Weed Biocontrol

WHAT'S NEW?

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Contents

Key contacts

EDITOR: Lynley Hayes
Any enquiries to Lynley Hayes
hayesl@landcareresearch.co.nz

THANKS TO: Ray Prebble
LAYOUT: Cissy Pan

CONTRIBUTIONS: Alison Evans

COVER IMAGE: Tusan beetle

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Final Phase for Tutsan Project

After more than a decade of research and enthusiastic volunteer input, the tutsan project is now reaching its final phase. "This project has produced several new science discoveries and has been of considerable interest to both farmers and other researchers around the world," said Hugh Gourlay, who has led the project. "Much of the success of this project has been due to the strong collaboration between the Tutsan Action Group (TAG) and their communities. This helped to secure the necessary co-funding and co-operation from farmers and land managers," said Hugh.

It all started in 2007 with a group of farmers who were concerned about the growing problem with tutsan (*Hypericum androsaemum*) in the central North Island, which led to the formation of the TAG. Their first key milestone was gaining funding from the Sustainable Farming Fund (SFF) to support a study into whether biocontrol of tutsan might be feasible. This study found that surveys of the plant in the native range were needed, since the natural enemies of tutsan were generally not well known. The TAG then successfully applied to SFF for funds to do these surveys, and CABI-Switzerland got this work underway in Europe in 2010. Research undertaken by MSc student Elena Olsen suggested that the centre of origin for tutsan in Europe is Georgia, in the Caucasus. This meant that surveys in Georgia were especially important, since the centre of origin is where the richest diversity of natural enemies can be expected, in addition to surveying other parts of Europe where tutsan is common.

One natural enemy of tutsan was well known, having been present in New Zealand since the 1950s. Tutsan rust (*Melampsora hypericorum*) appears to be controlling tutsan in the South Island, where the plant is not invasive, but not in the North Island. Molecular studies have shown that there are two main strains of the rust present in New Zealand, with one type in the South Island and the other in the North Island. (Stewart Island has both.) Also, four genotypes of tutsan are present in New Zealand, although two of these are rare (see map). The two common genotypes, like the rust, are mainly divided between the North and South Islands. In Europe eight tutsan genotypes were found and four rust genotypes, including the two found here. "Testing was undertaken to see if the two new rust genotypes identified might be useful, but unfortunately the North Island tutsan genotype was found to be resistant to all of the rust strains found in Europe," explained Hugh. This helps to explain why tutsan is problematic in the North Island but not in the South.

The surveys also looked for insects, and two with good potential were found. The larvae of the tutsan moth (*Lathronympha strigana*) feed on shoot tips and inside stems, reducing plant growth. The larvae also feed inside the fruits, destroying the seeds. Both the adults and larvae of the tutsan beetle (*Chrysolina abchasica*) feed on the leaves and can strip the foliage. A third successful SFF application by the TAG allowed these insects to be host-range tested and approved for release in New Zealand, followed by mass-rearing and the first field releases of both in 2017.

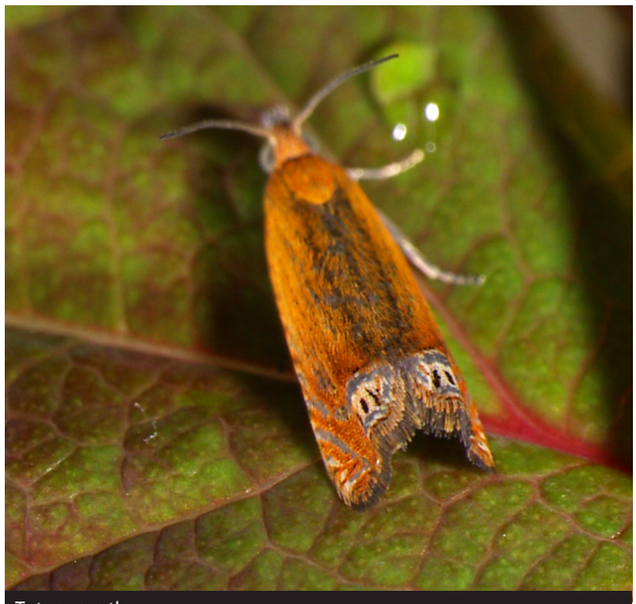
"We have had some issues with a microsporidian disease appearing in our tutsan moth-rearing colony. It was a bit perplexing as routine testing (including molecular tests) after shipments of the moths were imported would show that moths were disease-free, but later, when testing was done prior to gaining permission to release them from containment, the disease would be found", said Hugh. After further investigation we now believe that the disease is most likely being introduced to the moths post-border rather than the moths bringing it with them undetected. Native and unwanted pest leafrollers, which do commonly frequent tutsan, have microsporidian diseases and it seems likely that the tutsan moths are catching the disease when fed foliage grown outdoors. Such diseases have been poorly studied, and more work is needed to confirm this. Also, time will tell whether the establishment success and effectiveness of

the moth, which has now been released widely in the central North Island, will be affected. However, leafrollers commonly reach pest populations despite have microsporidian diseases, and so the impact on the tutsan moth may not be significant.

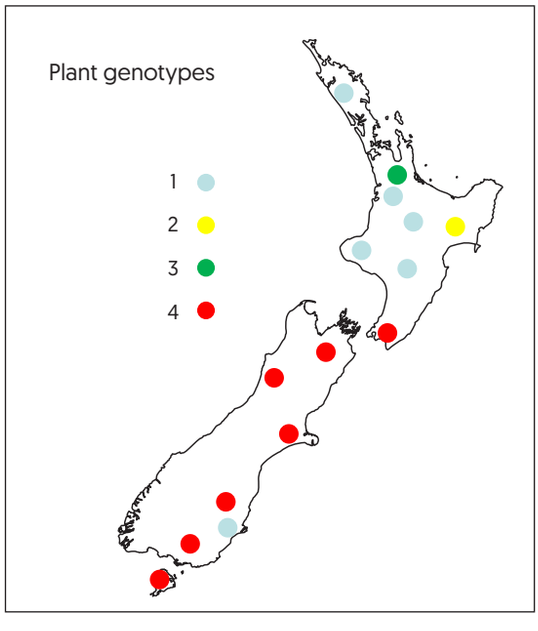
The tutsan beetle proved quite difficult to rear. This beetle is unusual in that adult females usually produce larvae directly rather than eggs. However, eventually enough beetles were produced to make releases at about a dozen sites. The beetle is closely related to the highly successful St John's wort beetles (*Chrysolina* spp.), and it is hoped they will be able to deliver a similar result.

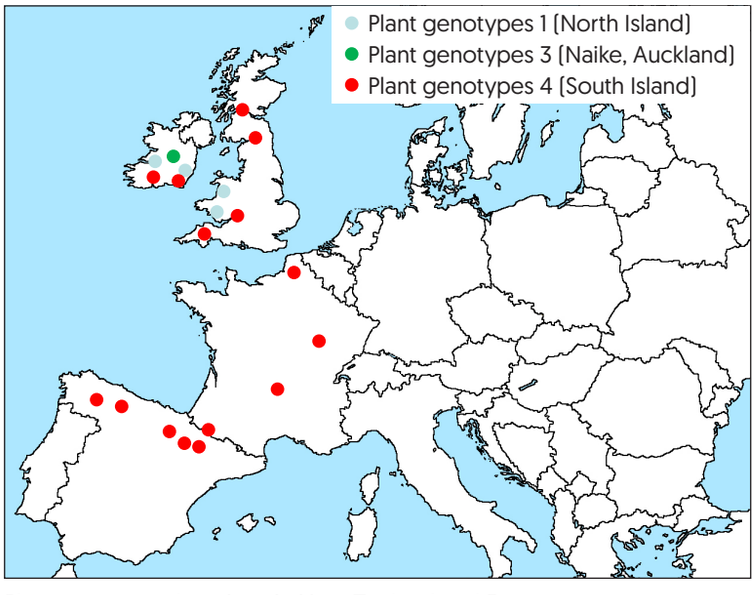
While the final SFF project is now officially drawing to a close, the work will not end there. Monitoring of the establishment success of the tutsan agents will continue with the help of TAG members, and there will be some work required to help spread them around to all areas where they are needed. Manaaki Whenua – Landcare Research will also be continuing to undertake some field experiments with the tutsan beetle. In laboratory host-range tests the beetles were able to utilise two native *Hypericum* species. However, they did poorly on these native plants and the evidence overwhelmingly suggests that the beetles will not attack them in the field (i.e. it is a lab-testing artefact). However, as per current best practice, where there is any potential for non-target attack this is always closely followed up.

A huge thanks to the members of the Tutsan Action Group for their efforts, and to the organisations who supported them. Thanks also to the Ministry for Primary Industries for awarding the three Sustainable Farming Fund grants that made this project possible. Follow-up work on the field host range of the tutsan beetle and origins of the microsporidia in tutsan moth is being funded by the Ministry of Business, Innovation and Employment as part of Manaaki Whenua – Landcare Research's Beating Weeds programme.


Tutsan moth

CONTACT
Hugh Gourlay – gourlayh@landcareresearch.co.nz
or from May until September
Arnaud Cartier – cartiera@landcareresearch.co.nz





Plant genotypes locations in New Zealand and Europe.

Twists and Turns for Banana Passionfruit

In New Zealand the term 'banana passionfruit' is used to refer to a group of vigorous vines that grow up to 10 m tall and originate from the high Andes of South America. The species of concern all have edible fruits and belong in the same sub-genus, *Tacsonia*. The three most problematic species, and the regions where they are most commonly found, are: *Passiflora tripartita* var. *mollissima* (Wellington, Nelson and Marlborough), *P. tripartita* var. *azuayensis* (Wellington, Canterbury and Otago), and *P. tarminiana* (northern North Island). Less widespread species, but also of concern since they are spreading, include *P. mixta* (Auckland and Marlborough), *P. pinnatistipula* (Canterbury and Otago), *P. ´rosea* (Banks Peninsula), and *P. antioquiensis* (Auckland and Marlborough).

Banana passionfruit species have naturalised in New Zealand relatively recently, and in a short period of time have become serious weeds of native bush (particularly forest margins and gaps), roadsides and waterways, especially in moist, frost-free, lowland and coastal areas of New Zealand. Banana passionfruit is spread locally by rats, possums, pigs and birds feeding on the fruits, and humans can be responsible for long-distance dispersal. Control is difficult using conventional methods. Cutting the vines and applying herbicide treatment is time consuming and can cause damage to non-target plants, and the plants can quickly regrow from small fragments.

The first efforts to explore biocontrol for banana passionfruit in New Zealand began with a feasibility study in 1999. This study identified the need to find agents that could reduce the vigour and spread of weedy passionfruit species without harming our native passionfruit, kōhia (*P. tetrandra*) or the commercially grown black passionfruit (*P. edulis*). "Fortunately kōhia and black passionfruit are in different sub-genera, *Tetrapathaea* and *Passiflora* respectively, to the weedy species," explained Hugh Gourlay, who has been leading this project. Also a number of potential agents had been identified for Hawai'i, where banana poka, as it is known there, is also a problem weed. But the project has proven much more challenging than ever expected, for a number of reasons.

A fungus (*Septoria* sp.), which has been used with some success in Hawai'i, was tested and ruled out in 2005, since it was able to attack black passionfruit. Attention then turned to two moth species. The first of these, the passionfruit moth *Glyphodes perelegans* (formerly *Pyrausta perelegans*), is reported to be a major pest of banana passionfruit in its native range, with its larvae destroying a high proportion of flower buds, shoot tips, and young fruits. Female passionfruit moths lay eggs on the foliage, and the resulting larvae burrow into the shoot tips. Larger larvae tunnel into the flower buds and fruits. This moth has been released in Hawai'i but has not become abundant there, which is believed to be due to heavy attack by parasitoids. Parasitism was expected to be less of an issue in New Zealand since the main parasitoids that attack the moth in Hawai'i are not present here, and there is no ecological equivalent for the passionfruit moth in New Zealand, which also reduces the risk. The other moth is a stem borer (*Odonna passiflorae*), about which relatively little was known as it is not widespread in its native range, and so the passionfruit moth was prioritised for study.

With the help of collaborators in Colombia (Victoria Barney and Martha Rojas), several shipments of the passionfruit moth were sourced for testing in the early 2000s. The process of gaining permits and shipping the moths to New Zealand proved to be fraught and uncertain. Finally, in 2006 a healthy shipment was received when Vicki delivered it by hand. Hugh was also able to bring back another shipment in 2010. However, the moth proved challenging to test, producing inconsistent results, and it appeared to be one of those species that becomes confused under confined conditions and unable to discriminate between hosts and non-hosts in the usual way. It seemed that a more natural field trial in Colombia would be the only way forward, and again our Colombian collaborators agreed to help.

There were many challenges in successfully shipping and establishing kōhia plants in South America, with only four plants eventually establishing successfully at the site. They have also grown slowly, and after nearly a decade have not yet produced flowers. However, on the bright side there has been no sign of them being attacked by the passionfruit moth. Conveniently, the field site turned out to also have stem-boring moths present, which provided the opportunity to see if they would attack kōhia (which they haven't).

"In 2018 the risk of relying on just four kōhia plants to conclusively prove the passionfruit moth was safe felt like too risky a strategy," explained Hugh. The plants could potentially be lost in a severe storm, and also over the years there have been times when the site has been unsafe to visit due to political tensions, which means continued access cannot be guaranteed. So a decision was made to attempt further indoor testing in New Zealand using larger cages and natural light. Hugh Gourlay travelled to Colombia once again in November 2018 and brought back a shipment of the passionfruit moth. Disappointingly, this time the moths failed to lay fertilised eggs. We reviewed the possible reasons for this failure, but no obvious cause could be determined (see table).

"At that point we also reviewed priorities for the project in light of the results emerging from the field trial," explained Hugh. The stem-boring moth has killed many large *P. tarminina* plants at the trial site, and replacement plants are now beginning

Some common reasons moths won't mate in captivity*

Stress	Some species lose interest in pairing if handled too much.
Artificial light	The biological clock of moths is regulated by the day/night cycle. Artificial light can disturb their biological clock, causing desychronised periods of activity or inactivity.
Apathy	Refusal to mate is seen in adults that hatch from cocoons shipped over a large distance: the stress and shock from postage/transport can lead to developmentally impaired adults. Apathetic adults can also be produced when caterpillars are raised on an unusual diet that lacks the specific compounds they need to produce pheromones.
No ventilation	Males are unable to find the females because the whole room or container is filled with the females' pheromones.
Insufficient temperature/ lighting	Most moths are not picky and will pair in a dark room in front of a window at room temperature. But some have specific needs, such as a high degree of humidity, UV light or specific temperatures.
Intensity of pheromone	Some moths have populations that live in very low densities and find each other using more concentrated or stronger pheromones. These species are prone to 'sensory overload' if not given a lot of space and ventilation.

* adapted from https://breedingbutterflies.com

to suffer the same fate, while kōhia remains unharmed. It is now becoming clear that the stem-boring moth is much more damaging than the passionfruit moth and is potentially a more useful agent. More work is needed to understand the life cycle and ecology of the stem-boring moth, and to develop rearing techniques to allow host-range testing to be undertaken. The larvae appear to be long-lived and are likely take a year to complete development. We have now asked our Colombian collaborators to undertake some studies to learn more about this moth, and we hope to be able to import a shipment for host-testing around the middle of 2020.

If the stem-boring moth proves to be a suitable agent for New Zealand, some consideration has been given as to what might best complement it. The stem borer has the potential to kill large, mature vines, but younger, smaller plants might still manage to flower and make fruits before being attacked. So currently the top prospect for a second agent appears to be a fly (*Dasiops caustonae*), which damages the seeds inside pods. This fly was discovered by a PhD student, Charlotte

Victoria Barney

Field site in Colombia, where it has been necessary to replant *Passiflora tarminiana* plants after the original ones were killed by a stem-boring moth (inset above).

Causton, in the 1990s. She rated its potential highly but it has not been studied since. It is anticipated that further studies of the fly will be undertaken as funds for the project permit. For now a decision has been made to put further work with the passionfruit moth on hold, but this could be revisited in the future if the stem-boring moth and the fly prove to be unsuitable.

This project is funded by the National Biocontrol Collective.

CONTACT
Hugh Gourlay – gourlayh@landcareresearch.co.nz
or from May until September
Lynley Hayes – hayesl@landcarerearch.co.nz

A Green Solution for a Gold Problem

An Australian plant, Sydney golden wattle (*Acacia longifolia*), is the focus of a proposed application to the Environmental Protection Authority (EPA) for approval to release two new biocontrol agents into New Zealand. The application is expected to be submitted by the Northland Regional Council (NRC) later this year, following consultation with stakeholders. Richard Hill, a research associate with Manaaki Whenua – Landcare Research, is assisting NRC to prepare this application.

Sydney golden wattle (SGW) is a shrub that can reach 10 m tall. It grows particularly well in dune ecosystems, where it forms dense, shady stands that displace native species and increase fire risk. Like so many other weeds here, it was introduced as an ornamental plant in the late 1800s. Although not considered a major problem in New Zealand yet, SGW has the potential to occupy many coastal habitats and it is steadily getting worse. The Department of Conservation has invested considerable effort to reduce its prevalence in the nationally significant Kaimaumau swamp in Northland. SGW is also a problem in new pine plantations on Matakana Island (Bay of Plenty) and in the far north, at Muriwai (Auckland), and in dunes near Wanganui and Levin. SGW grows as far south as Christchurch, and is now considered too widespread to control manually. "Biocontrol seems to be the only way now to prevent the adverse effects of SGW spreading widely through coastal areas of the North Island," said Richard.

As its name suggests, SGW is native to Australia but it is weedy in a number of countries, especially South Africa and Portugal. This shrub was introduced into South Africa around 1827 with the aim of stabilising drift sands on the Cape flats, but it became a major weed, invading the delicate and unique 'fynbos' vegetation as well as mountain and river ecosystems. There was some resistance to the release of biocontrol agents in South Africa, as wattles (*Acacia* species) are commonly used as a source of wood and tannins. "As a compromise two agents were introduced in the 1980s that just attack the reproductive structures," explained Richard. The gall-forming wasp (*Trichilogaster acaciaelongifoliae*) and seed-feeding weevil (*Melanterius ventralis*) proved highly effective and hence are now being considered for release in New Zealand. The wasp has also more recently been released in Portugal.

The gall wasp creates golfball-sized galls in the flower buds, preventing flower production, while the weevil larvae finish the job by destroying the seeds in those few pods that escape gall wasp attack. Working together, these two agents limit seed production in South Africa by over 90%, and galling by the wasp is often so severe that it causes the whole SGW plant to die. The success of the agents appears to be closely associated with climate. The performance of the wasp can be negatively affected by long, dry periods with high temperatures, which result in desiccation of the eggs. The performance of the seed-feeding weevil in South Africa is dictated by the short period of time the seed pods exist on the host plant (allowing only one generation of weevils per year), as well as the success of the gall wasp at destroying the flowers. "Conditions in New Zealand appear to suitable for both insects," confirmed Richard.

Comprehensive host-range testing prior to the introduction of these agents to South Africa and Portugal means that no further testing for New Zealand is required. Although they belong to the same family, New Zealand's native legumes are only remotely related to the acacias. There are a number of exotic *Acacia* species grown as ornamentals. *Acacia melanoxylon* is the only species grown commercially here, but it makes up <2% of forest plantations. There is strong evidence to suggest that the risk these insects pose to non-target, economic or ornamental legume species here is negligible. If approval to release these agents in New Zealand is granted by the EPA, it is anticipated that both agents will be imported into containment late next year and released shortly thereafter.

Funding to support this project is being provided by the Northland Regional Council and a Medium Envirolink Advice Grant (NLRC213). For more information about this project and the EPA approval process see: https://www.landcareresearch.co.nz/science/plants-animals-fungi/plants/weeds/biocontrol/approvals/current-applications/sydney-golden-wattle

CONTACT
Richard Hill – hillr@landcareresearch.co.nz

Richard Hill

Severe dieback in a 10 m tall Sydney golden wattle tree in South Africa resulting from heavy galling of flower buds by the gall wasp.

Two Steps Forward and One Back for Wild Ginger Project

Despite the efforts of regional councils and volunteer community groups around the country, wild ginger (*Hedychium gardnerianum*) remains one of the biggest threats to regenerating native forest in the North Island. "So far over 5,000 ha of land are thought to be affected by wild ginger in Northland, including pine forests, which are a valuable economic resource for the region," said Ashlee Lawrence, of the Northland Regional Council. "We have a dual problem because the weed not only invades open areas but is sufficiently shade tolerant to supress any regeneration beneath closed forest canopies, creating large zones where the entire understorey is ginger," she said. The rhizomes of the weed make the ground impenetrable, so that native birds such as kiwi have a difficult time probing for food. The enormous scale of the infestation across the region makes widespread control unfeasible in forested areas. In 2016 the Northland Regional Council formed the Stop Wild Ginger Group (SWGG) to raise public awareness of the threat of wild ginger to northern forests, and to seek better control tools.

A project to develop biocontrol for wild ginger began back in 2008, funded by the National Biocontrol Collective and a consortium of sponsors from Hawai'i. Initially the project went well, with CABI-UK, who were contracted to do the work, finding a number of natural enemies during surveys in India that seemed to have potential as biocontrol agents. Of particular interest was a shoot-mining fly (*Merochlorops* cf. *dimorphus*) and a large red-and-black weevil (*Metaprodioctes trilineata*) that feeds on almost all parts of the plant. However, with the host-range testing of these insects tantalisingly close to completion, the project essentially had to go on hold for several years. Authorities in India required new paperwork and agreements to be drawn up to allow the collaborative project work to continue while conforming with central Indian Government guidelines relating to the fair and equitable sharing of benefits arising from the utilisation of genetic resources.

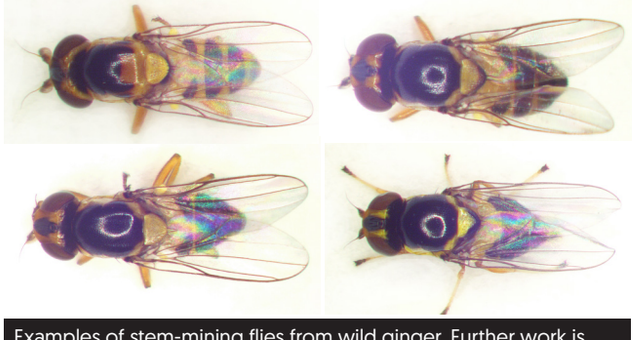
However, in 2018 the paperwork was finally sorted and the way was clear for the project to resume under a 3-year collaborative agreement with the Indian Council of Agricultural Research. Around the same time the SWGG successfully applied for funds from the Ministry for Primary Industries' Sustainable Farming Fund to support the development of biocontrol for wild ginger. So with strong new funding secured for the next 3 years and work able to get under way again in India, the disappointments of previous years appeared to be behind us. However, as so often happens in weed biocontrol projects, it wasn't long before a fresh challenge arose.

"It turns out that the stem-mining fly is not a single species but likely two (or more) cryptic species which cannot be reliably identified by morphological features," explained Djami Djeddour of CABI. More studies are needed, including molecular work, to get to the bottom of this. One of the flies has definitely been shown to have too wide a host range to be considered as a biocontrol agent. The other, which is probably new to science, is potentially more specific but it is not clear whether this one is able to attack kahili ginger from New Zealand and Hawai'i, which has been shown to be a hybrid between *H. garderianum* and *H. coronarium*.

"The failure of the 'new' flies to successfully attack this hybrid material in tests could just be due to not having the right sex ratio," explained Djami. Infested stems are collected in India, and once the flies emerge they are used for testing. However, the flies are difficult to sex and possibly emerge asynchronously (males first, followed by females). So the question of whether the more specific fly can attack the kahili ginger hybrid still needs to be resolved. "If the fly cannot attack it then efforts will instead focus on other agents such as hispine beetles and several defoliating moths," explained Ashlee of the SWGG. If it turns out the stem-mining fly can attack our wild ginger, then all the host testing will need to be repeated with a culture that is known to consist of only this species. Meanwhile work is also continuing shortly with the weevil.

For more information about the Stop Wild Ginger Group, see www.stopwildginger.co.nz. Co-funding for this project is also being provided by forestry companies and territorial authorities in Northland, Manaaki Whenua – Landcare Research, and the National Biocontrol Collective.

CONTACT
Hugh Gourlay – gourlayh@landcareresearch.co.nz
or from May until September
Arnaud Cartier – cartiera@landcareresearch.co.nz



CABI

Examples of stem-mining flies from wild ginger. Further work is needed to understand how subtle variation in morphology aligns with two or more cryptic species.

Butterflies go West

In February, Paroa School and Greymouth High School were lucky enough to have a visit from our very own Hugh Gourlay and Murray Dawson, and independent educator Robinne Weiss. The trip was made possible by the Guardians of Paroa Taramakau Coastal Area Trust, who are undertaking important restoration work in Westland. Since Japanese honeysuckle (*Lonicera japonica*) is a key weed threatening their work, the Trust applied for, and secured, Curious Minds funding to allow the Honshu white admiral butterfly (*Limenitis glorifica*) to be released there. Although the butterflies, which are native to Japan, have been released elsewhere around New Zealand, these were the first releases in the Westland area.

"When Fran Cohen from the Trust contacted us, she suggested that we release the white admiral on Japanese honeysuckle growing in the area in conjunction with a local primary and a high school," said Hugh. This was a great opportunity for the students to put into action some of the things they had been learning about. It also extended the reach of another Curious Minds project called The Great Weeds Hunt Aotearoa, which has been raising awareness about weeds and how to identify them with school-aged children in Auckland and Canterbury.

"Working with schools and local communities to release new biocontrol agents provides an opportunity to expose people to the science behind biocontrol and fosters local ownership and monitoring of the releases," said Hugh. "As well as participating actively in the first regional releases of this Japanese honeysuckle biocontrol agent, the students were also able to engage directly with environmental scientists from Manaaki Whenua – Landcare Research," said Fran.

"The Trust and Paroa School have been actively working to restore biodiversity near the school and it was great to be able to raise students' awareness of invasive weeds and involve them in natural weed control methods," said Murray. Day one began with a visit to Paroa School, where Robinne led the students through some weedy puzzles and activities, before Hugh spoke about biocontrol and passed around a container of the spectacular butterflies. Then in the afternoon more than 1,000 white admiral caterpillars were released by the students onto Japanese honeysuckle growing just over the fence from the school playground. This was followed by the students learning how to use the iNaturalist app to document plants growing in and around the school grounds. About 50 plant species were detected around the school grounds, with two invasive plants, tree privet (*Ligustrum lucidum*) and arrow bamboo (*Pseudosasa japonica*), also found nearby. A wide variety of other weeds were also reported, which included the usual culprits, gorse (*Ulex europaeus*) and blackberry (*Rubus fruticosus* complex).

The following day Hugh guided Greymouth High School Year 12 biology students through PowerPoint presentations on the science behind biocontrol, the methods of finding and collecting suitable agents from their native ranges, rearing them in containment, and host-range testing. He also emphasised the economic benefits of biocontrol programmes. The Trust also did a presentation about their organisation, weed-busting, and options for control. "It is the first time our Trust has worked with Greymouth High School students, and we are thrilled to have gained the funding to make this project possible," said Fran. Then it was time for these older students to release their caterpillars at a site not far away from Paroa School, and to learn about the local weeds and native plants.

Provided the conditions prove to be suitable, it is hoped that the butterflies will establish and eventually reduce the incidence of Japanese honeysuckle in Westland to the benefit of native vegetation in restoration plantings and more widely. The students will be able to observe when the next generation of adult butterflies emerge, and to monitor the damage of successive generations of caterpillars, as well as, over time, the recovery of the native vegetation.

During the visit Hugh also took the opportunity to speak to the local Rotary group about his work with collecting and rearing biocontrol agents, both overseas and in New Zealand.

Curious Minds Funding is made available by the Ministry of Business, Innovation and Employment to help New Zealanders to be more connected with science. For more about the projects described above, see: https://www.landcareresearch.co.nz/information-for/citizen-science/weeds/about .

CONTACT
Murray Dawson – dawsonm@landcareresearch.co.nz

Hugh explains how the white admiral caterpillars are going to be released.