

WHAT'S NEW IN

# Biological Control of Weeds?

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Tradescantia stem beetle damage

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Landcare Research  
Manaaki Whenua

# Tradescantia Beetles Gain Momentum

Tradescantia (*Tradescantia fluminensis*) ranks among the top targets for environmental weeds in New Zealand. This is because it forms a dense mat and suppresses native regeneration in forest remnants, and once established it is extremely difficult to eradicate. Any broken stems are capable of resprouting and forming new plants. Herbicide needs to be applied multiple times and can be damaging to beneficial plants. Happily, surveys in the native range of the weed in Brazil identified many natural enemies that prevent it from forming the dense mats that are so harmful here. Since tradescantia is also a major problem for many home gardeners there are likely to be a lot of very happy people if biocontrol can be successful.

Following the successful release of the tradescantia leaf beetle (*Neolema ogloblini*) in March last year, a second beetle species, the tradescantia stem beetle aka “Knobbly” (*Lema basicostata*), has now joined the attack against this weed. The stem beetle has been liberated this autumn at sites in Northland, Auckland, Bay of Plenty, Waikato and Wellington, with further releases planned for next spring. The stem beetle is a similar size (4-5 mm) to the leaf beetle but is black and has bumps on the elytra (wing cases), hence the nickname. Unlike the leaf beetle which feeds on the foliage, the larvae of this species mines the stems of the plant.

“While the two beetles are expected to co-exist happily and be complementary in their damage, we are initially releasing

them at different sites to prevent any competition during the critical establishment phase, and to enable the impact of each species to be assessed,” said Quentin Paynter. “We are really excited about the stem beetle because in Brazil, its larval mining was associated with fairly dramatic wilting and collapsing stems, and it is absolutely demolishing the plants that Chris Winks is mass-rearing it on in Auckland.”

Since the original release of the leaf beetle in Auckland, a further 28 releases have been made around New Zealand. Damage to tradescantia plants has been observed already at a number of release sites checked to date, so establishment is looking promising. Typical damage to the leaves to look for includes notches along the edges through to skeletonised leaves where the beetles have grazed all the green tissue off the leaf surface. “The adult beetles can be hard to spot as they tend to drop to the ground when disturbed but the slug-like larvae and ‘styrofoam-like’ pupal cases may be visible on the leaves,” said Chris.

It is not known how fast the two beetles will breed in New Zealand but it is hoped that there will be at least two or three generations each year in warmer areas. “Biomass samples of tradescantia have been taken from a range of sites prior to the release of the beetles so that later on we can determine how well the beetles are suppressing tradescantia. Once establishment of the leaf beetle has been confirmed (i.e. survived two winters), a more intensive monitoring programme will begin,” confirmed Simon Fowler.

A third beetle which attacks the tips of a range of tradescantia leaves, nicknamed “Stripy” (*Neolema abbreviata*) has not been released as yet. However, despite only having a small number of gregarine-free adults to work with initially, mass rearing is going well and releases are expected to begin next spring. Permission to import and release a fourth agent, a Brazilian fungus (*Kordyana* sp.), is next on the agenda for tradescantia – see story on facing page.

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CONTACT: Simon Fowler

fowlers@landcareresearch.co.nz



Typical stem beetle larval damage (adult inset).

# Another White Smut in Shining Armour?

The white smut fungus *Entyloma ageratinae* has been a very successful biological control agent against the weed mist flower (*Ageratina riparia*) in New Zealand. Now we have another white smut fungus (*Kordyana* sp.), which looks like an excellent potential biocontrol agent for tradescantia (*Tradescantia fluminensis*) to add to the insect attack (see previous story). Although a white smut, this fungus causes large distinctive yellow spots to form on the leaves so is commonly referred to as the tradescantia yellow leaf spot.

A list of promising plant pathogens found during surveys of tradescantia in Brazil has been slowly whittled down to this one species by a team of researchers, led by Drs Robert Barreto and Davi Macedo, at the University of Viçosa, Brazil. Some organisms proved to be too benign (e.g. a *Ceratobasidium* sp.), one species requires further research (the bacterium *Burkholderia andropogonis*) and other organisms were just too hard to work with in the laboratory/glasshouse (e.g. a rust named *Uromyces commelinae*).

However, the yellow leaf spot has provided its own set of challenges which have had to be overcome. After much effort, the researchers at Viçosa were able to grow the yellow leaf spot on artificial media, but as the fungus really prefers living plant tissues the fungal structures produced in culture were unable to infect plants. Field observations showed the fungus had no trouble moving from plant to plant on its own so initially, host range tests were designed to take advantage of this natural spread.

62 non-target species, from 31 different plant families, were included in host range tests. Test plants were placed in a shade-house in Viçosa with infected tradescantia plants. Tradescantia plants propagated from material originating in New Zealand were also included as positive controls (i.e. the test would only be valid if the target plants became infected under the conditions provided). New Zealand tradescantia plants showed symptoms one month after they were placed in the vicinity of infected plants in the shade house, but none of the other test plants became infected. "These results demonstrate that the yellow leaf spot is highly host specific," reported Dr Barreto.

Meanwhile, research continued in the laboratory and a method was developed that allowed the spores to be applied more directly to test plants. Leaves of infected tradescantia plants were collected and attached (with Vaseline) to the underside of a sheet of glass with the leaf surface pointing

downwards so fungal spores could fall on to test plants below. This sheet of glass was then placed over the test plants in a dew chamber where ideal conditions for infection were provided for 48 hours. Then plants were transferred to a greenhouse for observation. This direct method was used on 13 species in the Commelinaceae family which had already been tested in the shade-house experiment. Happily, the results were exactly the same, with only *Tradescantia fluminensis* proving to be susceptible.

An application to the Environmental Protection Authority to import and release the yellow leaf spot is now being prepared. However, even if approval is given there will be some challenges to overcome in achieving a clean colony of the yellow leaf spot. The fungus will not produce fully functional spores on artificial media, and it is not possible to collect and ship spores produced naturally because of their tiny size and fragility. So the yellow leaf spot will have to be imported as actively growing colonies on living tissues from which it will be difficult to exclude other micro-organisms. Fortunately, construction of a pathogen-proof containment facility is now underway in Auckland so we will be able to safely import this material and over time obtain a clean colony which can be released.

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CONTACT: Jane Barton  
Jane.barton@ihug.co.nz



Tradescantia yellow leaf spot.

# Broom Control in the Wilderness



In November last year, Simon Fowler and Quentin Paynter ventured out into the wilderness (well, the Wilderness Reserve in Te Anau!) to set up permanent plots to measure the impact of two biocontrol agents: the broom psyllid (*Arytainilla spartiophila*) and the broom twig miner (*Leucoptera spartifoliella*), which appear to be having a noticeable impact on broom (*Cytisus scoparius*) there. Biocontrol impact assessment data tend to be in short supply for most biocontrol projects, so this is an important step in the right direction.

The project is a joint initiative between Environment Southland and Landcare Research and aims to quantify the amount of damage these two agents are doing to broom in the region. To do this it is necessary to look at recovery of broom when feeding pressure from the two biocontrol agents is removed. Ten of the twenty plots will have the insects removed by spraying insecticide and the remaining ten plots will not be sprayed, so that the biocontrol agents can keep doing what they do best – damaging broom.

“A previous study in North Canterbury showed that the broom twig miner stunted plants early in the year, but the effect was not sustained and plants recovered over the growing season. This experiment will monitor the impact of both the broom twig miner and the broom psyllid,” said Quent. In addition to this project, we have also set up long-term plots near Hanmer, in North Canterbury and at Waiouru on the North Island where, respectively, the broom gall mite (*Aceria genistae*) and the broom leaf beetle (*Gonioctena olivacea*) are establishing well.

It is difficult to predict in advance what the combined impact of all the broom agents will be. “We try to select agents that complement each other and maximise the cumulative impact on the target weed. For example, given enough summer rainfall we know that broom can shrug off even quite heavy early spring attack by the broom twig miner. This is where the broom leaf beetle should step in attacking the compensatory growth of the plant later in the season. However, in practice it can be hard to tell how agents will combine in new environments, which is why we need to test this experimentally,” said Simon.

The Wilderness Reserve is the best surviving remnant of the strangely stunted podocarp, bog pine (*Halocarpus bidwillii*). This plant grows not only in bogs (as its name suggests) but



Simon Fowler and Jesse Bythell setting up broom plots at Wilderness Reserve.

also on the well-drained, stony substrates common on river beds. Bog pine hosts the well camouflaged native caterpillar *Dasyuris callicrena*. Also at the site are threatened plants such as *Hebe armstrongii*, *Coprosma intertexta*, *Senecio dunedinensis* and *Carmichaelia crassicaulis*. Also resident at the reserve is the threatened moth *Ericodesma cuneata*. The reserve is an example of a ‘frost flat’ ecosystem, characterised by leached terraces with low fertility and extreme ranges between winter and summer temperatures.

The exclusion experiment in the Wilderness Reserve in Te Anau will compare the rate of growth of broom plants, the percentage of broom cover within the plots, seed production, and recruitment of new broom plants in plots with and without the biocontrol agents. The survival of indigenous plant species, including bog pine, is also being measured. The data will be used to determine what level of control the agents are providing and whether the levels of attack reported at the Wilderness Reserve will be likely to control broom populations at other sites.

Other broom biocontrol agents are being established in Southland. The broom seed beetle (*Bruchidius villosus*) is now widespread. Establishment of the broom shoot moth (*Agonopterix assimilella*) is uncertain, but the broom leaf beetle (*Gonioctena olivacea*) and the broom gall mite (*Aceria genistae*) appear to be doing well, and it is hoped they will add even more pressure to the broom in due course.

*This project is funded by the Ministry of Science and Innovation through the Beating Weeds Programme.*

**CONTACT:** Simon Fowler  
fowlers@landcareresearch.co.nz

# Pampas – the Search Begins!

After surveys of pampas (*Cortaderia selloana* and *C. jubata*) in New Zealand found few natural enemies attacking the plant it was decided that potential biocontrol agents in the native range should be sought. In 2011 a multi-agency group, known as the National Pampas Biocontrol Initiative, was successful in gaining funds to allow this to happen.

The first task was to identify where in the native range of pampas in South America we should look for potential biocontrol agents. *C. jubata* was reported to be native to Argentina, Bolivia, Ecuador and Peru, with *C. selloana* native to Brazil, Argentina, Uruguay and Chile. However, it quickly became apparent that the taxonomy of *Cortaderia* is complex with many issues needing to be resolved. It is not possible to distinguish different species of *Cortaderia* by taxonomic features alone so molecular studies were essential. There was a suggestion in the literature that Argentina was the likely source of New Zealand pampas, so with the assistance of botanist Dr Carlos Villamil (Universidad Nacional del Sur, Argentina) we got samples from there first.

Molecular analysis revealed that none of the samples of *C. jubata* from Argentina matched *C. jubata* plants from New Zealand. "In fact the plants currently referred to as *C. jubata* are significantly different genetically, and have previously been in another species," said plant population geneticist Gary Houlston. An American study had previously shown that invasive *C. jubata* from invaded regions in California, Hawai'i and New Zealand consisted of the same single clone that matched the most common clone identified in herbarium specimens from southern Ecuador. We confirmed that all New Zealand *C. jubata* matched this genotype and then searched for collaborators in southern Ecuador who could help with surveys to look for potential biocontrol agents. Luckily plant pathologists Dr Maria Eugenia Ordonez and Dr Charles Barnes, and entomologist Dr Alvaro Barragan (Pontificia Universidad Católica del Ecuador) were able to help. With Dr Villamil along to help identify the correct species, a preliminary survey of *C. jubata* was undertaken in April 2012. While the plants appeared to be generally quite healthy, a smut and a fly that damage the flowerheads were observed that are worth further study.

Trying to locate a match for *C. selloana* has been more challenging. None of the samples collected from Argentina, nor the single sample sourced from Chile, have proven to be a good match for New Zealand material with one exception. Some small infestations of *C. selloana* growing in Nelson and

Southland are genetically different from *C. selloana* in the rest of New Zealand and are similar to Argentinean material. This material should be considered a third type of pampas for New Zealand. We have recommended these infestations should be eradicated, as they have the potential to make the pampas problem here even worse if they allow new genetic combinations to form, and/or if any biocontrol agents released down the track are unable to attack them. "Our plan is to now source samples from other parts of the reported native range to look for a match," explained Gary.

We have also considered the feasibility of an inundative approach to pampas biocontrol using plant pathogens already present in New Zealand. "Unfortunately none of the pathogens found on *Cortaderia* have all of the characteristics necessary to make them a good candidate for development as a bioherbicide," concluded Stan Bellgard. We are now looking at whether any of the endophytes/secondary pathogens already present on or in pampas leaves in New Zealand have the potential to disrupt any biocontrol agents that we may wish to introduce. We found a fungus (*Epicoccum purpurascens*) on pampas here which has been used overseas as a biocontrol agent to control peach rot (*Monilinia* spp.), hence the need to look into this further.

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**CONTACT:** Lynley Hayes



Carlos Villamil

Black smut fungus found damaging *C. jubata* flowerheads in Ecuador.

# How Could Ecological Research be Used to Improve Safety of Weed Biocontrol?

Many ecologists have a negative opinion of biocontrol while practitioners argue that it offers a cost-effective solution to many invasive weed problems. Meanwhile practitioners are under pressure to implement effective weed biocontrol more quickly, cheaply and safely. Recently Simon Fowler and colleagues were asked to prepare a paper for the Journal of Applied Ecology on how advances in ecological research could help to deliver on these aims while minimising any potential negative outcomes. Below is a summary of that paper which is divided into two parts: avoiding direct and indirect non-target effects.

## Part One: Avoiding Direct Non-Target Effects

Host range testing is undertaken to determine which plant species will be damaged by a biocontrol agent. The most conservative test is a 'no-choice' test where an agent can either attack a plant or not. Such tests may involve feeding by an insect, egg-laying by a female insect or infection by a pathogen (in all cases, the stark alternative is starvation, death and failure to reproduce). Other tests provide potential biocontrol agents, particularly insects, with a selection of test plants to see which ones they eat (a 'choice' test).

There are problems with using 'no choice' and 'choice' tests. In 'no-choice' tests, an agent is rejected if it attacks plants of value (native species or plants of economic importance). However, there can be a high rate of 'false-positive' results meaning that potential biocontrol candidates are rejected or overlooked. "There is a real danger of eliminating potential agents unnecessarily as often the non-target impact of agents

may not even occur or be minimal once they are released into the field," explained Simon.

The potential for missed opportunities is highlighted by a current study led by Ronny Groenteman that retrospectively tested the host range of two beetle species introduced into New Zealand in 1943 and 1965 to control St. John's wort (*Hypericum perforatum*). These tests showed that, under current protocols, the two beetles would not meet the requirements for release in New Zealand. However, the beetles have undoubtedly been successful in controlling this serious pasture weed with minimal impacts on native *Hypericum* species.

On the other hand, 'choice' tests are not always good indicators of the agent's behaviour when the host plant's availability is reduced, creating a 'no choice' situation in the field. For example, the gorse pod moth (*Cydia succedana*), which was released in New Zealand to target gorse (*Ulex europaeus*), was later found in the seed pods of other plants, especially during times when the gorse pods were not abundant. Similarly, there is uncertainty surrounding whether 'choice' tests adequately predict whether an agent will damage plants of value when they disperse away from their normal hosts, and again find themselves in a no-choice environment.

Ideally, to get the most realistic results potential agents would be tested on plants of value in the field or in the environment that they are going to be released into. But the practicalities of keeping potential agents safely contained in the field prevent this. Another option is to do the host range testing in the native range of the biocontrol agent using plants from New Zealand, but the logistical issues involved are often insurmountable.

It is apparent that unless we improve our risk assessment procedures, we will either reject potentially successful and safe agents based on overly conservative host range testing or conversely, underestimate the damage that agents can do when faced with limited host plant availability. How could better ecological studies help? "What is required," said Quentin Paynter, "is a framework for better assessing whether non target impacts are significant without having to rely on field based testing."



We need to avoid rejecting safe, effective agents like the St John's wort beetle, where host testing results overestimate likely non-target damage in the field.

Another area that would benefit from further study is the risk of host-range expansion over time. This is currently believed to be a minor risk but we need to improve our understanding of which agents might be at greater risk of evolving to do this, and under what conditions. For example, if we go down the track of targeting multiple weeds in one hit by using less highly specific agents, are we setting ourselves up for trouble? Or is there a higher risk where highly specific agents are known to have slightly different host-ranges in different geographical areas?

## Part Two: Avoiding Indirect Non-Target Effects

Large scale changes in food webs resulting from the introduction of biocontrol agents are rare but something we need to continue to be careful to avoid. As well as food web effects, other “indirect effects” arising from the introduction of biocontrol agents include changes to pollination systems or mutualistic relationships between species.

Some potential food web effects are obvious and are already considered in weed biocontrol programmes. For example, some broom biocontrol agents could also attack tree lucerne (*Cytisus proliferus*) which is an important spring food for native pigeons. These “conflicts of interest” are carefully addressed early on during biocontrol programmes, and under the Hazardous Substances and New Organisms (HSNO) Act (1996) any species that have the potential to “cause any significant displacement of any native species within its natural habitat” are not approved for release. Retrospective studies have allowed us to get better at identifying, and therefore avoiding, agents that have a high potential for indirect non-target effects, e.g. those that become common but have no impact on the target plant, or become popular targets themselves (through disease, predation or parasitism –for recent breakthroughs on the latter see “*Is it Possible to Predict Parasitism?*” in Issue 49).

“Although many of the implications of releasing weed biocontrol agents for food webs are predictable, there may be more subtle effects that have previously flown beneath the radar,” explained Simon. For example, a recent high profile debate in the USA centred on the implications of releasing gall flies (*Urophora* spp.) to control knapweed (*Centaurea* spp.). As the gall flies increased in number, the food supply and abundance of native deer mice (*Peromyscus maniculatus*) also increased. Elevated numbers of deer mice could have a range of effects in food webs, even potentially impacting human health because the mice are the main reservoirs of hantavirus (a rare but serious disease in humans).

It is clear that we need to avoid major impacts on “keystone species” and avoid triggering “trophic cascades” where one disturbance creates a ripple effect on other species.



Consideration was given early on to the likelihood the broom leaf beetle might damage tree lucerne.

However, while our understanding of how food webs function is good enough to predict major unwanted consequences from relatively simple interactions, our ability to predict the impact of more subtle or less obvious indirect effects is not. More research is needed, especially to allow us to forecast the magnitude of effects, and determine whether they are significant in the context of reduced weed abundance should an agent be successful.

“While some indirect non-target effects are inevitable when a new biocontrol agent is established, the key issue is the size and importance of these effects both geographically and over time,” confirmed Simon. If effects are highly localised around the target weeds, or confined to a small period of the year, or only happen while the agent is common and bringing the weed under control (although this might take 5-10 years in typical programmes), then they may not be important in the overall picture.

Biocontrol practitioners are often constrained from delving into studying the ecological systems associated with the release of biocontrol agents by the realities of delivering applied research. However, biocontrol systems offer a wealth of experimental opportunities for ecologists ranging from food-webs, to advanced predator-prey interactions, interspecific plant competition and modelling parasitic relationships. Clearly there is a wealth of fascinating research opportunities that could better inform biocontrol science, and any interest by universities in becoming involved would be welcomed.

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Fowler SV, Paynter Q, Dodd S, Groenteman R 2012. How can ecologists help practitioners minimize non-target effects in weed biocontrol? *Journal of Applied Ecology* 49 (2): 307–310. <http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2011.02106x/pdf>

CONTACT: Simon Fowler

[fowlers@landcareresearch.co.nz](mailto:fowlers@landcareresearch.co.nz)

# Is Biocontrol an Option for Paper Wasps in New Zealand?

In New Zealand, we have two species of exotic paper wasps, *Polistes humilis* which is native to Australia and *Polistes chinensis antennalis* which is native to Asia. Both species have been in New Zealand for several decades and are now widespread but limited by climatic conditions. Paper wasps are predatory and attack butterfly and moth larvae as well as compete for nectar resources with other insects and birds. They reach high densities (>200 nests per hectare) in places like the far north of New Zealand where conditions are optimal. Paper wasps are also a significant nuisance to animals and humans, giving painful stings.

Options for controlling paper wasps are limited because unlike *Vespula* wasps (German and common wasps), paper wasps are not attracted to protein baits. Trapping individual workers does not have a major impact on numbers, although manually destroying nests can be successful on a small scale. So, recently, Quentin Paynter and Darren Ward have investigated the potential for biological control of these pests.

Biocontrol of paper wasps has not been attempted anywhere in the world to date. Biocontrol against *Vespula* wasps has been attempted here using parasites (*Sphexophaga* spp.) but has unfortunately failed to make much of a dent in wasp numbers. This is thought to be at least in part due to the fact that the *Vespula* wasps vigorously defend their nests against unwanted intruders. "However, there are reasons to be more optimistic regarding the potential for biocontrol of *Polistes* wasps," explained Quentin. The lack of a nest envelope on *Polistes* nests makes their nests harder to defend. Also while the incidence and impacts of parasitism and disease on Asian and Australian paper wasps are not well known there is, for example, good data from other paper wasps that they are attacked by a wide range of parasitoids, including scavenger moths that exert a major influence on colony longevity.

Once nests are bored by such moths, they lose structural strength and cannot be used for long. Furthermore, it has been noted that unlike *Vespula* spp., *Polistes* wasps do not have meconium-extracting behaviour (removal of larval waste) which could explain why their nests appear to be more attractive to these scavenger moths.



Asian paper wasp attacked by unknown fungus in Auckland.

There are two options for advancing a biocontrol programme for paper wasps in New Zealand. The first would involve conducting surveys in the native ranges of the two species to identify their natural enemies and any prospective biocontrol agents. The second, cheaper approach would be to consider the natural enemies already known to have a major impact on other *Polistes* species and whether they might be suitable for New Zealand. The advantage of using less specific agents is that any new species of paper wasps that manage to invade New Zealand in the future might also be suppressed early on. Fortunately, because our native hymenoptera are not closely related to the introduced paper wasps, it is unlikely that any potential biocontrol agents would pose a threat to them.

There are many reports of paper wasps preying on monarch butterflies (*Danaus plexippus*), and native moths and butterflies such as the kawakawa looper (*Cleora scriptaria*) and kowhai moth (*Uresiphita polygonalis maoralis*). However, paper wasps do benefit gardeners to some extent by helping to control pests such as the cabbage white butterfly (*Pieris rapae*). The importance of this to organic gardeners needs to be assessed, especially since biocontrol agents have been established in New Zealand to specifically target these butterflies.

"Overall our review suggests that biocontrol for paper wasps appears quite promising," concluded Quent. Further research will be undertaken as funds permit.

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**CONTACT:** Quentin Paynter  
paynterq@landcareresearch.co.nz