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Manaaki Whenua
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Weed Biocontrol

WHAT'S NEW?

Contents

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Sydney golden wattle bud-galling wasp
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A New Tool for Prioritising Biocontrol Targets

In New Zealand the number of native plant species (2,414) is outnumbered by the 2,430 naturalised, exotic plant species. Given such a high number of exotic plant species, the limited resources for tackling weed invasions must be prioritised effectively. The National Biocontrol Collective (NBC) is a consortium of regional councils, unitary authorities, and the Department of Conservation that funds applied weed biocontrol research in New Zealand. In 2022 it trialled a new framework for prioritising weed biocontrol targets.

"It has taken a long time to get to this stage," said Quentin Paynter, who spearheaded the development of the framework. "And it all started with our work on weed prioritisation for the Australian government." MWLR and Research Associate Richard Hill first began work on the prioritisation of weed biocontrol targets in 2008, when we were awarded funding from the Australian federal government to prioritise weed targets in Australia. We, as an independent external agency, were contracted to assist with weed prioritisation because the individual Australian states and territories could not reach a consensus on the top priorities.

"The system we developed recognised that weed prioritisation must take three factors into account: (i) weed importance, which is based on the negative impacts a weed creates; (ii) the likely susceptibility of the weed to biological control; and (iii) the cost of implementing biocontrol, to determine which weed target is likely to result in the 'best bang for your buck'," explained Quentin.

Weed importance: "For this aspect of developing the tool, the Australian government had already invested a lot of effort into ranking weeds by their importance when they determined their Weeds of National Significance (or WoNS). So rather than reinventing the wheel, we used the WoNS scoring system to rank weed importance in New Zealand, but focused on developing a system to predict biocontrol impacts," he added.

Biocontrol success: To predict biocontrol impacts, Quentin and researcher Chris McGrannachan compiled a list of factors that had been hypothesised to influence biocontrol success, and then assembled a database of published information on the impacts of past biocontrol programmes so that these hypotheses could be tested. The next step was to develop a system that scored weeds higher or lower depending on how many traits they possessed that were correlated with biocontrol success. The researchers found that this worked quite well: biocontrol impacts were invariably high against weeds that had high scores, while biocontrol had often failed against weed targets with very low scores.

Thereafter, funding from the Foundation for Research, Science and Technology was used to refine this approach by calling on the expertise of Jake Overton (MWLR Research Associate). Jake recently helped develop new statistical techniques that we could use to model the impacts of the various traits that were correlated with biocontrol success, alone or in combination, to produce a model with a combination of traits that best predicted biocontrol impact.

The results showed that the success of repeat programmes (biocontrol programmes using agents already developed and released in overseas weed biocontrol programmes) is predicted by the success of the novel, pioneering programme. For novel biocontrol targets, three traits provided a good ability to predict success: weediness of the target weed in its native range, mode of reproduction (sexual or asexual), and ecosystem type (aquatic or wetland versus terrestrial).

Weediness in the native range is important because species that are abundant enough to be considered weeds in their native range may become abundant there because they benefit from disturbances to ecosystems resulting from human activities such as fire or over-grazing. If human-related disturbance drives the abundance of a particular species, then biocontrol is less likely to succeed. On the other hand, if a target plant is uncommon or a minor component of the native flora but is weedy in its introduced range, it may be benefiting from the absence of specialist natural enemies in the introduced range. Biocontrol is therefore likely to be successful.

Mode of reproduction is important because clonal weeds tend to have lower genetic diversity in the introduced range compared to species that reproduce sexually. In extreme examples, such as the case of tradescantia (T*radescantia fluminensis*) in New Zealand, a single clone may be present, so there is very limited opportunity for the evolution of resistance to biocontrol to occur. In contrast, genetically diverse, outcrossing, sexually reproducing weeds such as gorse (*Ulex europaeus*) are more likely to evolve resistance. For example, winter flowering in gorse is likely to have evolved because of selection by seed-feeding biocontrol agents, which are most active in spring and summer.

In terms of ecosystem type, aquatic and wetland weeds are more susceptible to biocontrol than terrestrial weeds, which may be related to habitat stability. For example, in static waterbodies, conditions don't change much, and floating weeds tend to provide a stable resource for biocontrol agents. On land, however, a disturbance such as a bush fire can temporarily wipe out populations of weeds and biocontrol agents. Weed populations often recover quickly from soil seed banks, but it can take a lot longer for biocontrol agents to reinvade the regenerating weed and build up damaging populations, resulting in patchy biocontrol impacts.

Predicting the cost of biocontrol: We already knew that repeat programmes are much cheaper than novel/pioneering programmes, because repeat programmes omit costly overseas survey work and most, if not all, host specificity testing. To quantify this, we used MBIE funding to compile a database of New Zealand biocontrol programmes and went through past budgets to calculate the cost of each. Our analysis showed that two factors explained virtually all the variation in programme cost. Pioneering programmes cost about 4.2 times more than repeat programmes, and cost also increases with the number of agents released, indicating that more efficient agent selection should reduce the cost of future programmes.

Once this work was published, ranking weeds by importance was the only remaining task to enable prioritisation. Auckland Council had already developed a tool for ranking weed biocontrol targets, which we refined on the basis of a model developed by Paul Downey and colleagues (University of Canberra). Their model had been used to rank environmental weeds in New South Wales without quantitative data on weed impacts. Our aim was to develop a system (in this case, an Excel file) that produces meaningful data for the NBC without being too onerous for councils to input information. We felt the system should score weed importance according to weed distribution and weed impacts, summed across a range of habitats. The system also needed to consider factors important to the NBC that were not included by Downey, such as the socio-political pressure to control, and the ease and cost of control by existing means, so that species that are difficult and expensive to control score higher than species that are more easily controlled using existing methods.

In September 2021, a workshop was held to discuss the tool and it was agreed that it strikes a good balance between selecting important weeds and good biocontrol targets. One point of discussion was the high ranking of weeds such as gorse, which has been a long-term biocontrol target but with limited impacts to date. This is partly explained by the ecosystem impact scoring favouring widespread terrestrial weeds and the relatively low cost of implementing biocontrol against existing targets compared to novel targets. This led to a modification to the ranking system by amalgamating some terrestrial ecosystems and splitting aquatic ecosystems so that static waterbodies (lakes and ponds) and flowing water (streams and rivers) were scored separately, to reduce the scoring bias towards terrestrial weeds.

Another issue was the ranking of current biocontrol targets. This can potentially be misleading due to inevitable lags between agents being released and successful biocontrol, which can result in weeds being ranked highly when further work on developing biocontrol agents may not be necessary. This is likely to be the case for tradescantia, for example, which ranked number one. Hence, for existing (or past) targets, such as gorse and tradescantia, a discussion is required on a case-by-case basis to decide whether further work is justified or should be abandoned. In other words, the ranking system is designed to help identify the best targets, but it does not need to be followed slavishly.

In conclusion, the NBC prioritisation tool, which now ranks 158 weeds of importance to members of the NBC, is a much better system than previously used to guide decisions about prioritising funds for weed biocontrol research, but the tool is only as good as the information provided. It is crucial that information used to rank weeds is kept up to date and the rankings regularly reviewed, since these could change dramatically; for example, if an overseas programme results in successful control and could be repeated in New Zealand. By following and refining this prioritisation approach we hope to see a tangible benefit to the NBC through increased cost-effectiveness of our biocontrol work in the years to come.

This project was funded by the National Biocontrol Collective, and Envirolink through the Ministry of Business, Innovation and Employment.

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A Wasp for a Weedy Wattle

We're very excited to report that we have a new biocontrol agent in our midst. Dubbed 'the friendliest wasp in the world' by funder and collaborator Craig Davey (Horizons Regional Council), a bud-galling wasp (*Trichilogaster acaciaelongifoliae*) was released against Sydney golden wattle (*Acacia longifolia*) in early December 2022 after receiving Environmental Protection Authority (EPA) approval just a week before, in late November. It was a brief and eventful timeframe to say the least!

Sydney golden wattle is native to south-eastern Australia and was introduced to New Zealand for ornamental purposes and dune stabilisation. Each plant/small tree produces enormous quantities of seed that can stay viable for decades. Sydney golden wattle quickly spreads and invades disturbed and coastal areas, threatening our fragile dune and wetland ecosystems. It is now forming thick stands and outcompeting our native flora in Horowhenua, in the Kaimaumau swamps in Northland, and on Matakana Island. It is also becoming a problem in new pine plantations in the north.

Both South Africa and Portugal have also been severely impacted by Sydney golden wattle, and both countries have developed biocontrol programmes. This put us in a fortuitous position to consider the agents already released there. The programme in South Africa was initiated in the early 1980s with the release of two agents, the bud-galling wasp and a seed-feeding weevil (*Melanterius ventralis*). The bud-galling wasp is a tiny wasp (3–4 mm) that lays eggs inside the flower and vegetative buds of the plant, leading to the formation of large growths (called galls) in place of flowers and new shoots. This reduces seed production and growth. The programme in South Africa was highly successful, with reductions in seed production of more than 90%. This mitigated the economic and environmental impacts of the weed to such an extent that it is no longer a priority for control.

Portugal initiated a biocontrol programme for Sydney golden wattle in 2005, involving extensive host range testing on the gall wasp, which was approved for release in 2015. The wasp established quickly despite asynchronous seasons, with the wasp being introduced to the northern hemisphere from South Africa.

Evans, Richard, Craig and Robbie (left to right) at the first release site

Our process to get approval to introduce biocontrol agents for Sydney golden wattle began in the early 2000s, when Research Associate Richard Hill conducted a feasibility study. In 2018 a new organism application to the EPA was in progress, and Richard initially wrote the application for both the bud-galling wasp and the seed-feeding weevil. However, surveys of the weed in New Zealand revealed a self-introduced seed-feeding weevil (believed to be *Storeus albosignatus*) that is expected to fulfil the role of the weevil introduced into South Africa along with the wasp.

Given the extensive research conducted on the gall wasp in South Africa and Portugal it was not necessary to undertake laboratory host range testing here. Instead, Richard conducted surveys of New Zealand native plants (such as kōwhai, *Sophora* spp.) closely related to Sydney golden wattle and growing in Australia in close proximity to Sydney golden wattle that had been visibly attacked by the bud-galling wasp. This provided additional supporting evidence that the wasp is highly host specific and no New Zealand natives are at risk of attack by the wasp.

An EPA application was finally submitted by Horizons Regional Council in June 2022. By November, plans were already in place to import a consignment of galls, hand-carried by our South African collaborator, Fiona Impson (University of Cape Town), despite still awaiting EPA approval. "This put us in a bit of a predicament over losing high numbers of adult wasps that emerged but could not yet be released. The adults are extremely short-lived, usually only surviving a few days, so we had to slow down development of larvae and pupae inside the galls by placing them in cool temperatures to delay adult emergence," explained the technician on the project, Arnaud Cartier. When EPA approval was granted, we quickly transferred the galls to warm conditions, and 5 days later, Richard and project leader, Angela Bownes made the first releases of the wasp in Whanganui along with Horizons staff, Craig Davey, Evans Effah, and Robbie Sicely.

By mid-December we had released 201 wasps at two sites in Manawatū-Whanganui where Sydney golden wattle is a serious problem. While we are very hopeful the wasps will establish, we won't waste any time trying to confirm the presence of galls when they should first be visible in May.

This project is funded by the National Biocontrol Collective and the Ministry for Primary Industries' Sustainable Food, Fibre and Futures Fund (Grant #20095) on multi-weed biocontrol.

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Is Lagarosiphon a Good Target?

Lagarosiphon (*Lagarosiphon major*) is one of New Zealand's worst invasive aquatic weeds, and it is the first aquatic plant to be targeted for biocontrol here. Native to southern Africa, lagarosiphon has become problematic in regions outside its native range where it was intentionally introduced as an ornamental, including Ireland and the United Kingdom. In non-native regions lagarosiphon grows rapidly, outcompeting native vegetation and reducing the availability of oxygen.

A biocontrol programme for lagarosiphon was considered in Ireland in the early 2010s, and two candidate agents, a leaf-mining fly (*Hydrellia lagarosiphon*) and a shoot-mining midge (*Polypedilum tuburcinatum*), were prioritised. Testing of the leaf-mining fly was completed, which showed it to be host-specific. Preliminary testing was started on the midge, but this was not completed due to a hiatus in funding, and the project has not been renewed and no agents were released. Given our interest in pursuing a biocontrol programme for lagarosiphon here, we piggy-backed on the research in Ireland with the hope of releasing both agents simultaneously.

As part of our baseline research for the programme it was important to assess whether biocontrol is likely to be an effective management tool for lagarosiphon. Only two submersed aquatic plants, dense water weed (*Egeria densa*) and hornwort (*Ceratophyllum demersum*), have biocontrol programmes elsewhere in the world (USA and South Africa, respectively), and so far control attempts have had only limited to partial success. As part of this undertaking we employed a PhD candidate, Nompumelelo Baso, at Rhodes University in South Africa, with an interest in understanding the success of invasive species in their introduced ranges. Nompumelelo is particularly fascinated by the 'enemy release hypothesis' (ERH), which states that invasive species have an advantage over native species because they are freed from their natural enemies. In the absence of herbivory and disease, invasive species can focus on growing and reproducing, becoming more competitive than they are in their native range.

As part of Nompumelelo's research she tested the ERH by comparing lagarosiphon biomass and other factors in the native range of South Africa, where the candidate biocontrol agents are present, to the same parameters in New Zealand, where lagarosiphon was presumed to not have any significant natural enemies. "To do this, I travelled to the plant's native distribution range in South Africa, collecting biomass samples with a specially designed submersed macrophyte sampler a.k.a. 'the crank'," explained Nompumelelo. "The crank has blades that cut the stems of lagarosiphon from root to tip to get a measure of weight per unit area. This is then repeated for replication, and at multiple sites both in South Africa and New Zealand," she added. Unfortunately, Covid disrupted Nompumelelo's plans to do the research in New Zealand in 2021 and 2022, so the sampling was conducted by the project leader, Angela Bownes, and technician Arnaud Cartier. Fortunately she was able to join the most recent sampling trips undertaken in January and February 2023.


Nompumelelo sampling at King Edward Park, Stratford

Although Nompumelelo's analysis of the full data set is incomplete, a preliminary analysis showed that lagarosiphon has a remarkable tolerance for different environmental conditions. The results also indicate that the plant has higher biomass in its invaded range compared to the native range, supporting the theory that it can invest more in growth when freed from the pressures exerted by natural enemies. The study found that fewer plant species co-occur with lagarosiphon in the invaded range compared to the native range, further supporting the notion that it is a superior competitor without its natural enemies.

"Nompumelelo's research has made a significant contribution to our understanding of lagarosiphon, and provides a strong indication that biocontrol has the potential to be a viable management option," said Angela. "It tells us that herbivore pressure from introduced biocontrol agents can reduce its biomass and competitive dominance. Further, this effect should be maximised in New Zealand since the leaf-mining fly is heavily parasitised in its native range, whereas it is unlikely to be parasitised in New Zealand due to a lack of native analogues in our biota. Without this top-down pressure, the fly should build up good populations capable of reducing the invasiveness of lagarosiphon," she added.

Next steps to progressing the biocontrol programme include completing host range testing of the shoot-mining midge, but obtaining a viable laboratory colony has been a challenge, one that is hopefully resolvable in the near future.

This project is jointly funded by the Ministry of Business, Innovation and Employment, as part of Manaaki Whenua – Landcare Research's Beating Weeds programme, and the National Biocontrol Collective.

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Do Antagonistic Fungi Interfere with Successful Biocontrol?

Weed biocontrol is one of the best weed management options, but the outcomes of weed biocontrol programmes are variable. Quantitative data documenting agent impact is often limited, with most reports of significant impact either anecdotal or subjective, but the most recent assessment suggests that 25% of all agents released worldwide are being classified as successful, such that no other management interventions are necessary.

Some of these successes are attributed to rusts – plant diseases caused by pathogenic fungi of the order Pucciniales. These include a rust (*Puccinia chondrillina*) released against skeleton weed (*Chondrilla juncea*) in Australia and North America, a rust (*Puccinia myrsiphylli*) released against bridal creeper (*Asparagus asparagoides*) in Australia, and the balloon vine rust (*Puccinia arechavaletae*) released against balloon vine (*Cardiospermum grandiflorum*) in the Cook Islands. Despite these successes, 60% of rust fungi intentionally released for biocontrol are reportedly having only a medium or variable impact on their target weed, and at least 15% of all rusts released have failed to establish at all, have established but had no impact on the target weed, or their impact is unknown or not documented.

There are many explanations and over 12 hypotheses to explain why fungal weed biocontrol agents fail to establish or are ineffective when they do. One of these, the 'endophyte-enemy-release hypothesis' (E-ERH) is modified from the enemy release hypothesis (ERH), which underpins weed biocontrol. The ERH states that invasive species dominate local species in novel environments because they don't have their natural enemies that keep them in check in their region of origin. The E-ERH explains why the presence or absence of mutualistic endophytes can, in part, be responsible for the variable outcomes of classical weed biocontrol. Their presence increases plant fitness in the absence of co-evolved natural enemies, or their absence, coupled with the release from co-evolved natural enemies, contributes to increased plant fitness but leaves them highly vulnerable to classical biological control agents.

There is a diverse range of microorganisms likely to be associated with an invasive weed that may significantly affect the pathosystem. These include fungal endophytes that form part of the microbial community (or microbiome) and inhabit above- and below-ground tissues of all plants without causing visible infection or disease. Fungal endophytes affect plant ecology, fitness, and evolution, and shape plant communities. They are able to change the plant community structure and the diversity of associated organisms through increased fitness (by conferring abiotic and biotic stress tolerances, increased plant biomass, or decreased water consumption), or decreased fitness (by altering resource allocation).

It is important to understand not only the interaction between endophytes and host plants but also the interaction between endophytes and plant pathogens to determine their impact on the efficacy of classical biological control. Recent publications highlight how fungal endophytes interact with and affect classical fungal biocontrol agents of invasive weeds.

For example, interactions between endophytic fungi of the invasive weed Japanese knotweed (*Fallopia japonica*) and the rust fungus (*Puccinia polygoni-amphibii* var. *tovariae*) were studied in the native range of Japan to look for potential synergistic interactions. Pre-inoculation of the host plant with five endophytic fungi most frequently associated with Japanese knotweed gave varying results in terms of the number of rust pustules (raised masses of coloured spores that rupture epidermal leaf tissue) produced by the rust fungus. Two of the endophyte species (*Alternaria* sp. and *Phoma* sp.) reduced/suppressed the production of rust pustules, while two other species (*Colletotrichum* sp. and *Pestalotiopsis* sp.) were neutral, having no effect. The presence of a fifth species of endophytic fungus (*Phomopsis* sp.) increased the number of pustules produced by the rust, thereby increasing its potential as a biological control agent.

Similarly, variable disease severity of a rust fungus (*Sclerotinia sclerotiorum*) on Californian thistle (*Cirsium arvense*) led to the hypothesis that the variability was caused by the presence or absence of key endophytic assemblages. Using both culturing and molecular techniques, the researchers identified which endophytic fungi were present in the plants, and the amount of variation present within a plant and between plants at varying distances. The authors showed that endophytic fungi had a significant impact on the ability of *S. sclerotiorum* to cause disease on *C. arvense* and potentially influenced the success/failure of this biocontrol agent.

Clearly endophytic fungi can play a role in the success of fungal weed biocontrol agents, but there is another variable to be factored into the mix: whether other types of fungi could play a role in the success of rust fungi as weed biocontrol agents. Rust fungi have their own natural enemies, called 'mycoparasites'. Mycoparasites are essentially fungi that parasitise other fungi. These mycoparasitic interactions form part of the microbiome of the plant and are considered a significant contributor to fungus–fungus antagonism. In fact, mycoparasitic interactions have been observed on several fungal biocontrol agents, either in the native range of the weed or in the introduced range, and two of these examples are well known to us.

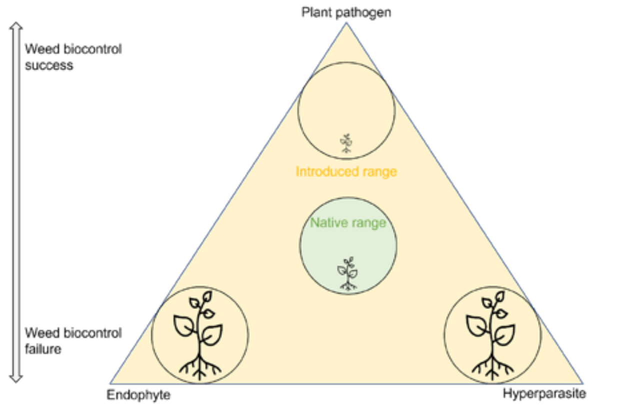
A rust fungus [*Puccinia araujiae*] approved for release against moth plant [*Araujia hortorum*] was found to be heavily parasitised by another fungus [*Cladosporium uredinicola*] in the field in Argentina. Attempts to obtain a mycoparasite-free culture through superficial disinfection and multiple sequential inoculations [>8] in the laboratory were only partially successful. However, despite the high levels of mycoparasitism, testing for pathogenicity and host range were successfully completed, and the rust was approved for release by the EPA in 2015. The release has not yet been exercised due to delays with obtaining an export permit for the rust from Argentina.

The same mycoparasite [*Cladosporium uredinicola*] that parasitises the moth plant rust fungus in Argentina is present in New Zealand, associated with other native rust fungi. If we go ahead and release the moth plant rust, the question remains whether the mycoparasite could parasite the biocontrol agent and reduce its impact in the field. However, evidence from Argentina suggests it would be a successful agent since the rust is still damaging to its host plant there, causing heavy defoliation even in the presence of high levels of parasitism.

A rust fungus [*Uromyces pencanus*] recently imported into New Zealand as a potential biocontrol agent for Chilean needle grass [*Nassella neesiana*] was found to be associated with a mycoparasite [*Simplicillium* sp.] during pathogenicity and host range testing in Argentina. The mycoparasite was not obvious in the field but emerged in the glasshouse, which impeded the production of 'clean' rust spores to conduct the testing. Fortunately, our Argentinian collaborator, Dr Freda Anderson [CERZOS-CONICET], was able to produce clean rust cultures by storing them in the freezer, which killed off the mycoparasite but not the rust spores.

With all this evidence from weed biocontrol programmes worldwide, three of our researchers, Alana Den Breeyen, Claudia Lange, and Simon Fowler, recently conducted a review of how antagonistic fungi potentially affect fungal weed biocontrol programmes. Because the impact of fungal antagonists on the establishment and effectiveness of intentionally released fungal agents for invasive weed biocontrol is not well studied and often anecdotal, their review focused on how endophytic fungi and mycoparasites potentially reduce the effectiveness of classical biocontrol agents.

Plants, pathogens, and antagonists interact with each other in the environment, and an imbalance of these interactions can lead either to weed invasion or to successful weed control. In the native range the interactions are in balance and the plant is non-invasive. However, in the introduced range the plant is present as an introduced exotic species.



Interactions between plant pathogens and fungal antagonists

Three scenarios are discussed in the paper:

- The plant pathogen, introduced as a biocontrol agent, successfully suppresses the plant. Its effect is stronger than that of any present endophytes or mycoparasites.
- A protective fungal endophyte inhibits the plant pathogen. Biocontrol fails, and the plant remains an invasive weed.
- A mycoparasite inhibits the plant pathogen. Biocontrol fails, and the plant remains an invasive weed.

Five main challenges were identified from the literature and anecdotal evidence in terms of how the inadvertent introduction of naturally occurring fungal antagonists potentially contributes to the varying establishment and success of intentionally released fungal weed biocontrol agents: reduced infection pressure in the field, potentially affecting agent efficacy and the ability to keep the agent alive; reduced inoculum availability during spore production, affecting the ability to complete laboratory and glasshouse tests; reduced inoculum safety, due to inability to produce mycoparasite-free cultures for testing in the invaded range; reduced efficacy, due to potential accumulation of native mycoparasites in the invaded range; and reduced impact in the field, due to accumulation of the native pathogen.

The authors concluded that these naturally occurring endophytic fungi and mycoparasites may well contribute to the reduced success of intentionally introduced fungal biocontrol agents. A lack of actual evidence highlights the need for the collection and publication of plant-associated and mycoparasitic taxa. Investigations of the how the antagonists infect their fungal hosts, their host range, and their response to abiotic factors will ultimately improve our understanding of the interactions between the target plants, biocontrol pathogens, and potential antagonists that can disrupt successful biocontrol.

Further reading: Den Breeyen A, Lange C, Fowler SV 2022. Plant pathogens as introduced weed biological control agents: could antagonistic fungi be important factors determining agent success or failure. Frontiers in Fungal Biology. doi: 10.3389/ffunb.2022.959753.

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Autumn Activities


Galls of the broom gall mite

Gall-forming agents

- Check broom gall mite (*Aceria genistae*) sites for signs of galling. Very heavy galling, leading to the death of bushes, has been observed at many sites. Harvesting of galls is best undertaken from late spring to early summer, when predatory mites are less abundant.
- Check hieracium sites, and if you find large numbers of stolons galled by the hieracium gall wasp (*Aulacidea subterminalis*) you could harvest mature galls and release them at new sites. Look, also, for the range of deformities caused by the hieracium gall midge (*Macrolabis pilosellae*), but note that this agent is best redistributed by moving whole plants in the spring.
- Check nodding and Scotch thistle sites for gall flies (*Urophora solstitialis* and *U. stylata*). Look for fluffy or odd-looking flowerheads that feel lumpy and hard when squeezed. Collect infested flowerheads and put them in an onion or wire-mesh bag. At new release sites hang the bags on fences, and over winter the galls will rot down, allowing adult flies to emerge in the spring.
- Check Californian thistle gall fly (*Urophora cardui*) release sites for swollen deformities on the plants. Once these galls have browned off they can be harvested and moved to new sites (where grazing animals will not be an issue), using the same technique as above.
- Look for swellings on giant reed (*Arundo donax*) stems caused by the giant reed gall wasps (*Tetramesa romana*). These look like small corn cobs on large, vigorous stems, or like broadened, deformed shoot tips when side shoots are attacked. Please let us know if you find any, since establishment is only known from one site.

Honshu white admiral (*Limenitis glorifica*)

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

Privet lace bug (*Leptoypha hospita*)

- Examine the undersides of leaves for the adults and nymphs, especially leaves showing signs of bleaching.
- If large numbers are found, cut infested leaf material and put it in chilly bin or large paper rubbish bag, and tie or wedge this material into Chinese privet at new sites. Aim to shift at least 1,000 individuals to each new site.

Tradescantia leaf, stem and tip beetles (*Neolema ogloblini, Lema basicostata, N. abbreviata*)

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

Tradescantia yellow leaf spot (*Kordyana brasiliensis*)

- Look for the distinctive yellow spots on the upper surface of the leaves, with corresponding white spots underneath, especially after wet, humid weather.
- The fungus is likely to disperse readily via spores on air currents. If human-assisted distribution is needed in the future, again you will need permission from MPI to propagate and transport tradescantia plants. These plants can then be put out at sites where the fungus is present until they show signs of infection, and then planted out at new sites.

Tutsan moth (*Lathronympha strigana*)

- Look for the small orange adults flying about flowering tutsan plants. They have a similar look and corkscrew flight pattern to the gorse pod moth (*Cydia succedana*). Look, also, for fruits infested with the larvae. Please let us know if you find any, as establishment is not yet confirmed.
- It will be too soon to consider harvesting and redistribution if you do find the moths.

Woolly nightshade lace bug (*Gargaphia decoris*)

- Check release sites by examining the undersides of leaves for the adults and nymphs, especially leaves showing signs of bleaching or black spotting around the margins.
- It is probably best to leave any harvesting until spring.

National Assessment Protocol

For those taking part in the National Assessment Protocol, autumn is the appropriate time to check for establishment and/or assess population damage levels for the species listed in the table below. You can find out more information about the protocol and instructions for each agent at: www.landcareresearch.co.nz/publications/books/biocontrol-of-weeds-book

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Target	When	Agents
Broom	Dec–April	Broom gall mite (*Aceria genistae*)
Lantana	March–May	Leaf rust (*Prospodium tuberculatum*) Blister rust (*Puccinia lantanae*)
Privet	Feb–April	Lace bug (*Leptoypha hospita*)
Tradescantia	Nov–April	Leaf beetle (*Neolema ogloblini*) Stem beetle (*Lema basicostata*) Tip beetle (*Neolema abbreviata*)
	Anytime	Yellow leaf spot fungus (*Kordyana brasiliensis*)
Woolly nightshade	Feb–April	Lace bug (*Gargaphia decoris*)