
Blackberry rust (*Phragmidium violaceum*)	Leaf rust fungus, self-introduced, common in areas where susceptible plants occur, can be damaging but many plants are resistant.
Boneseed leaf roller (*Tortrix s.l.* sp. "chrysanthemoides")	Foliage feeder, not yet released, application for permission to release currently with ERMA.
Broom psyllid (*Arytainilla spartiophila*)	Sap sucker, becoming more common, slow to disperse, one damaging outbreak seen so far, impact unknown.
Broom seed beetle (*Bruchidius villosus*)	Seed feeder, becoming more common, spreading well, showing potential to destroy many seeds.
Broom twig miner (*Leucoptera spartifoliella*)	Stem miner, self-introduced, common, often causes obvious damage.
Californian thistle flea beetle (*Altica carduorum*)	Foliage feeder, released widely during the early 1990s, not thought to have established.
Californian thistle gall fly (*Urophora cardui*)	Gall former, rare, galls tend to be eaten by sheep, impact unknown.
Californian thistle leaf beetle (*Lema cyanella*)	Foliage feeder, rare, no obvious impact, no further releases planned.
Californian thistle rust (*Puccinia punctiformis*)	Systemic rust fungus, self-introduced, common, damage not usually widespread.
Echium leaf miner (*Dialectica scalariella*)	Leaf miner, self-introduced, becoming common on several *Echium* species, impact unknown.
Gorse colonial hard shoot moth (*Pempelia genistella*)	Foliage feeder, limited releases to date, established at two sites, impact unknown but obvious damage seen at one site, further releases planned.
Gorse hard shoot moth (*Scythris grandipennis*)	Foliage feeder, failed to establish from small number released at one site, no further releases planned due to rearing difficulties.
Gorse pod moth (*Cydia succedana*)	Seed feeder, becoming more common, spreading well, showing potential to destroy seeds in spring and autumn.
Gorse seed weevil (*Exapion ulicis*)	Seed feeder, common, destroys many seeds in spring.
Gorse soft shoot moth (*Agonopterix ulicetella*)	Foliage feeder, released widely and has established but thought to be rare; however, an outbreak was seen in Canterbury last spring, impact unknown.
Gorse spider mite (*Tetranychus lintearius*)	Sap sucker, common, often causes obvious damage, but persistent damage limited by predation.
Gorse stem miner (*Anisoplaca pytoptera*)	Stem miner, native insect, common in the South Island, often causes obvious damage, lemon tree borer has similar impact in the North Island.
Gorse thrips (*Sericothrips staphylinus*)	Sap sucker, limited in distribution as the UK strain is slow to disperse but the more recently released Portuguese strain should move faster, impact unknown.
Hemlock moth (*Agonopterix alstromeriana*)	Foliage feeder, self-introduced, common, often causes severe damage.
Hieracium crown hover fly (*Cheilosia psilophthalma*)	Crown feeder, permission to release recently granted, rearing underway to enable releases to begin.
Hieracium gall midge (*Macrolabis pilosellae*)	Gall former, has recently been widely released, established but not yet common at sites in both islands, impact unknown but very damaging under laboratory conditions.

Hieracium gall wasp (*Aulacidea subterminalis*)	Gall former, has recently been widely released, established but not yet common in the South Island, impact unknown.
Hieracium plume moth (*Oxyptilus pilosellae*)	Foliage feeder, only released at one site so far, impact unknown, further releases will be made if rearing difficulties can be overcome.
Hieracium root hover fly (*Cheilosia urbana*)	Root feeder, only one release made so far and success unknown, rearing underway to enable releases to begin.
Hieracium rust (*Puccinia hieracii* var. *piloselloidarum*)	Leaf rust fungus, self-introduced?, common, may damage mouse-ear hawkweed but plants vary in susceptibility.
Heather beetle (*Lochmaea suturalis*)	Foliage feeder, released widely in Tongariro National Park, established at at least one site there and also at Waiouru and Rotorua, severe localised damage seen already.
Mexican devil weed gall fly (*Procecidochares utilis*)	Gall former, common, initially high impact but now reduced considerably by Australian parasitic wasp.
Mist flower fungus (*Entyloma ageratinae*)	Leaf smut, common and often causes severe damage.
Mist flower gall fly (*Procecidochares alani*)	Gall former, now well established and common at many sites, impact not yet known.
Nodding thistle crown weevil (*Trichosirocalus mortadelo*)	Root and crown feeder, becoming common on several thistles, often provides excellent control in conjunction with other nodding thistle agents.
Nodding thistle gall fly (*Urophora solstitialis*)	Seed feeder, becoming common, often provides excellent control in conjunction with other nodding thistle agents.
Nodding thistle receptacle weevil (*Rhinocyllus conicus*)	Seed feeder, common on several thistles, often provides excellent control of nodding thistle in conjunction with the other nodding thistle agents.
Old man's beard leaf fungus (*Phoma clematidina*)	Leaf fungus, common, sometimes causes obvious damage especially in autumn.
Old man's beard leaf miner (*Phytomyza vitalbae*)	Leaf miner, common, laboratory studies suggest it is capable of stunting small plants, one severely damaging outbreak seen so far.
Old man's beard sawfly (*Monophadnus spinolae*)	Foliage feeder, widespread releases have now begun, establishment success and impact unknown.
Phoma leaf blight (*Phoma exigua* var. *exigua*)	Leaf spot fungus, self-introduced, becoming common, can cause minor–severe damage to a range of thistles.
Scotch thistle gall fly (*Urophora stylata*)	Seed feeder, limited releases to date, appears to be establishing readily, impact unknown.
Cinnabar moth (*Tyria jacobaeae*)	Foliage feeder, common in some areas, often causes obvious damage.
Ragwort flea beetle (*Longitarsus jacobaeae*)	Root and crown feeder, common in most areas, often provides excellent control in many areas.
Ragwort seed fly (*Botanophila jacobaeae*)	Seed feeder, established in the central North Island, no significant impact.
Greater St John's wort beetle (*Chrysolina quadrigemina*)	Foliage feeder, common in some areas, not believed to be as significant as the lesser St John's wort beetle.
Lesser St John's wort beetle (*Chrysolina hyperici*)	Foliage feeder, common, often provides excellent control.
St John's wort gall midge (*Zeuxidiplosis giardi*)	Gall former, established in the northern South Island, often causes severe stunting.

Naturally occurring fungal agents under development as mycoherbicides, e.g. silver leaf fungus (*Chondrostereum purpureum*) and white soft rot (*Sclerotinia sclerotiorum*), are not included in this table.

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If you need assistance in locating any of the above references please contact Lynley Hayes.

What's New in Biological Control of Weeds? issues 1–28 are available from Lynley Hayes and issues 11–28 are available from the Landcare Research website (details below).

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