WHAT'S NEW IN

Biological Control of Weeds?

Issue 68 May 14

Trichilogaster acaciaelongifoliae galls on *Acacia longifolia*

John Hoffmann

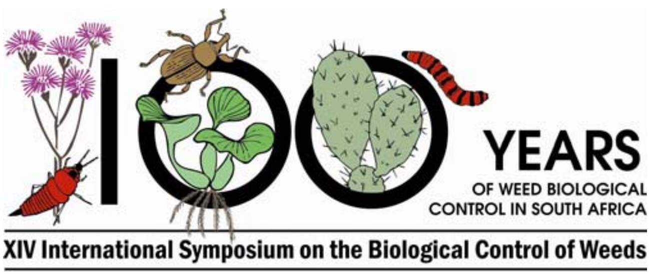
What's Inside?

Landcare Research
Manaaki Whenua

International Weed Biocontrol Symposium

In March around 155 weed biocontrol practitioners from 24 countries descended on Kruger National Park, South Africa, for the 14th International Symposium on Biological Control of Weeds (ISBCW). Despite the drawcard location, the number attending was down on previous events, as around the world the current economic climate is requiring most science organisations to reduce expenditure. However, for those who were able to attend, the symposium was a memorable experience, and as always was an important forum for refining international best practice and developing new collaborations. Since classical weed biocontrol projects always involve an overseas component of work, and weeds come from all over the globe, international collaboration is critical. The symposium is normally held every 4 years, but was moved a year forward this time to coincide with the 100-year anniversary of weed biocontrol in South Africa (see *South Africa Scores a Century*, pg 5). We have another 11 years to go in New Zealand before we hit this milestone.

Although New Zealand is a small country, with a modest budget for weed biocontrol, it continues to more than hold its own on the international stage, and our people were again given a number of speaking slots. Lynley Hayes chaired the first session of the conference, which dealt with exploring new biological control possibilities. This session included 3 oral papers and 12 rapid-fire poster presentations – a good way of covering a lot of material in a short time! On day two Mike Cripps (AgResearch) spoke about recent breakthroughs in working with the rust *Puccinia punctiformis* on Californian thistle (*Cirsium arvense*) (we covered this story in *Issue 64* of this newsletter). We also heard that CABI China have undertaken surveys in northwest China, an area that has previously received little attention, to look for additional potential biocontrol agents for Californian thistle. They have found a fungus, *Pustula spinulosa*, that they believe offers potential. This white blister rust attacks the leaves, stems and flowers, and preliminary host-testing suggests it might be suitable for New Zealand if additional agents are required (provided our populations prove to be susceptible). Next Hugh Gourlay outlined the international effort to develop biocontrol for tutsan (*Hypericum androsaemum*) in New Zealand (covered in *Issue 66*). Earlier we heard from Elena Olsen, the student attached to CABI-Switzerland who has been undertaking surveys to look for potential biocontrol agents for tutsan in Europe. She reported that none of the additional strains of the tutsan rust (*Melampsora hypericorum*) found in Europe to date appear to offer better control options for North Island tutsan populations, which appear to have some resistance to them. So, for now, insect agents appear to offer the best prospects for improving tutsan control. After the conference we heard that the Tutsan Action Group has been successful in their application to the Ministry for Primary Industries' Sustainable Farming Fund for support to test, import and release potential new tutsan agents.



On day three Quentin Paynter gave two papers. In the first Quent shared his newly created risk index, which will hopefully in the future be able to assist regulatory authorities to assess the risk of approving new agents that show some ability to potentially use non-target plants (see *Data Diving Provides Pearls of Wisdom*, pg 8). Later that day Quent presented data showing that broom (*Cytisus scoparius*) seeds in New Zealand are substantially bigger on average than broom seeds in Europe, and as a consequence broom seed beetles (*Bruchidius villosus*) are also larger in New Zealand. We will explain what these findings mean for broom biocontrol in the next issue of this newsletter. Also, Simon Fowler gave a paper outlining the discovery of *Liberibacter* in broom in New Zealand (which we covered in *Issue 64*) and subsequent research that has determined this disease likely came in with the broom psyllid (*Arytainilla spartiophila*). The consequences of the introduction of this disease to New Zealand are still being evaluated but fortunately do not appear to be serious. However, this discovery will have ongoing ramifications for the use of phloem-feeding insects like psyllids. Molecular tools are now available to detect whether potential biocontrol agents are carrying unwanted organisms like *Liberibacter*, which could potentially be transferred and cause harm to other hosts. However, it remains to be seen if it would be possible to rid the insects of their unwanted companions and make them safe to release. Finally on day three, Sarah Dodd, en route to Ghana to undertake African tulip tree (*Spathodea campanulata*) surveys, outlined the new 5-year programme to develop biocontrol for serious weeds in the Cook Islands (covered in *Issue 67*).

On the final day of the conference Ronny Groenteman spoke about her work to determine whether St John's wort beetles

(*Chrysolina* spp.) provide effective control of St John's wort (*Hypericum perforatum*) (see *Whodunnit? Solving the Case of the Disappearing St John's Wort*, pg 7).

Overall there were mixed feelings about how biocontrol is going worldwide. In South Africa and Europe biocontrol is booming. South Africa has overcome regulatory issues experienced during the 2000s, and the European Union, after years of being uncertain how to deal collectively with invasive species or regulate biocontrol activities, is now getting its act together. Other countries like Brazil are taking the first steps towards developing their own weed biocontrol projects, after years of assisting other countries to find agents for weeds of Brazilian origin. Developing countries like Indonesia are also keen to explore biocontrol opportunities. However, other countries like Australia, the USA, and those in east Africa are struggling with capacity, funding or regulatory issues. Australia at the height of its weeds research capacity in the 1980s and 1990s had around 30 scientist FTEs and is now down to just 7.5. The retirement of a number of key scientists (some of whom paid their own way to attend the symposium), the ending of the Weeds Co-operative Research Centres, disinvestment in the Weeds of National Significance Scheme and winding back of the National Weeds Strategy, plus a succession of conservative governments, combined with less enthusiasm for environmental projects and less familiarity with biocontrol by regulators, have all taken their toll. The loss of skills and capacity in Australia is serious and likely to result in an increased need to pool resources and rely on the efforts of other countries. New Zealand currently appears to be holding its own, producing excellent underpinning science and developing many new agents, ably supported by an excellent regulatory system and some very supportive end-users. But funding remains tight and is not guaranteed, and we need to remain on our guard that our capacity to undertake weed biocontrol is not gradually eroded.

Below are some summaries of projects of special interest to New Zealand.

Fireweed (*Senecio madagascariensis*)

A project to develop biocontrol for fireweed (*Senecio madagascariensis*) in Australia has identified KwaZulu-Natal, South Africa, as the best place to look for agents, so CSIRO and the University of KwaZulu-Natal have joined forces to work on it. Fireweed is toxic to livestock and reduces farm productivity. Recent surveys in South Africa found 64 insect herbivore species feeding on the plant. Of these the most promising ones identified for further study include a fly and moth that reduce seed production, four stem-borers, a foliage-feeding lace bug and a flea beetle that possibly has root-feeding larvae. These potential agents will be studied further. Australia has a diverse native *Senecio* flora so

Doug Foster

Fireweed in on the increase in Northland, New Zealand.

highly-host-specific agents will be required. Hawai'i also has a problem with fireweed, but no native *Senecio* species to contend with, and was recently able to release a defoliating moth (*Secusio extensa*), which is not suitable for Australia.

Fireweed is widespread in New Zealand and beginning to cause concern in some areas such as Northland. The plant is referred to here as gravel groundsel (*S. skirrhodon*) but the taxonomy is complex and not totally resolved. The *S. madagascariensis* complex may include *S. skirrhodon*. A molecular study needs to be undertaken to clarify the identity of New Zealand material, and seeds have been sent to South Africa for this purpose. New Zealand also has native *Senecio* species so highly specific agents would be needed here too. The seeds sent to South Africa will also be used in a common garden experiment comparing introduced (Australian, New Zealand) and native (South African) fireweed populations. This will explore whether there has been a trade-off between growth and dispersal ability against competitiveness and resistance to herbivory (which is hypothesised to result in the rapid evolution of invasiveness). Experiments will also test the efficacy of potential agents. Preliminary results suggest that natural enemies in South Africa are putting some pressure on the plant.

Lagarosiphon (*Lagarosiphon major*)

Researchers from the Biocontrol Research Unit, University College Dublin, made a number of presentations on their work to develop biocontrol for lagarosiphon (*Lagarosiphon major*) in Ireland. The most promising agents they have identified include a leaf-shredding moth (probably *Synclita* sp.), a shoot-mining midge (*Polypedilum* sp.), and a leaf-mining fly (*Hydrellia lagarosiphon*), none of which have been released yet. Studies have been undertaken to see how complementary these three agents might be. These studies showed that fly larval survival was negatively impacted by the moth but not the midge. The fly and the midge appear to have a synergistic effect resulting in cumulative damage. Since lagarosiphon is a serious aquatic weed in New Zealand there is considerable interest in developing the fly and midge for release here as funds permit. The Irish researchers recently agreed to undertake some testing to see if the leaf-mining fly would be suitable to release in

New Zealand, which is expected to be completed mid-year. They have studied the best way to rear this fly as they were finding egg production to be quite low when methods developed for other *Hydrellia* flies (used as biocontrol agents for *Hydrilla verticillata*), involving artificial diets, were used. By experimenting with the components of artificial diets they have come up with a mixture that increases the development and reproduction rates of the fly, allowing the flies to be produced much more quickly and cheaply.

Mexican devil weed (*Ageratina adenophora*)

Mexican devil weed as it is known in New Zealand is referred to as crofton weed in other countries where it has become invasive. The plant was introduced for ornamental purposes, and is generally considered to be a minor weed in New Zealand. It is believed that an introduced gall fly (*Procecidochares utilis*) and leaf blight (*Passalora ageratinae* formerly *Phaeoramularis eupatorii-odorati*) are exerting some level of control, although this has not been formally measured. If additional pressure on this weed is required then other potential agents could be considered. South Africa has recently undertaken additional surveys in Mexico resulting in the collection of 76 species of insects from which a shortlist will be developed for further study. An application to release a rust fungus (*Baeodromus eupatorii*) has, since the conference, been approved by the Australian authorities and it is hoped releases can get underway soon. This rust is highly host specific and damaging, and would require little or no additional testing if there was interest in pursuing it for New Zealand. We also heard from CSIRO that biocontrol of the close relative mist flower (*Ageratina riparia*) has proven to be highly successful in Australia. The white smut (*Entyloma ageratinae*), which did such a good job in Hawai'i and New Zealand, was discovered in Queensland in 2010. The smut spread quickly in Australia causing severe defoliation of mist flower after 5–6 months, and at some sites it was hard to find any mist flower plants at all after 1 year. As in New Zealand, native plants at previously infested sites have been able to quickly recover.

Louise Morin

Mist flower in the Kangaroo Hills, Victoria, before and after establishment of the white smut.

Montpellier broom (*Genista monspessulana*)

Montpellier broom (*Genista monspessulana*), also known as Cape or French broom, forms dense infestations in southern Australia, western North America, Chile and South Africa. While not a major weed in New Zealand currently, there are warning signs that Montpellier broom could become more problematic in coming decades. An accidentally released psyllid (*Arytinnus hakani*) is providing impressive control of Montpellier broom in Australia. CSIRO reports that all stands where the psyllids were released have been decimated, and within a year typically only a few small debilitated plants remain. Once the psyllid has been distributed to all remaining infestations in Australia it is expected that Montpellier broom will be under complete control. In light of the research showing that the broom psyllid (*Arytainilla spartiophila*) brought a species of *Liberibacter* with it to New Zealand, it would be important to show that the Montpellier broom psyllid had no similar association if introduction to New Zealand is considered down the track. Because of concerns that the psyllid could damage native lupins it is not being considered for release in North America, and a weevil (*Lepidapion argentatum*) that attacks the seeds and forms stem galls is being studied instead.

New World Catalogue

The last (5th) version of Julien and Griffiths' *A World Catalogue of Agents and Their Target Weeds* was published in 1998. For many years this was the go-to place to find out what weed biocontrol agents have been released around the world and how successful they have been, but had become seriously out of date. During the past 4 years a team of researchers, led by Rachel Winston, has undertaken a major revision and expansion of this catalogue, which now includes 224 weeds and 552 agents. This was a huge task. Funding was mostly provided by the United States Department of Agriculture's Forest Service. A full online version of the catalogue is expected to be available in June (www.ibiocontrol.org), including a fully query-able database. A shorter print version is also being prepared. Ways to keep the information maintained and up to date are being considered. Note that all previous ISBCW proceedings have been scanned and are now available on this website.

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South Africa Scores a Century

Biocontrol of weeds got underway in South Africa in 1913 with the introduction of a cochineal insect (*Dactylopius ceylonicus*) to combat an invasive cactus called drooping prickly pear (*Opuntia monacantha*). It was to be the start of great things. Drooping prickly pear was within a few years brought to its knees, and has remained under control ever since. This inaugural project gave many the impression that weed biocontrol was quick and easy, when in fact most projects have required years of careful research, with no assurance of success, and a long wait for benefits to be realised. One hundred and six species of biocontrol agents have now been released against 48 plant species resulting in the establishment of 75 species.

“There have been some pretty spectacular successes against a range of weeds but in particular aquatic plants, cacti, and trees have proven amenable to this approach,” concluded John Hoffmann of the University of Cape Town. Because a number of invasive trees in South Africa provide important social and commercial benefits (e.g. firewood, shade, fodder and timber) only agents that target the reproductive structures have been released. “This allows the trees to remain and be used while preventing unwanted spread,” explained the chair of the 14th ISBCW, Fiona Impson. Twelve weeds are now considered to be under complete biological control, and a further 20 are under substantial control (see table pg 6). Cost–benefit analyses confirm that investment in weed biocontrol in South Africa is reaping some remarkable returns. A recent analysis suggested the most modest cost–benefit ratio was a still highly respectable 1:8 for red sesbania (*Sesbania punicea*) with the highest a whopping 1:3726 for perennial invasive Australian trees, with cacti not too far behind on 1:2731.

Just as important as achieving success has been the lack of negative consequences. No significant damage to crop plants or native species has occurred as a result of the released agents. Despite this record of success and safety the South African weed biocontrol programme, like many others internationally, began in the 1980s to suffer from an escalation in exaggeratedly risk-averse attitudes and restrictive political structures and processes for gaining approval to release new agents. This meant that during the past decade the release of new agents nearly ground to a halt. However, fortunately during the centenary year, common-sense has prevailed with key agencies (Department of Agriculture, Fisheries and Forestry; Department of Environmental Affairs, and the South African National Biodiversity Institute) reactivating a peer-review process for assessing release applications. “This has allowed a protracted stalemate to be broken and for new agents to again be approved and released,” confirmed John.

A hallmark of the successful South African biocontrol programme is interagency collaboration and cooperation to make the best use of resources. The Working for Water (WfW) programme (set up to clear catchments of woody vegetation, along with providing social benefits like employment), Plant Protection Research Institute, and South African universities work closely together on weed biocontrol programmes together with local and national conservation bodies. “Quarterly technical liaison meetings, workshops and also a planning meeting attended by 70–100 participants are held annually,” said Fiona. The WfW programme, which provides most of the funds for weed biocontrol activities in South Africa, has recently engaged a new partner to help out. The South African Sugarcane Research Institute, which rears many biocontrol agents for insect pests of sugar cane, has expanded its scope to mass-rear weed biocontrol agents, allowing greater numbers to be produced and released more rapidly. With an estimated 20 million hectares of land in South Africa infested with unwanted plants there is still much to be done. Fortunately increased funding has been made available and overall, as the rainbow nation moves into its second century of weed biocontrol activity, the future appears bright.

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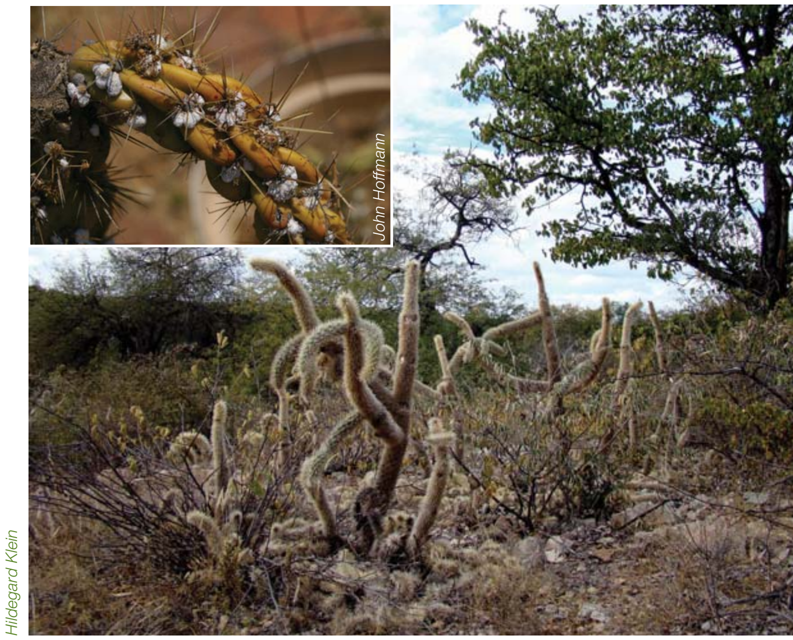

Chain-fruit cholla (*Cylindropuntia fulgida* var. *fulgida*) is one of the cacti under complete control in South Africa since the establishment of a cladode sucker (*Dactylopius tomentosus*) (inset).

	Complete Control	
	Weed	Damaging agents
Aquatics	*Azolla filiculoides* (red water fern)	*Stenopelmus rufinasus* (frond feeder)
	Salvinia molesta (salvinia)	*Cyrtobagous salviniae* (stem borer)
	Pistia stratiotes (water lettuce)	*Neohydronomus affinis* (leaf and stem borer)
Cacti	*Cylindropuntia fulgida* var. *fulgida* (chain-fruit cholla)	*Dactylopius tomentosus* (cladode sucker)
	Cylindropuntia leptocaulis (pencil cactus)	*Dactylopius tomentosus* (cladode sucker)
	Cereus jamacaru/C. hildmannianus (queen of the night)	*Hypogeococcus pungens* (stem sucker), *Nealcidion cereicola* (stem borer)
	Harrisia martinii (harrisia/moon cactus)	*Hypogeococcus pungens* (stem sucker), *Nealcidion cereicola* (stem borer)
	Opuntia monocantha (smooth/drooping prickly pear)	*Cactoblastis cactorum* (cladode borer), *Dactylopius opuntiae* (cladode sucker)
Trees	*Sesbania punicea* (red sesbania)	*Neodiplogrammus quadrivittatus* (stem borer), *Rhyssomatus marginatus* (seed feeder), *Trichapion lativentre* (flowerbud feeder)
Other	*Ageratina riparia* (mist flower)	*Entyloma ageratina* (leaf pathogen)
	Hypericum perforatum (St John's wort)	*Chrysolina quadrigemina* (leaf feeder), *Zeuxidiplosis giardi* (shoot-tip galler)
	Substantial Control	
Aquatics	*Eichhornia crassipes* (water hyacinth)	*Cercospora rodmanii* (leaf pathogen), *Eccritotarsus catarinensis* (leaf sucker), *Neochetina bruchi* and *N. eichhorniae* (stem borers), *Niphograpta albiguttalis* (petiole borer), *Orthogalumna terebrantis* (leaf miner)
	Myriophyllum aquaticum (parrot's feather)	*Lysanthia* sp. (leaf feeder)
Cacti	*Cylindropuntia fulgida* var. *mamillata* (boxing-glove cactus)	*Dactylopius tomentosus* (cladode sucker)
	Cylindropuntia imbricata (imbricate prickly pear)	*Dactylopius tomentosus* (cladode sucker)
	Harrisia bonplandii	*Hypogeococcus pungens* (stem sucker)
	Opuntia aurantiaca (jointed cactus)	*Cactoblastis cactorum* (cladode borer), *Dactylopius austrinus* (cladode sucker)
	Opuntia engelmannii (small round-leaved prickly pear)	*Cactoblastis cactorum* (cladode borer), *Dactylopius opuntiae* (cladode sucker)
	Opuntia ficus-indica (mission prickly pear)	*Cactoblastis cactorum* (cladode borer), *Dactylopius opuntiae* (cladode sucker), *Metamasius spinolae* (stem borer)
	Opuntia salmiana	*Cactoblastis cactorum* (cladode borer), *Dactylopius ceylonicus* (cladode sucker)
	Opuntia stricta (Australian pest pear)	*Cactoblastis cactorum* (cladode borer)
Trees	*Acacia cyclops* (red eye/rooikrans)	*Dasineura dielsi* (flower galler), *Melanterius servulus* (seed feeder) *Melanterius ventralis* (seed feeder),
	Acacia longifolia (long-leaved wattle)	*Trichilogaster acaciaelongifoliae* (bud galler), *Melanterius acaciae* (seed feeder)
	Acacia melanoxylon (Australian blackwood)	*Melanterius maculatus* (seed feeder), *Trichilogaster signiventris* (bud galler)
	Acacia pycnantha (golden wattle)	*Melanterius compactus* (seed feeder),
	Acacia saligna (Port Jackson willow)	*Uromycladium tepperianum* (gall former)
	Paraserianthes lophantha (stink bean)	*Melanterius servulus* (seed feeder)
Other	*Hakea sericea* (silky hakea)	*Carposina autologa* (seed feeder), *Erytenna consputa* (green-seed feeder)
	Lantana camara (lantana) some varieties only	*Aceria lantanae* (flower galler), *Calcomyza lantanae* (leaf miner), *Falconia intermedia* (leaf sucker), *Octotoma scabripennis* (leaf miner), *Ophiomyia camarae* (leaf miner), *Ophiomyia lantanae* (seed miner), *Teleonemia scrupulosa* (leaf sucker), *Uroplata girardi* (leaf miner)
	Solanum elaeagnifolium (silverleaf nightshade)	*Leptinotarsa defecta* (leaf feeder), *L. texana* (leaf feeder)
	Solanum sysimbriifolium (wild tomato/dense-thorned bitter apple)	*Gratiana spadicea* (leaf feeder)

100 YEARS OF WEED BIOLOGICAL CONTROL IN SOUTH AFRICA
XIV International Symposium on the Biological Control of Weeds

Whodunnit? Solving the Case of the Disappearing St John's Wort

Although we are often able to provide simple data showing that weeds decline once biocontrol agents are released, this may not provide sufficiently robust evidence of cause and effect for other scientists reviewing our work. We have to be prepared, sometimes, to demonstrate experimentally that the biocontrol agents are responsible for the decline in weed populations and not other factors. Ronny Groenteman presented a paper at ISBCW about her research to nail the reason for St John's wort *(Hypericum perforatum*) decline in New Zealand, which she has been undertaking for 5 years now. Ronny reminded the audience that it is essential to start with appropriate experimental design so that the results can clearly support or refute a hypothesis, and to be able to analyse the results appropriately. "I then showed how multi-model inference analysis can be used as a framework to demonstrate cause and effect in a biological control programme. This type of analysis provides a more holistic approach," explained Ronny.

When Ronny undertook an insecticide exclusion experiment on St John's wort, she was able to clearly demonstrate that if St John's wort beetles *(Chrysolina hyperici* and *C. quadrigemina*) are removed from the plants using insecticide, the plant recovers and becomes more abundant. But because Ronny also recorded all the factors that could affect the population dynamics of the plant (e.g. rainfall, temperature, disease, insecticide effects, and herbivory by other insects), she was able to gauge how important these factors were in explaining the results. The multi-modelling approach allows us to test the dominance of biocontrol over all other factors," said Ronny. And yes it was the St John's wort beetles that did it!

St John's wort is a good weed to study because the plants grow quickly and there are good numbers of beetles attacking it. Rather than just assuming their presence, Ronny quantified the background number of beetles present. "It is surprising how often biocontrol scientists neglect to document a basic element like biocontrol agent abundance in an experiment. It takes more resources to undertake this type of work but some of the variables such as changes in ground cover are relatively simple to quantify and can be assessed retrospectively from time-sequence photographs," added Ronny.

By using population dynamics modelling to analyse the data, Ronny will be able to identify the most vulnerable life-stage of the plant. This is particularly useful in biocontrol studies because agents that affect the plant at the population level are needed rather than agents that just stunt its growth temporarily. The technique can also be used to predict the responses of biocontrol systems to changes in seasonal weather patterns. For example, beetles (*Lochmaea suturalis*) released to control heather *(Calluna vulgaris)* in the Tongariro National Park can survive heavy snowfall in the winter but die when subjected to pronounced diurnal temperature fluctuations in the spring. Predicting the response of agents and weeds to variable weather conditions can be important. This allows times when additional resources may be required to manage weeds to be flagged, such as when seasonal conditions are forecast to be less suitable for the agents or particularly favourable for the weed. Predicting responses of agents to weather conditions is also vital when selecting suitable source populations for new agents overseas. New Zealand is already renowned for its variable weather, and climate change may add a new dimension to agent selection if biocontrol agents need to be able to survive more extreme weather events in the future.

Ronny admits that the experimental process she is advocating is intensive but encourages others to adopt similar frameworks when designing and conducting their research so that their results are sufficiently robust and transparent enough to show clear cause and effects of the agents on the target weed. "This 'data-hungry' framework is not practical or affordable for every biocontrol experiment," Ronny added, "but should be seriously considered for flagship programmes and for programmes that are likely to prove particularly challenging."

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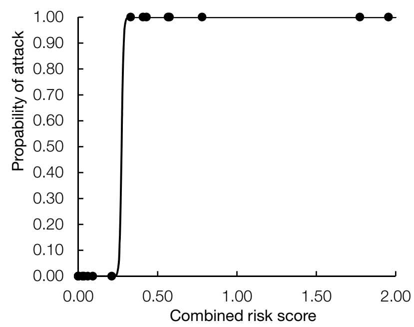
Unprotected plot in the foreground attacked by beetles, compared with plot behind protected with insecticide.

Data Diving Provides Pearls of Wisdom

Being able to accurately predict the likely field host-range of potential biocontrol agents is critical. Quite often when testing new agents indoors we get a low level of attack on a few non-target plants. We then need to determine whether this attack is due to laboratory conditions, and would never occur in the field, or a real risk. The best way to resolve this question currently is to undertake more natural field tests in the native range, but this is not always logistically possible. We cannot always get permission to plant out the test plants if they do not already occur in the country, or get the plants to thrive. When a field test is too difficult to undertake, there is a real danger of rejecting perfectly good agents because the dilemma cannot be resolved. When there are limited candidate agents to choose from this could mean the success or failure of a project. Even when a field test can be arranged it often takes several years to get permission, make the necessary arrangements, physically set up the trial and leave it long enough to gain meaningful results. All this adds to the cost of projects and time taken to develop new agents.

So finding a better way of assessing the risk when potential agents show some ability to potentially utilise non-target plants would be helpful, and recently Quentin Paynter has been looking into whether this might be possible. Quent carefully looked back over host-testing data for New Zealand agents and compared results with actual field data to see if these could provide any insights that might help. "The answer was yes and I have been able to develop a protoype risk index, which I presented at ISBCW," explained Quent.

So what did Quent do? He reviewed host-range-test data for 23 agents and compiled a database of plant species growing in New Zealand (native and exotic) that supported development of the agents in no-choice tests (i.e. fundamental hosts). Then he calculated relative performance scores for how well the agents did on each test plant compared with on the target weed (e.g. laid 90% fewer eggs). Next Quent consulted the literature to identify which of the fundamental hosts identified above are field hosts in New Zealand. Where the latter was unknown Quent, with help from colleagues, conducted some field surveys to look for attack. Once Quent had all the information he ran some statistical analyses on it.



Threshold for expected non-target attack using no-choice larval survival and oviposition tests as a combined risk score.

"I found that when I combined no-choice larval survival and oviposition tests into a combined risk score there was a clear threshold score (0.33) below which no attack occurred in the field," said Quent (see graph).

The technique did not work so well for choice test data, which did not produce a clear threshold point for predicting target attack in the field. Quent believes this is due to choice tests being inappropriate for seed-feeders because no-choice situations can arise in the field. For example the broom seed beetle (*Bruchidius villosus*) can emerge from hibernation before Scotch broom (*Cytisus scoparius*) has produced pods, but tree lucerne (*Cytisus palmensis*) pods are available. "No-choice tests are more appropriate for seed-feeders than choice tests," added Quent. "When I excluded seed-feeders, the choice tests then did have a threshold score, like the no-choice tests."

Quent reminded the ISBCW audience that this risk assessment tool is only a prototype at this stage, and would benefit from further data from overseas studies. He asked for help to do this and some offers have already been forthcoming. So it looks likely that in the near future a useful new risk assessment tool will be available to assist both scientists and regulatory bodies to assess the risk posed by new agents.

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