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Protect

New Zealand Biosecurity Institute

Our mission: Working together to ensure New Zealand is protected from the adverse impacts of invasive species

Protect

Spring 2009

Magazine of the New Zealand Biosecurity Institute

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Editor's Note

Greetings everyone, how is life with you? Isn't it great to see the lovely summer weather. This time of year it is a good time to observe exotic weeds in native bush or scrub, as the flowers are so visible. Unfortunately though, possums and rabbits are more active and the damage to our bush is very obvious. They are also a pest in our garden as they love the new spring growth.

NETS is nearly here and this year's committee has a great line-up of speakers and field trips. If you haven't registered yet you still have a few days left.

This edition of *Protect* highlights the issue of biocontrol. Biocontrol is a very important tool in the war against animal and pest plants. In many areas the pest is too remote or widespread or too costly to control. Biocontrol may help reduce its vigor or in some cases almost eliminate it.

Let me know what your thoughts are about this subject.

Our summer issue of Protect will highlight what happened at NETS. It would be really great if you would like to write an article on a field trip, the dinner, the speakers or just a general overview on the conference. Please feel free to contact me before or during NETS.

Thanks to everyone who has contributed to *Protect* over the last year I really appreciate the effort you have gone to.

Regards, **Lynne Huggins**

email : folstergardens@xtra.co.nz
phone: 03 214 1769
http://folstergardens.blogspot.com/

New Zealand **Biosecurity** Institute

The New Zealand Biosecurity Institute can be found on the web at **www.biosecurity.org.nz**

Executive contacts

Craig Davey	President	(06) 952 2800	Craig.Davey@horizons.govt.nz
Greg Hoskins	Vice-President & Northland/Auckland	(09) 832 6681	greg.hoskins@arc.govt.nz
Neil Gallagher	Vice-President	(06) 952 2800	neil.gallagher@horizons.govt.nz
Louise Cook	Secretary	(03) 363 3090	louise.cook@tbfree.org.nz
Helen Braithwaite	Treasurer	(03) 371 3751	hbraithwaite@doc.govt.nz

Other officers

Helen Braithwaite	New Members Officer (Acting)	(03) 371 3751	hbraithwaite@doc.govt.nz
Dave Hodges	Central North Island	(07) 859 0999	David.Hodges@ew.govt.nz
Pedro Jensen	Lower North Island	(04) 526 5322	pedro.jensen@gw.govt.nz
Lynne Huggins	*Protect* Editor	027 668 1009	folstergardens@xtra.co.nz
Randall Milne	Otago/Southland	(03) 211 5115	randall.milne@es.govt.nz
Lindsay Vaughan	Top of the South	(03) 543 8432	lindsay.vaughan@tdc.govt.nz
Gemma Bradfield	Canterbury	(03) 353 9007	gemma.bradfield@ecan.govt.nz
David Brittain	Web manager		david.brittain@kiwicare.co.nz
Alistair Fairweather	Travel/Study Awards Co-ordinator & Vertebrate Pests secondment	(07) 858 0013	afairweather@doc.govt.nz

Seconded Members:

John Gardner	Ministry of Health	(04) 460 4925	john_gardner@moh.govt.nz
John Sanson	Biosecurity New Zealand	(04) 894 0836	John.Sanson@maf.govt.nz

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News from the Executive

Kia ora and hello from the Executive. I hope winter has treated you well in your neck of the woods. My town had severe (for us) frosts for what seemed like weeks and then the warmest August on record to confuse me and the daffodils.

The big news over the last period has been the proposal to reduce the number of MAFBNZ border staff. This news must have been very disappointing for the staff involved especially given the reduced job market at the moment. The only upshot has been that biosecurity has been thrust back into the forefront of public debate. There have been many sectors rightfully advocating for not just the current level of staff but an increase of biosecurity activity due to the importance of pests and biosecurity risk management to their industry.

Executive meeting

The Executive met in Wellington on July 28 to have an in-depth discussion on a number of matters. We began by welcoming two new members to the Executive: David Hodges as Central North Island branch rep, and John Sanson as the seconded member from MAFBNZ.

It was encouraging to hear the many good things happening at the branch level. Some branches have been holding mini-NETS while others have been getting down and dirty planting in restoration projects. The Canterbury branch deserves to be especially recognized for proactively searching out funds to the tune of $23,000 for a restoration project at Nicholson Head/Taylors Mistake.

The treasurer reports that our funds are stable and we have a healthy reserve. This year has been the first year of running a GST registered NETS and we have also taken on a new bank to assist with the internal running of the differences associated with GST. Helen Braithwaite, our treasurer, deserves a special mention as she has put in considerable effort fixing glitches and managing the transfer.

We have a new-look Awards committee that is headed up by Alastair Fairweather and includes Gemma Bradfield and David Hodges. If you want to know what funds you or someone you know may be eligible for please visit the Awards section of the website.

The Exec spent some time discussing the importance of NETS to the Institute. NETSs are fantastic events and one of the best ways we have of bringing people together to share ideas and learn. As such the Executive is keen to continue their consistent quality and ensure they meet expectations of delegates and sponsors. Currently there is a users' guide to running a NETS resource and this may be refreshed and refined to meet the ever-changing world we live in.

The Executive also discussed the current issues of wilding pines and carbon credits, the Future of Pest Management Project and the lack of invertebrate research money, thanks to John Sanson and Lindsay Vaughn. It was agreed that we would include current issues that MAFBNZ are dealing with into our website via a short paragraph linking to more in-depth information from the MAF website. Our aim is to have the NZBI website act as a hub where members can find out about current biosecurity issues.

For more information please visit the minutes on the NZBI website.

NETS2009

The scenery is set, the presenters are ready, and the organising committee is waiting to welcome you. It's not too late to register for what will be another fantastic NETS. Don't miss out if you can help it – Queenstown October 14-16.

New members

The Executive would like to welcome the following new members who have joined since the last edition of *Protect*. All the best for your biosecurity endeavours.

Gail Townsend .... Northland
Dave Beattie .... Auckland
Paul Craddock .... Auckland
Gene Browne .... Auckland
Bill Nagle .... Auckland
Jillian Fulcher .... Auckland
Cynthia Roberts .... Hamilton
Andrew James McKay .... Bay of Plenty
Ann Thompson .... Wellington
Verity Forbes .... Hokitika
Martin Carson .... Christchurch
Steven Henry .... Southland

Website

The new website has been fuelling a number of new contacts with the NZBI and visits have increased by 210% in the first three months. The Executive decided to continue adding old copies of *Protect*

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into an archives folder. We will eventually have the archive available for non-members to view while the current (less than a year old) issues remain in the member's only section. As always it is people who keep the Institute ticking along and I'd like to thank David Brittain for his continued effort of upgrading and updating the content.

17AWC

If the question is "Where the bloody hell are you?" The answer is Christchurch 2010. New Zealand has the Bledisloe Cup in the NZRFU trophy cabinet and in 2010 we also have the Council of Australasian Weed Societies (CAW) annual conference. See inside for more details on what will be an excellent conference on working together to beat weeds. The conference is a collaboration of the New Zealand Plant Protection Society (NZPPS) and CAWS.

Craig Davey
President
Craig.Davey@horizons.govt.nz

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News from the branches

Auckland/Northland Branch

Over the last year, the branch has run smoothly and has held three meetings that have been informative and educational. Branch membership has remained steady with a total of about 90 members.

Our most recent meeting was held at the Wellsford Fire Brigade House on June 24, 2009 starting with morning tea, followed by our AGM, and then general business. After the formalities, we had three talks: the eradication of Argentine ants on Norfolk Island; marine biosecurity; and weed project management workshops in Micronesia. This was followed by a hearty lunch that was enjoyed by the 25 members present.

The first talk on eradicating Argentine ants from Norfolk Island was presented by Dr Gene Browne, manager of FBA Consulting. Argentine ants were first discovered on Norfolk Island in 2003 at Anson's Bay. Norfolk Island is about 34.6 sq km in size and is situated about 750 km north of New Zealand and 1400 km east of Australia. The island was first discovered by Captain Cook in 1774 and was used for many years as a penal colony. It is now a popular tourist destination with regular flights from New Zealand and Australia.

The Argentine ants were severely affecting the people living on the island and its unique fauna. The ants were spreading and had developed huge nests in the grass at Anson's Bay, dominating all other fauna. They were attacking birds, insects, spiders, and native ants, and farming aphids that affected cropping. People's pets were being driven away and houses were becoming overrun by the ants.

Steps in the eradication programme included detection, containment, control and eradication. "Extinguish" ant bait was applied in a grid throughout the infected area including down cliff faces and up trees. The local refuse station was a problem as ants could potentially spread from there to the rest of the island. As well as the cliff faces, other hazards to baiters included muttonbird nesting burrows. Funding for the project came from the Australian government.

Don McKenzie from Northland Regional Council spoke on marine biosecurity and highlighted the risks of marine pests to the Northland and New Zealand coastal environment. Marine pests are the responsibility of a number of organisations including MAFBNZ, regional councils, industry, health and landowners. The categories of pest management include exclusion, eradication and suppression, and management.

Norfolk eradication: An ant tends a mealy bug.

Community awareness is important for early detection of exotic marine pests if eradication is to be possible. There is a need for research into new controls for marine pests and taxonomy expertise for early detection and surveillance. The North Pacific seastar is an example of a marine pest that was introduced to Australia and has become a major pest to their shellfish farming industry. Seastar could cause major problems if it became established in New Zealand.

Pathways for marine pests include shipping such as ocean liners, oil ships, log transport ships and recreational yachts from Australia and South Pacific islands. Marine pests could be carried on the vessel

Pest: The North Pacific seastar, which since introduction to Australia has become a major pest to their shellfish farming industry.

NZBI News from the Branches Continued

hull and other external areas, or in seawater or marine sediments retained in the vessel. Goals Don highlighted for marine biosecurity included, prevention of incursions, response, stopping the spread, protection of high-value sites, and training and education.

Dave Moverley, Te Ngahere Native Forest Management and Bill Nagle, Pacific Invasives Initiative spoke on projects they were involved with in Micronesia. Bill Nagle has been involved with *Mimosa pigra* control in Papua New Guinea and biocontrol of *Merremia peltate*, an invasive vine in Vanuatu. A rabbit shooter from Central Otago was used to help control rabbits on the Phoenix Islands, part of the Kiribati group, in a restoration project to help nesting sea birds that were having their habitat destroyed by the rabbits.

Dave Moverley has been running weed project management workshops in the Federated States of Micronesia. The workshops are hands-on and look at planning, implementation, monitoring and evaluation. The workshops include developing best practice methods for control, recording meaningful data and reporting the results in a meaningful and useful manner.

The workshops use case studies and examples from New Zealand and the Pacific to help participants develop their own projects. Most projects are currently weed-led but they are also looking at site-led projects for the future. Site characteristics that affect the projects include the small size and remoteness of the islands and lack of herbicide options available due to adopted legislation and the close proximity to local crops and lifestyle consumables.

Difficult access: Getting people and supplies through the reef, Phoenix Islands Protected Area, Republic of Kiribati.

Greg Hoskins
Executive member
Auckland/Northland Branch

Weed workshops: Participants of the first full weed management workshop, held in Pohnpei in February 2009, stand in front of* Merremia peltata *(canoe plant), a common weed throughout Micronesia.

Nursery award

Most Weedwise Nursery Award goes to Ngaruawahia nursery

Forest Flora, the native plant nursery run by Wayne Bennett and his daughter, Julia, is the winner of the 2009 Most Weedwise Nursery Award for New Zealand.

The award was presented to Wayne and Julia by Dr Doug Wright, Chair of Environment Waikato's North Zone Biosecurity Committee. Awards are presented annually in both New Zealand and Australia to celebrate nurseries that sell only "environmentally friendly" plants that are unlikely to invade and damage natural areas.

Nurseries nominated for the award must not sell plants likely to cause problems in native bush areas because their seeds are carried there by birds, or if they get "dumped" on roadsides or in reserves by people tidying up their gardens. Other important criteria include the correct labelling of plants, and efforts by the nursery to educate customers and others about the possible impact of invasive plant species on the environment.

Forest Flora (www.forestflora.co.nz) specialises in helping and supporting restoration of natural areas in the Waikato. The nursery only sells native species, and specialises in eco-sourced plants – plants of known provenance. In its catalogue it records the locality the seed was collected as well as the number of individual plants from which seed was taken, to ensure the preservation of natural diversity.

The awards are organised by the Council of Australasian Weed Societies (CAWS: www.caws.org.au/index.php), represented in New Zealand by the NZ Plant Protection Society (www.nzpps.org). The next Australasian Weeds Conference, which is organised by CAWS, will be held in Christchurch in September 2010 (www.17awc.org).

Dr Doug Wright, Chair of Environment Waikato's North Zone Biosecurity Committee, presents the award to Julia and Wayne Bennett.

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Australasian Weeds Conference

17th Australasian WEEDS CONFERENCE
New Frontiers in New Zealand
Together we can beat the weeds

The 17th Australasian Weeds Conference is to be held in Christchurch from 26 to 30 September, 2010. This is the first time this conference will be held in New Zealand and offers a unique opportunity to meet and share ideas with our Australian colleagues.

In the past this conference has only been held in Australia but the recent inclusion of the New Zealand Plant Protection Society into the Council of Australasian Weed Societies (CAWS) means we are eligible to host the conference in our country.

This conference brings together a stimulating mix of practitioners, researchers and managers and covers a wide range of topics. For more information on the range of topics please go to the conference webpage at www.17AWC.org for a copy of the draft programme.

As well as the wide range of papers that will be presented, there will also be five day-long field trips covering: environmental weeds, aquatic weeds, forestry weeds, weeds of cropping and weeds of pastures.

The conference webpage is now open to receive paper abstracts and the close-off date is 31 October 2009. All papers will be published in a pre-printed proceedings but can be offered to the conference as either oral presentations or poster presentations. All instructions for authors are on the conference website.

Note also that members of the NZBI qualify for the "members" fee category when registering for the conference.

For further information you may contact me at trevor.james@agresearch.co.nz

Trevor James
President,
New Zealand Plant Protection Society

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Biosecurity personnel profile: Simon Fowler

Role: Entomologist,
Landcare Research
Lincoln

Simon Fowler is an entomologist at Landcare Research, Lincoln. He manages a group of about 10 scientists and research technicians whose aim is to undertake world-class research in weed biocontrol and related subjects, as well as solve practical weed management issues in New Zealand

The scientific push in this team is provided by the "Beating Weeds" programme he leads that undertakes research to improve the management of environmental weeds in New Zealand, particularly through biological control. This research programme meshes in with the more applied weed biocontrol programmes associated with the team, which are funded primarily by regional councils, Department of Conservation and other government agencies. The Beating Weeds programme has recently been successfully rebid, with a 20% annual increase in funding and six years duration: by far the team's best funding outcome under the Foundation for Research, Science & Technology. The same Landcare Research team also tackles agricultural and other productive sector weeds in collaboration with AgR and Scion, and has recently started collaborating with NIWA to develop classical biological control of aquatic weeds in New Zealand.

Law 'n' order: Simon Fowler undertaking some "lawn control" on his "life-stealing" block in Okuti Valley, Banks Peninsula.

Recent research highlights from the Landcare Research team include the world's most thorough national surveys of impacts of introduced biocontrol agents on non-target plants species, providing excellent evidence that current host range testing procedures are acceptable. In a past life, Simon was responsible for the UK field collection and host range testing of heather beetle in the early 1990s (at the International Institute of Biological Control, CABI). So the poor success and impact of this agent until recently was almost a personal affront. The resulting research into climate matching and host plant nutritional effects on biocontrol agents has been a major theme in the Beating Weeds Programme, leading to new insights into how best to establish biocontrol agents. Heather beetle is now well established in New Zealand and currently there are annually expanding outbreaks of beetles damaging and killing many hectares of the weed in the central North Island (but there's a lot of heather to go!).

Another highlight has been the successful biocontrol of mist flower which was monitored through a cost-effective programme working closely with Auckland Regional Council staff in particular. Recent follow-up studies in 2009-10 show that the agents remain common and weed suppression has if anything increased.

Another project that Simon has been substantially involved with targets the understorey weed, *Tradescantia fluminensis*. Despite very productive field trips to southeastern Brazil producing an almost bewildering range of promising biocontrol agents (both insects and pathogens), progress has been frustratingly slow largely because of difficult-to-eradicate gut parasites in the first short-listed agents. The significance of insect gut parasites and diseases in weed biocontrol agents is

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now a research theme in Beating Weeds, so in future we should be able to avoid such pitfalls, for example by developing better (DNA-based) detection methods and improved rearing protocols.

Backtracking somewhat, Simon was brought up in the beautiful city of Bath in southwest England. He did his BA (Zoology) at Oxford, and his PhD at York under the stimulating supervision of John Lawton. The PhD used the fauna of birch trees on a wet, midge-infested, peat bog to test various hypotheses on the effects of host-plant chemistry on insect herbivores.

A postdoc prolonged the stay in Yorkshire until 1985, when the temptations of applied research and tropical travels lured Simon to Cardiff to work in Mike Claridge's Rice Research Unit. Even the worst drizzle that South Wales offered was counteracted by the exotic ambience of Sri Lanka, where research concentrated on natural enemies of rice brown planthopper, especially really minute chalcid egg parasitoids. Towards the end of his time in Cardiff, annual pre- and post-monsoon trips to Calcutta for rice pest management research started a trend that continued for nearly 10 years. In 1988, Simon joined the International Institute of Biological Control near London, and engaged in projects including collection, host range testing and shipment of biocontrol agents for gorse and broom for the Department of Scientific & Industrial Research (soon to morph into CRIs including Landcare Research).

At IIBC, Simon was often travelling for three to five months a year to a range of countries on biocontrol and IPM programmes. A notable success during this period was the biocontrol of the exotic scale, *Orthezia insignis*, on St Helena island which saved its endemic national tree from extinction.

Trips to New Zealand convinced Simon that the wonderful scenery, opportunities for outdoor activities, not to mention hands-on biocontrol research, could easily compensate for a country with no historic towns, inhabited by people too good at rugby, with beer that had "room for improvement" (this has changed now – thank you Emersons et al!). To come to New Zealand, Simon had to cut short a secondment to an Imperial College fruit fly project based in Mauritius, and left behind the project house (by a coral reef), car, maid and gardener!

Simon has now been directly involved with weed biocontrol programmes for New Zealand for more than 10 years, which despite some challenges regarding funding, has been productive and enjoyable.

Interspersed in the above has been an abiding interest in outdoor activities, natural history and photography. From school, until he got a bit too sensible, Simon was a keen caver. Highlights in caving included discovering and exploring Pozu del Xitu, a cave more than 1000m deep in the Picos de Europa in northern Spain, exploring limestone regions and their wildlife in Madagascar and mapping huge cave systems in China. New troglobitic arthropods were discovered on all these trips, and Simon has a very obscure Spanish millipede and a Chinese beetle named after him.

Simon now lives with his partner Alison and two gorgeous daughters – Sophie (2¾ years) and Isabelle (1¼) – plus Jade the dog, and Dudley and Dolly the donkeys, on a magnificent lifestyle block on Banks Peninsula. Looking after 8ha of regenerating bush, exotic plantation trees and pasture, not to mention a great house, deck and garden, can make this more of a "life-stealing" block – but they wouldn't change a thing!

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Biocontrol is an integral part of horticulture's future

John G Chrarles
New Zealand Institute for Plant & Food Research Limited,
Private Bag 92 169,
Auckland 1142

The fruit trees and vines imported into New Zealand by early European colonists came with insects, on or in the plants or the soil around their roots, or as "hitchhikers" on agricultural equipment. These became the first commercial pests when orchards were developed from the 1860s. One was the codling moth, which was sufficiently serious for an Act of Parliament (The Codlin Moth Act 1884) to be written for its control. New pests continued to arrive with new immigrants and the development of international trade. They established at a more or less constant rate of about seven species per decade, and now, 150 years later, there are about 120 species of insect and mite pests of fruit crops in the country (Charles 1998). Despite this number, New Zealand remains crucially free of many of the worst pests that devastate these crops elsewhere in the world. Our distance from anywhere else has helped to keep them out, but their absence is also a testament to the diligence of biosecurity officers who have been present at our ports under various guises for most of the past 100 years or so. It is also why biosecurity remains so essential today, why vigilance for new pests must be eternal, and why eradication (when they do arrive) is so worthwhile.

Nearly all phytophagous insects are attacked and eaten by other insects that fall roughly into two groups, predators or parasitoids. Predators are typically ladybirds, lacewings and hoverflies, while parasitoids are usually small wasps or flies, of often strange appearance and bizarre biology. These natural enemies can often control pest populations in their native countries to very low numbers. Some natural enemies have a wide host range, but many others will attack only a single host, so that their life-histories are inextricably entwined. Historically, exotic predators and parasitoids began to arrive in New Zealand along the same pathways and at much the same rate as the pests they attack (Charles 1998). As a result, most of our exotic horticultural pests are attacked by at least some natural enemies. However, just as our isolation has acted to our advantage by restricting the number of pests in New Zealand, it has been to our disadvantage by restricting the accidental arrivals of natural enemies of those pests. Hence our exotic pests are attacked by fewer species of natural enemies than in their countries of origin.

The absence of natural enemies was recognised by early natural historians, and deliberate attempts to import new species of predators and parasitoids into New Zealand began in the 1870s (Cameron et al. 1989). In the USA, the vedalia beetle was introduced to California in 1889 to control cottony cushion scale, and effectively saved the citrus industry. It was such a spectacular success that it cemented the idea that natural enemies could be used as an effective pest management tool. The deliberate use of natural enemies to control insects became known as biological control, or simply biocontrol. Some very successful early biocontrol programmes included the introduction of *Aphelinus mali* against woolly apple aphid and *Coccophagus gurneyi* against citrophilus mealybug (see Cameron et al. 1989). These days, biocontrol also includes the use of insect pathogens, such as viruses, but does not include the use of "bio-rational" insecticides such as *Bacillus thuringiensis*, ryania or derris dust.

But does a 133-year-old technique, born of natural historians in an era prior to the development of ecological science, have a place in today's world of international trade in high-value horticultural products? I believe the answer is emphatically yes. In fact, I argue that biocontrol has more to offer now and in the future than at any time in the past. This article looks at biocontrol in New Zealand from the perspective of intensive horticultural systems, but its underpinning message applies to all of our plant-based primary industries.

The pesticide era 1870 – 2005

Part of the reason that biocontrol has been

Adapted from a paper presented at NZPPS "Future Challenges in Crop Protection: Repositioning New Zealand's Primary Industries for the future", Napier, 13 Aug 2007 (Charles, 2008).

underrated in recent years stems from attitudes that became rather entrenched during the height of the so-called "pesticide era". The decades after the Second World War period saw the introduction to New Zealand of a large number of powerful insecticides: the organochlorines, organophosphates, carbamates and synthetic pyrethroids. They provided cheap and hugely successful pest control. They had a broad spectrum of activity and killed insects indiscriminately – pests and natural enemies alike. Biocontrol, not surprisingly, was effectively non-existent in most sprayed orchards. Interest in biocontrol resumed from the 1960s as part of the development of integrated pest management (IPM) and then integrated fruit production (IFP) programmes, but faced stiff competition from cheap insecticides. In addition, it became clear that natural enemies alone were often (but not always) unable to reduce pest numbers to the very low economic thresholds increasingly required by customers demanding fruit of the highest quality. These difficulties helped to promote a widely held mindset that biocontrol did not work in fruit crops (and research funds were invested elsewhere). Such a mindset was noticeably absent in programmes against forest insect pests and environmental weeds. Here biocontrol continued to be strongly supported, perhaps because (a) there were no "artificially" low economic thresholds of the kind required by exporters of fresh fruit, and (b) the widespread use of pesticides was simply not an economically feasible option.

Importantly, the negative impact of broad-spectrum insecticides on biocontrol was not a new phenomenon, even in the 1950s. We tend to think that the "pesticide era" started with the widespread use of DDT, and that in earlier times crops were grown in some sort of pesticide-free nirvana to which we should aspire today. In fact, the pesticide era had started in the previous century. Codling moth and a few other pests became a problem at about the same time as the development of a product based on aceto-arsenite of copper, called "Paris Green". This was the product that really started the modern age of insecticides. It provided hugely successful control of the Colorado potato beetle in the USA in the 1870s, and then was widely adopted for insect pest control around the world. This was despite the fact that it contained 28% arsenic and was extremely toxic to humans. As an aside, the ready acceptance of Paris Green, despite warnings that improper use could result in "…disagreeable effects or dangerous illness… or possibly death" (Ormerod 1890), provides a fascinating insight into how our attitudes to risk have changed since then. Despite the known dangers, Paris Green was soon followed by many other commercial insecticides, including additional arsenical formulations, nicotine, paraffin oil, carbon bisulphide, caustic soda/potash, hydrogen cyanide, and lead arsenate, all of which were used widely in New Zealand until the 1940s.

The point is that all of these chemicals had broad-spectrum activity, and killed natural enemies just as effectively (or more so) than the target pests. This means that biocontrol in New Zealand's horticultural crops has been compromised for virtually their entire history, not just the past few decades.

The future of biocontrol

From the 1960s, hesitantly at first, but with increasing momentum, a blend of biological, economic, environmental and social forces – such as pesticide resistance, environmental persistence, non-target toxicity and the publication of Rachel Carson's *Silent Spring* – first heralded and then drove the decline of broad-spectrum insecticide use in New Zealand's crops. The end game is still in play, but it is undeniable that, for the past few years, orchards and vineyards in New Zealand have never been as free of broad-spectrum insecticides. The result has been a burgeoning of insect species of all description (e.g. Suckling et al. 1998). This increased biodiversity, including many species of natural enemies, is one of the key indicators of environmental sustainability in our primary industries.

However, the ingrained perception that biocontrol "does not work" has been hard to erase, despite the science of insect population dynamics which shows that it does, in fact, "work". Beddington et al. (1978) pointed out that insect numbers are typically depressed to about one-hundredth of their former abundance after introducing an effective natural enemy. Other studies confirmed that biocontrol agents significantly reduced pest abundance, fecundity and damage to host plants, and significantly increased pest mortality (Stiling & Cornelissen 2005). So, from a practical viewpoint, it seems inconceivable that a management tool that reduces a pest population to 100th of its potential size would not be welcomed, especially if it is self-perpetuating in the form of persistent populations of natural enemies.

In fact, all growers throughout New Zealand already make use of biocontrol. Most of the natural enemies of our horticultural pests are small to tiny insects, and are unnoticed by nearly everyone. Yet they are constantly at work, both inside and outside the crop boundaries. Their impact outside the crop, for example by reducing immigration of pests, may be crucial to successful pest control in the orchard. This background level of biocontrol should be regarded as a vital ecosystem service, but like abundant water and healthy soils, it is usually taken for granted and either ignored or accepted as a free service that should not require additional expense to maintain.

A key question, then, is that if we already have a self-perpetuating ecosystem service of natural enemies, why do we need more? One simple answer, already mentioned, is that many natural enemies of exotic pests are absent from New Zealand, and so pests are not controlled to their maximum potential. In addition, new pests continue to arrive without their natural enemies. Classical biological control (CBC) is a strategy of deliberate importation of a new natural enemy from a pest's country of origin, and is called "classical" in tribute to its 19th century origins. It has been practised in New Zealand since 1874 when ladybirds were introduced to kill aphids, and its value as a pest management tactic was well recognised by the end of the 19th century, with some important programmes targeted against a wide range of agricultural and forestry pests (Cameron et al. 1989). Most 19th century introductions were of predators, reflecting our almost complete ignorance of parasitoids at that time. As the 20th century got under way, CBC became an important activity for contemporary horticultural research organisations and focused increasingly on parasitoids. With the demise of broad-spectrum insecticides, CBC again has the potential to add significant value to pest management tactics.

Future pest management strategies will be increasingly holistic, and we will be unable to rely on a single tactic (the "silver bullet" approach of old-style pesticide use). This is, in part, being driven by our export markets, which nowadays demand insect and insecticide-free fruit, as well as evidence of environmental stewardship (as signalled by environmental sustainability branding such as "clean and green" and "long-term sustainable horticulture"). Against this background, biocontrol is, and should be recognised as, a cornerstone of future pest management. There is a long list of potential new natural enemies for old pests, and this will grow as new pests continue to arrive.

Ecological science's role in biocontrol

A particular challenge for biocontrol researchers is that even after more than 100 years of development there is no critical or unifying ecological theory for biological control, nor is there likely to be one. Recent studies have attempted to analyse past biocontrol programmes to provide a scientific basis for the future. Yet these have consistently shown that there is no universal theory for predicting the success of individual natural enemies. Perhaps unsurprisingly, the different crop systems, pests and natural enemies under study all strongly influence the type of control that can be achieved (Yasuda 2006). In part, this is because a "pest" is an anthropomorphic construct that defies scientific definition (Charles 2008), but also because the economic and social complexities of farming always seem to throw up pest management scenarios that cannot readily be addressed by ecological theory.

However, the lack of an all-encompassing ecological theory of biocontrol does not mean that ecological theory is of no value in biocontrol, or that science cannot be used to improve it. Modern ecological science plays a crucial role in the choice of new CBC agents, and will ensure that new natural enemies are effective against their target pests with minimal risk to native, non-target organisms. Both the target pests and natural enemies selected for importation will need to be carefully chosen, and sometimes significant research carried out to measure the potential impacts on, and risk to, the environment. But it seems inevitable that each CBC programme will need to be judged on its own scientific and pest management merits, which fits well with New Zealand's HSNO Act legislation that considers new organism applications on a case-by-case basis.

Summary

More than 100 years of insecticide use in horticultural crops in New Zealand has compromised the ability of natural enemies to control insect pests. The declining use of broad-spectrum insecticides means that New Zealand's fruit crop sectors are now freer of insecticides than at any time in history. The resulting increase in biodiversity is, for the first time ever, allowing natural enemies to exert their full potential impact on pests.

Most of the insect natural enemies in New Zealand arrived accidentally, and many of them would probably never have been deliberately introduced by CBC programmes. However, they are here, and they provide a background level of pest control that should be regarded as a free and valuable "ecosystem service". Many pests have arrived without key natural enemies, and CBC programmes to introduce carefully selected natural enemies, based on sound ecological science, offer improved pest control as part of holistic, integrated pest management programmes. Growers, the economy and the environment should all benefit from making use of them, and the stage is set for CBC to become an integral part of New Zealand's future insect pest management systems.

Acknowledgements

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Biocontrol

Biocontrol of weeds in NZ – an overview of nearly 85 years of activity

Lynley Hayes
Landcare Research

The early days

Biocontrol of weeds research in New Zealand began at the Cawthron Institute, Nelson, in 1925 with a hiss and roar. The weeds targeted included blackberry (*Rubus fruticosus* agg.), foxglove (*Digitalis purpurea*), gorse (*Ulex europaeus*), and ragwort (*Senecio jacobaea*), plus one native plant: piripiri (*Acaena anserinifolia*). Seventeen insects were imported for study between 1925 and 1931, but only the cinnabar moth (*Tyria jacobaeae*), gorse seed weevil (*Exapion ulicis*), and piripiri sawfly (*Ucona acaenae*) were released. The latter failed to establish, but since piripiri and foxglove had begun to decline as the fertility of pastures was improved no further efforts were made to develop biocontrol for these targets. No agents were released against blackberry because all showed some potential to damage cultivated berries.

Between 1931 and 1965 biocontrol faded back into obscurity as new generation herbicides became available and grew in popularity. The DSIR took over responsibility for the work but only imported and released three agents for St John's wort (*Hypericum perforatum*) and one for Mexican devil weed (*Ageratina adenophora*). All four species established and neither of these weeds is a serious problem today – this can be attributed, at least in part, to these biocontrol agents.

Cinnanbar moth, the first biocontrol agent to be released in NZ.

The modern era

Growing disillusionment with herbicides led to a resurgence in biocontrol activity in the 1970s, which has continued until the present. When the DSIR was disestablished in 1992 the responsibility for this work shifted to Landcare Research. About this time environmental weeds began to receive more attention. Today the number of environmental weeds being targeted for biocontrol far outweighs agricultural weed targets (see Table 1).

Weeds targeted during the 1970s, 80s and 90s included gorse and ragwort for a second time, plus thistles (*Carduus nutans*, *Cirsium arvense*, and *Cirsium vulgare*), broom (*Cytisus scoparius*), hawkweeds (*Hieracium* spp.), heather (*Calluna vulgaris*), mistflower (*Ageratina riparia*), and the only aquatic species tackled

Alligator weed, *Alternanthera philoxeroides*
Banana passionfruit, *Passiflora* spp.
Boneseed, *Chrysanthemoides monilifera monilifera*
Climbing asparagus, *Asparagus scandens*
Chilean needle grass, *Nassella* spp.
Darwin's barberry, *Berberis darwinii*
Japanese honeysuckle, *Lonicera japonica*
Lantana, *Lantana camara*
Moth plant, *Araujia sericifera/hortorum*
Old man's beard, *Clematis vitalba*
Pampas, *Cortaderia* spp.
Privet, *Ligustrum* spp.
Tradescantia, *Tradescantia fluminensis*
Tutsan, *Hypericum androsaemum*
Wild ginger, *Hedychium* spp.
Woolly nightshade, *Solanum mauritianum*

Table 1: Current targets for which new agents are being sought.

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to date, alligator weed (*Alternanthera philoxeroides*). In total, 28 agents were released including the first fungal pathogens (old man's beard fungus, *Phoma clematidina*, in 1996 and the mist flower white smut, *Entyloma ageratinae*, in 1998).

The last decade has seen a strengthening of the attack against ragwort, thistles, and hawkweeds with two more agents developed for each of these targets, and three more for broom. New projects against boneseed (*Chrysanthemoides monilifera monilifera*) and buddleia (*Buddleja davidii*) have resulted in one agent being released against each of these targets. The buddleia project was developed by Scion. In the past year the first agent has been approved for release against tradescantia (*Tradescantia fluminensis*), and permission to release the first woolly nightshade (*Solanum mauritianum*) agent is expected soon.

St John's wort beetles forming an impressive feeding front.

New Zealand is currently releasing biocontrol agents faster than any other country for a number of reasons: the seriousness of weeds in New Zealand; good continued public support for biocontrol; well organised end-user groups providing funding and support for projects; and excellent legislation that ensures decision-making is thorough and timely, and based on scientific evidence rather than political whims. The formation of the National Biocontrol Collective (regional councils nationwide and the Department of Conservation) has been a great asset allowing collective decision-making to be made with a nationwide focus for the past five years.

The total number of agents released in New Zealand to date is 48. Two of these (gorse hard shoot moth, *Scythris grandipennis*; and hieracium plume moth, *Oxyptilus pilosellae*) were one-off token releases that not surprisingly did not establish. Of the remaining 46 species, 35 have established (85%), six have failed to establish, and it is too soon to know the status of the other five. By world standards our establishment success rate is high. This is likely to be due, at least in part, to the wonderful network of biosecurity officers and land managers throughout the country who assist

Target	Level of success	Extent of monitoring
Alligator Weed *Alternanthera philoxeroides*	Partial, good control in static water bodies	Good
Blackberry *Rubus fruticosus agg.*	Partial, less vigorous in some areas	Minimal
Bridal Creeper *Asparagus asparagoides*	No other control required in most areas	Minimal
Broom *Cytisus scoparius*	Partial, less vigorous in some areas	Ongoing (good)
Heather *Calluna vulgaris*	Partial, good control in areas with beetle outbreaks	Ongoing (good)
Mexican devil weed *Ageratina adenophora*	Partial, still common but less of a threat now	Almost none
Mist Flower *Ageratina riparia*	Complete, no other control required	Excellent
Nodding Thistle *Carduus nutans*	Partial, good control in some areas	Minimal
Ragwort *Senecio jacobaea*	No other control required in most areas	Moderate
St John's Wort *Hypericum perforatum*	No other control required in most areas	Minimal

Table 2: Successful projects to date.

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with finding suitable release sites, making releases and undertaking follow up monitoring. This network allows us to release more agents, more quickly, and therefore more often hit the jackpot, than would otherwise be possible.

At least four species have also self-introduced to New Zealand that help to control weeds. They include the broom twig miner (*Leucoptera spartifoliella*), hemlock moth (*Agonopterix alstromeriana*), blackberry rust (*Phragmidium violaceum*), and most recently the bridal creeper rust (*Puccinia myrsiphylli*).

How successful have we been?

Establishment success is one thing but having an impact on weed populations is another. Assessing the impact of biocontrol programmes has always been a tricky business, because it is technically challenging and expensive to undertake trials that yield meaningful data. Biocontrol is no quick-fix, and it may be many decades yet before we know how successful some of the agents released in the past 20 years have been. For these reasons the impact of many biocontrol agents has not yet been adequately assessed. However, there is some evidence to suggest that at least 10 weed species have already been tamed to some extent by biocontrol agents so far (see Table 2).

Funding for detailed population and ecosystem level assessments is always going to be difficult to find, so recently Landcare Research decided to try a new, more achievable approach to assessment, again involving the network of helpers nationwide. Simple activities (e.g. monitoring establishment success, population build up and damage levels of agents, and taking good before and after photos) if done well at many sites should give us useful information about how many agents are doing. A workshop is being held this spring to provide the first batch of regional council staff with the skills to get started on this new initiative.

Currently we are also lacking economic data about the benefits that biocontrol of weeds has provided to New Zealand. An economic impact assessment of the 104 years of weed biocontrol activity in Australia, where many similar projects have been undertaken, was published in 2006. Over the past century weed biocontrol has cost Australia on average $4.3 million per year and the annual return from this investment is estimated to be $95.3 million, a benefit to cost ratio of 23 to 1. Not all biocontrol programmes are successful (although this is often because funding runs out before the work is finished) and the huge annual return was produced by only 14 successful programmes. Unsuccessful biocontrol programmes cost $15 million, but this cost was insignificant compared with the benefits provided by successful ones. A surprising outcome from this study was that even a small reduction in a major widespread weed e.g. 5% of lantana (*Lantana camara*) or blackberry (*Rubus fruticosus* agg.) could more than pay for the cost of developing a biocontrol programme. A project to begin collecting economic data for New Zealand is expected to begin soon, and it will be interesting to see if New Zealand projects have, as we expect, produced similar benefits to Australian ones.

Vines are increasingly being targeted, Japanese honeysuckle near Nelson.

How is the safety record?

Some people still compare the introduction of biocontrol agents for weeds with the introduction of rabbits or ferrets, leading to fears of further ecological disasters. However, the reality is that biocontrol of weeds, both in New Zealand and overseas, has an excellent safety record. We have undertaken extensive follow-up surveys to check for non-target damage here, and the results have provided additional assurance that host-testing, if undertaken appropriately, is a good indicator of what will happen in the field. Non-target attack was largely absent, even when some might have been expected due to the inadequate host-testing (by today's standards) that was carried out in the earlier days of biocontrol.

Only two agents have unexpectedly attacked other plants in New Zealand. Broom seed beetles (*Bruchidius villosus*) attack tree lucerne (*Cytisus proliferus*), and the gorse pod moth (*Cydia succedana*) attacks seeds of several introduced closely related legumes including Scotch broom (*Cytisus scoparius*). Studying the reasons why this has occurred has provided an opportunity to refine best practice, and "no choice" tests are always included now when there is potential for such a "no choice" situation to arise, and no agents

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would ever be released from a population that had not been thoroughly tested, even if it is the same species. Molecular plant phylogenetics has revolutionised host-plant selection by allowing us to better identify the key species that need to be tested, and maximise resources by not testing any species unnecessarily.

Less is known about non-target effects that occur when biocontrol agents become a food source for, or competitor of other species. Such "ripple" or "downstream" effects may be positive or negative and they are considered before biocontrol agents are released but are generally impossible to predict with certainty given the current level of knowledge of ecosystem function. Research into food webs is being undertaken which will hopefully allow us to get better at predicting such indirect non-target effects in the future. A recent study into parasitism of weed biocontrol agents has shown this, at least, is not a major cause for alarm and will allow us to be better at selecting agents that are least likely to get knobbled in the future.

Mist flower white smut, one our most successful agents.

Are we moving fast enough?

With hundreds of weedy species to manage in New Zealand plus many sleeper weeds beginning to wake up, we really need to be working to develop biocontrol for many more species as quickly as possible. Resources are inevitably limited so we need to find better ways of prioritising where to direct our efforts, and recently Landcare Research undertook a project to do just this for the Australian Government. The framework we developed allows us to identify both likely "winners" and difficult targets, with a fair degree of confidence but, for many weeds, predicting success or failure is still a bit of a lottery. If we can identify further factors in the future that affect biocontrol success we should be able to make significant improvements to the predictive power of the framework. A project to run New Zealand weeds through the framework is expected to get under way soon.

Another way to tackle more targets is by using biocontrol agents with wider host ranges. New Zealand has a unique flora in which certain plant groups are under-represented. If a genus or tribe of introduced weeds is not represented in the native flora then such multi-targeting could be considered. However, detailed studies of the relationships between weeds and both undesirable and desirable species, and the potential risks of releasing biocontrol agents with wider host ranges would be needed. Multi-targeting is also likely to require fairly in-depth studies on the ecology and population dynamics of the target and potential weeds and possible agents, so the extra effort might only be warranted where a number of sleeper weeds might be prevented from awakening.

The future

Overseas it is becoming more difficult to use herbicides because weeds are developing herbicide resistance, products are being removed from sale following re-evaluation, rules governing usage are being tightened and the public is demanding more organic produce. Inevitably these drivers will become stronger here in due course. Biocontrol remains the only cost-effective way and sustainable way of managing widespread weeds. After nearly 85 years of weed biocontrol activity in New Zealand the reputation of biocontrol as a low risk activity remains intact, and research efforts will now largely focus on ways to further improve our success rate, get bigger bangs for the buck, and demonstrate more clearly the value of biocontrol of weeds projects to New Zealand.

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Biocontrol of aquatic weeds in NZ

Paul Champion & John Clayton
NIWA

In this article we will discuss a range of biological control options used in the field of aquatic plant management, using the broadest definition of biocontrol. These are:

- **Classical biocontrol**, where an organism (usually an insect or pathogen) is introduced to provide specific control of a weed, or closely related weed species by sustained presence in the new environment, reducing the impact of, but not eradicating, its host plant.
- **Generalist herbivory**, where an organism (in this case Chinese grass carp) is introduced and contained in an area of water. The stocking rate is such that all accessible aquatic vegetation is removed from the enclosed area. When the target plant does not produce seed (the case with nearly all the main problem species) then eradication of that weed can be achieved.
- **Mycoherbicide**, where a pathogen is cultured in the laboratory, and then applied in a concentrated form to a targeted area of weeds. The application acts like a herbicide, killing the plant, but not continuing to exert control after that time because the pathogen is only effective at elevated concentrations. Thus, this method is a short-term control option.

Classical biocontrol

Classical biocontrol options for aquatic weeds are few compared with terrestrial weeds. In New Zealand only two species-specific insects have been introduced and become established, both to control alligator weed (*Alternanthera philoxeroides*) (Hayes & Wilson-Davey 2009). This plant forms dense floating mats extending out from waterbody margins and also can dominate nutrient-rich wetlands. However, this plant has also established and become weedy in a range of terrestrial habitats including pasture, urban areas and arable crops such as onions and maize. It is a major problem weed in Northland and parts of Auckland, and is targeted for eradication in all other parts of New Zealand where it occurs. The flea beetle (*Agasicles hygrophila)* and moth *Arcola malloi* (**Plate** 1) were released in 1982 and 1987 respectively. Self-sustaining populations have now established, with the flea beetle common throughout much of the range of alligator weed. Good control has been achieved where this plant forms floating mats over static water bodies (Plate 2) (Hayes & Wilson-Davey 2009). However, control of terrestrial alligator weed

Plate 1: Alligator weed flea beetle (above) and moth (right). Photos: Quentin Paynter, Landcare Research

Plate 2: Alligator weed flea beetle damage
Photo: Quentin Paynter, Landcare Research Ltd

is not achieved, and poor overwintering ability results in limited control of alligator weed until late summer, leading Stewart et al. (1999) to report that the flea beetle is not suitable for the widespread control of alligator weed in New Zealand. In countries where temperatures are warmer, alligator weed flea beetle can provide spectacular success, as is the case in Florida where more than 80% of public water bodies used to be heavily impacted by this weed. Flea beetles were released into Florida waterbodies in the 1960s and now alligator weed control is rarely needed. Landcare Research is continuing screening for cold-tolerant biocontrol agents and those that could effectively control terrestrial forms of the plant (Hayes 2008).

Alternative classical biocontrol agents have been used overseas to control various aquatic weeds, including the submerged weeds hydrilla (*Hydrilla verticillata*) and Eurasian water milfoil (*Myriophyllum spicatum*), free-floating weeds such as water hyacinth (*Eichhornia crassipes*), salvinia (*Salvinia molesta*) and water lettuce (*Pistia stratiotes*), with great success on the free-floating weeds in many situations (Forno & Julien 2000). In New Zealand these weed species are not suitable for classical biocontrol agents, since Eurasian water milfoil is not present and the other species are already eradicated or well advanced towards eradication by other means, which could not be achieved with classical biocontrol.

Apart from the two insects already released for control of alligator weed in New Zealand there are no other classical biocontrol agents identified or evaluated for the potential control of our most problematic alien weed species, and in particular our submerged species (Champion et al. 2002). One potential target for biocontrol in New Zealand would be parrot's feather (*Myriophyllum aquaticum*), a sprawling emergent weed, which is common in much of the North Island and scattered in the South Island, with a recent find of it in Southland. Cilliers (1999) reports on the successful control of this plant in South Africa using a flea beetle (*Lysathia* n.sp.) over a range of sites from cold temperate to sub-tropical habitats. This warrants further investigation.

Generalist herbivory

The Ministry of Agriculture and Fisheries (MAF) imported grass carp (*Ctenopharyngodon idella*) from Hong Kong into New Zealand in 1971 to evaluate their potential for biological control of aquatic weeds (Rowe & Schipper 1985). These fish were initially kept in contained facilities and were later used in a field trial in the lower Waikato from where some escaped in 1984. Although these fish grew to maturity, grass carp have extremely specific spawning and rearing requirements, and these fish never established a self-sustaining population. There has been much controversy surrounding the use of grass carp as a weed control agent in New Zealand. Permission to use grass carp as biological control agents is currently required from the Minister of Conservation and Minister of Fisheries and in consultation with iwi and other stakeholders, before introducing grass carp to a new site (Clayton & Wells 1999). The ministers must decide if the risk that grass carp pose to the natural values (particularly biodiversity) in the proposed area is acceptable. An environmental impact assessment and an operational plan for the use of grass carp need to be prepared.

New Zealand trials on aquatic weed control in Lake Parkinson, Waihi Beach Reservoir Elands Lake, Lake Waingata and Western Springs Lake demonstrated that grass carp could eliminate virtually all aquatic plants in lake systems. The potential for restoration of lakes dominated by exotic macrophytes was demonstrated in Lake Parkinson where egeria oxygen weed (*Egeria densa*) was eradicated and native aquatic plants recovered naturally from seed banks following removal of grass carp (Rowe & Champion 1993). More recent releases of grass carp into natural lakes have occurred in lakes Tutira, Waikopiro and Opouahi (Hawke's Bay) and Lake Swan in Northland. In the Hawke's Bay lakes, grass carp were released in 2008 in a concerted programme to eradicate hydrilla from New Zealand (MAFBNZ 2009), following the successful eradication of this plant from Elands Lake using fish stocked in 1988 (Plate 3). Lake Swan, on the Pouto Peninsula of Northland, has been stocked with grass carp in order to eradicate hornwort (*Ceratophyllum demersum*) and egeria. This lake has the only known population of hornwort in the Pouto lakes district and eradication is sought to protect other high-value lakes (e.g. lakes Humuhumu, Kanono and Mokeno) in the vicinity of this lake (Wells & Champion 2009).

Plate 3: John Clayton holding a grass carp recovered from Elands Lake, Hawke's Bay.

In flowing water such as the channelised Mangawhero Stream, grass carp also effectively eliminated all vegetation (Rowe & Schipper 1985). Edwards & Moore (1975) reported effective aquatic vegetation removal in a drain that flowed into the Awakaponga Stream (Bay of Plenty). These sites are well-oxygenated, clear, cool, spring-fed channelised waterways, more characteristic of a natural stream than a drain. In New Zealand agricultural drains however, most grass carp releases have been unsuccessful as grass carp in these systems suffer frequent fish kills from low oxygen, acid pH, and predation (Wells et al. 2003).

Mycoherbicide

The principle of mycoherbicide biocontrol is that high-

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density populations of a fungus can be cultured and sustained only under laboratory conditions, but when applied at high density to target weed beds (inundative control) in the field the fungus can infect and destroy treated weeds but the fungus quickly declines and cannot spread or impact beyond the targeted area.

The first known attempt to develop a mycoherbide for control of submerged aquatic weeds in New Zealand started in 2002 based on USA initiatives on an aquatic fungus called *Mycoleptodiscus terrestris* ("Mt" for short). Mt is a naturally occurring fungal plant pathogen that was first isolated and identified from submerged aquatic weeds in the Waikato River in 2003. NIWA has been culturing and experimenting with Mt with the objective of developing an environmentally friendly mycoherbicide product for the control of submerged aquatic weeds. Major progress has been made to date over the culture and bulk growth of this fungus and in recent years a Reciprocal Evaluation Agreement and a Commercialisation Agreement have been signed with SePRO in the USA, which is inclusive of their partners (US Army Environmental Research and Development Centre and USA Agricultural Research Service). This collaboration seeks to bring together different technologies and expertise for the joint goal of developing a mycoherbicide product to control submerged aquatic weeds in New Zealand, USA and potentially other countries.

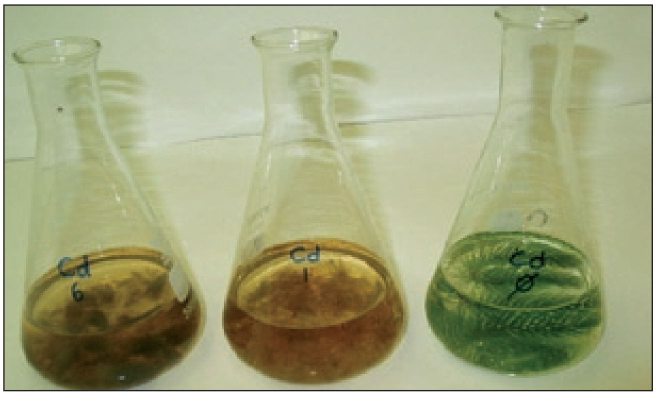

Plate 4: **Mycoleptodiscus terrestris** ***(Mt) impact on hornwort at two rates (left two flasks) compared to untreated control (right flask).***

Trails been completed in the laboratory (Plate 4) and in outdoor mesocosms using this mycoherbicide on a wide range of targets. Results have been encouraging and have now led to a successful application for a Discharge Permit to enable field trials to be carried out on target weed beds in Waikato hydrolakes. The challenges dealing with a living organism are substantial and further work is still required on refining culture methodology, drying and processing of product, and developing suitable formulation and application methods.

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Weed spreads

The spread of tutsan (*Hypericum androsaemum*) in New Zealand

D.Alker
Tutsan Advisory Group member

As you can see from the listing opposite, distribution of tutsan (*Hypericum androsaemum*) is widespread and gaining momentum. From feedback received most areas have tutsan but those contacted are not aware of the potential problem this weed may cause, particularly in waterways, retired areas, established forest, and land low in fertility.

It appears tutsan is becoming more abundant. I am sure there is more out there; if you see any in your travels it would be good to hear about your sightings. Shortly a booklet will be published, outlining what tutsan is and what has been done so far in the quest to find a suitable bio-control agent. Information has been gathered via the internet, NZBI members, regional councils, Department of Conservation and territorial local authorities.

Thank you to those that have already forwarded information.

The Tutsan Action Group (TAG) has completed the first stage and is proceeding with further research.

Tutsan (Hypericum androsaemum)

Tutsan Action Group member Dave Alker (HRC) and the group's chairman, Graham Wheeler, inspect a tutsan infestation.

Brief summary of the distribution of tutsan in New Zealand, on behalf of the Tutsan Action Group (TAG), Taumarunui.

- **Great Barrier Island (1-5 % cover approximately)**
- **Northland**
- **Rangitoto summit**
- **Southwest Rodney area.**
- **Coromandel (Thames Coast)**
- **Bay of Islands. (Puketi Omahuta, Otangaroa Rd)**
- **Bay of Plenty**
- **Taupo/Rotorua, Waioeka Gorge SH2**
- **Waikato**
- **Otorahonga, South Waikato**
- **Awakino Gorge**
- **Central Plateau, (5-15% – King Country, Ruapehu)**
- **Taranaki (Egmont National Park)**
- **Mokau River**
- **Manawatu Region,**
- **Wairarapa, Rumahaunga River corridors**
- **Wellington**
- **Chatham Islands**
- **Marlborough Sounds**
- **Nelson (Maitai Valley)**
- **Karamea to south of Haast, and inland to Otira and Reefton**
- **Christchurch city**
- **Queenstown**
- **Southland**
- **Stewart Island**

Note: The distribution is presence information only as sites vary in size and density. Most regions have minimal records and don't know the percentage area covered.

For this to happen we are going to require more funding; TAG needs to acquire 40 per cent of the estimated $300,000 required for the three-year project.

Canvassing of funding partners is under way and if your organisation wants to become part of this programme and contribute financially that would be great. The more monetary support we can get from other sources lightens the load on the local group, and the more likely we are to get funding approved. TAG believes that tutsan is a national problem and survey results suggest this to be so.

Biocontrol

Western Bay of Plenty biological control survey

Sara Brill
Pest Plant Officer
Environment Bay of Plenty

A survey of biological control agents in the western Bay of Plenty was undertaken in the summer of 2008-2009 by Environment Bay of Plenty summer student Josh Muller. The survey focused primarily on gorse and nodding thistle agents, their spread and impact on seed production in the region. The progress and observations of three agents for ragwort and one for Californian green thistle beetle were also recorded.

Gorse agents

The two agents for gorse surveyed were the gorse seed weevil (*Apion ulicis*) and gorse pod moth (*Cydia succedana*).

A total of 41 gorse sites were visited around the western Bay of Plenty. Over all 41 sites, 47.5% of gorse seed was destroyed by the combination of the gorse seed weevil and the pod moth. Ten percent of damage being attributed to pod moth and 37.5% attributed to seed weevil damage. Where damage was heaviest, 80-90% of the seed was destroyed

The destruction of gorse seed does not reduce the amount of gorse currently in the region but hinders the rate at which it can spread.

The gorse seed weevil is currently providing the most effective seed destruction of the two agents; it is the most widespread and was found in the largest numbers. The pod moth appeared to be less effective, its spread throughout the survey region was limited (only 28 of the 41 sites visited) and numbers at sites where the agent was found were minimal.

The pod moth is probably still at the "establishing" phase in the Bay of Plenty whereas the gorse seed weevil is well established across the region.

Effective population numbers of agents however, can be gauged by the effectiveness of individuals. One seed weevil larvae will only destroy on average one gorse seed. One pod moth caterpillar can destroy all the seeds in several pods. In this instance, one pod moth caterpillar may be just as effective as 20 seed weevil larvae. It can therefore be expected that when contribution to seed destruction by both agents is equal, numbers of the pod moth caterpillar on plants may be less than the number of seed weevils.

*Larvae of the pod moth (***Cydia succedana***).*
Photos: Walter Stahel

This survey did not take into account the effect on gorse caused by other biological control agents. The gorse thrip and gorse spider mite both feed on the plant itself. Both these insects can be found in areas around the Bay of Plenty.

Nodding thistle

Nodding thistle gall fly (*Urophora solstitialis*) and receptacle weevil (*Rhinocyllus conicus*) were the agents surveyed for nodding thistle.

Nodding thistle can be found throughout the Bay of Plenty. During the course of the survey, various sites containing nodding thistle plants were inspected. All sites examined (except one) showed evidence for the presence of the receptacle weevil and/or gall fly. The numbers of these agents varied greatly between sites. The number of sites where receptacle weevils were observed far outnumbered the sites where nodding thistle gall flies were found.

From the seed data obtained, it was calculated that between 81.76% and 88.24% of the seeds in the thistle

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heads were being destroyed. The seeds are transported mainly by wind and this intensity of seed destruction severely limits the spread of this pest plant.

A combination of both the nodding thistle gall fly and receptacle weevil biological control agents was observed to have the greatest effect on the viable seed production of nodding thistle plants. The damage to seed of nodding thistles caused by single agents was not as effective as the combination.

Ragwort

Both the flea beetle (*Longitarsus jacobaeae*) and plume moth (*Platyptilia isodactyla*) agents have been released on a site in Whakamarama. This site had been sprayed by the farmer but fortunately both biological control agents had spread into an adjacent area with a different landowner.

The flea beetle is now widespread throughout the Bay of Plenty region and evidence of its presence can be found on the majority of ragwort plants in the region. The plume moth is currently only established at a few sites.

From the data collected at the Whakamarama site it was difficult to conclude the extent of the damage to ragwort caused by the plume moth larvae. Several infested rosette plants did not mature, probably as a result of the larvae boring into the crown of the plant. Mature plants were often weakened causing them to snap off and die as a result of caterpillar damage. Most of the caterpillars were found further up the plant than expected, tunnelling into different sections of stem ranging from the bottom to the top of the plant.

Most likely the plume moth caterpillars are effecting the growth of ragwort in combination with damage inflicted by the flea beetle. Signs of the flea beetle and the beetles themselves were found on most plants in the quadrants surveyed.

The cinnabar moth (*Tyria jacobaeae*) was found in dense populations at specific sites and caterpillars were observed at several sites stripping entire ragwort plants down to just stalks. No data was recorded but the damage they were causing was noted. In large numbers the caterpillars are effective at controlling ragwort.

Californian green thistle beetle

The green thistle beetle (*Cassida rubiginosa*) is native to Europe, eastern Mediterranean, north Asia and northern Africa. The beetle was introduced to New Zealand in 2006 by Landcare Research on behalf of the Californian Thistle Action Group.

Sixty five Californian green thistle beetles were released at a site in the Bay of Plenty on November 11, 2008. An intial inspection revealed only a small amount of feeding damage and no sign of the beetle. A second inspection on February 2, 2009 found signs of leaf damage caused by the beetle larvae and adults in an estimated area of 80m².

Damage caused by the beetle at present is minimal. Plants where several beetles and larvae were spotted did show signs of extensive leaf damage, showing promise of the beetle's effectiveness, should population numbers increase. The presence of larvae (damaging stage of agent) indicates that the beetle has adapted to the conditions at the site and is continuing with its life cycle.

It is hoped that widespread releases can begin soon in the Bay of Plenty.

Larvae of the receptacle weevil (*Rhinocyllus conicus*).

Californian thistle beetle (*Cassida rubiginosa*).

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New hope for biological control of Californian thistle in New Zealand

Michael Cripps
Bio-Protection Research Centre

Californian thistle (*Cirsium arvense*) was inadvertently introduced to New Zealand about 130 years ago and quickly became a serious weed of arable and pasture land. Its common name reflects the probable source of importation into New Zealand and Australia, but in fact the plant is native to Eurasia.

Classical biological control of weeds involves the importation of co-evolved natural enemies (insect herbivores or pathogens) from a plant's native range with the aim of permanently suppressing weed abundance and/or dispersal.

Previous attempts at classical biological control of Californian thistle in New Zealand have been unsuccessful due to the failure of agents to establish, or lack of impact on the plant. However, hope for successful biological control is not lost. Because New Zealand has no native thistle plants, it can safely import natural enemies, thus providing many options for potential biocontrol agents.

Renewed interest in classical biological control of Californian thistle has resulted in the recent release of two new biocontrol agents in New Zealand: the stem-mining weevil, *Ceratapion onopordi*, and the leaf-feeding beetle, *Cassida rubiginosa*. As yet, it is too early to say what impact these agents will have, but research done in the plant's native range offers some insights.

A primary aspect of my PhD programme at Lincoln University was investigating the impact of these two biocontrol agents and the influence of natural enemies on Californian thistle in general. Part of my research was carried out in Switzerland, where I investigated the impact of natural enemies on this plant in its native range. The rest was done in New Zealand, allowing me to compare results between the plants' native and introduced range.

Studies included a comparative survey of Californian thistle growth and natural enemy pressure in Europe versus New Zealand, a test of the natural enemy influence on the population growth of the plant in Europe and New Zealand, and a specific assessment of the impact of the leaf-feeding biocontrol agent, *C. rubiginosa*.

The results of the field surveys showed that contrary

The stem-mining weevil,* Ceratapion onopordi*, on Scotch thistle (*Cirsium vulgare*) in St Ursanne, Switzerland.

Adult form of the leaf-feeding beetle,* Cassida rubiginosa*.

to popular belief, growth of Californian thistle is similar in Europe and New Zealand. However, as expected, natural enemy attack is severely reduced, or completely absent in New Zealand.

The field surveys in New Zealand showed that the biocontrol weevil, *Rhynocyllus conicus*, attacks approximately 24% of the seed heads on Californian thistle shoots in the North Island, but is absent in the South Island. This weevil primarily attacks nodding thistle (*Carduus nutans*), and levels of attack on Californian thistle in New Zealand were previously unknown.

The comparative field surveys also highlighted a complete lack of stem-miners inside New Zealand Californian thistle shoots, compared to the native range where stem mining is relatively common. These studies also confirmed that the specialised rust pathogen, *Puccinia punctiformis*, is widespread across New Zealand, although the proportion of shoots infected is generally less than 5%.

The use of *P. punctiformis* for biological control has been hampered by an incomplete understanding of its infection process. Within the last decade, studies by a European research group suggested that stem-mining weevils can promote rust infection, and it was presumed that their release in New Zealand might increase the effectiveness of rust for biocontrol of Californian thistle.

Bio-Protection

Bioprotection science for New Zealand

The Bio-Protection Research Centre is a Centre of Research Excellence focused on developing new biological knowledge of pest organisms and their interactions with host plants, leading to the development of novel biologically based solutions to these problems. This research contributes to enhanced sustainability of New Zealand's production systems, and is leading a shift away from pesticide-dependent control methods and towards integrated pest management.

The centre incorporates one of the strongest bio-protection postgraduate training groups in the southern hemisphere and is closely linked to renowned overseas institutes.

Feeding damage caused by larva of the leaf-feeding beetle,* Cassida rubiginosa*, on Californian thistle (*Cirsium arvense*) in St. Ursanne, Switzerland. The larva pictured is bearing its faecal shield.

However, my comparative field surveys showed that despite the presence of stem-miners in Europe, the incidence of rust disease there is just as low as it is here, suggesting that the new stem-mining biocontrol agent may not increase the incidence of rust in New Zealand. For this reason, monitoring its direct impacts after establishment will be important.

The European studies showed that when insects and pathogens are removed from thistle patches using insecticides and fungicides, thistle populations benefit, suggesting that natural enemies can have significant impacts on the population growth of Californian thistle. However, as it is still uncertain which natural

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enemies affect the plant in its native range, selecting the optimal biological control agent(s) for use here is challenging.

Experiments with the newly released leaf-feeding beetle (*C. rubiginosa*) showed that it can reduce thistle biomass both above and below-ground. This is important, as in established populations of Californian thistle the extensive clonal roots are the overwintering propagules from which new shoots arise the following season. Therefore, it is predicted that a reduction in root biomass caused by this beetle could reduce shoot production the following season.

How *Ceratapion onopordi* and *C. rubiginosa* adjust to their novel environment in New Zealand will be a critical factor in determining their success as biocontrol agents. In Europe both insects experience high rates of predation and parasitism, limiting their impact on Californian thistle. Levels of attack from predators are also likely to be a key determinant of their success in New Zealand.

The story of biological control of Californian, and other thistles, in New Zealand is certainly not over, but new hope is here, and the effectiveness of these new biocontrol agents will be monitored with much anticipation.

Californian thistle shoot infected with the rust pathogen,* Puccinia punctiformis*, at Pukeatua, New Zealand.

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Bioherbicides – what's happening in New Zealand?

Graeme W. Bourdôt
AgResearch
Lincoln, Private Bag 4749, Christchurch, New Zealand
graeme.bourdot@agresearch.co.nz

Bioherbicides typically utilise indigenous and, necessarily, facultative parasites (often fungi or bacteria) that are able to be mass-produced in vitro and applied to weeds in the field in the same manner as conventional herbicides (i.e. through hydraulic nozzles or granule spreaders). The obligate parasites preferred in "classical" microbiological weed control (because of their host-specificity, e.g. rusts) are unsuitable as bioherbicides. This is because they cannot be cultured without their host (Charudatten 1988), precluding their production by fermentation processes.

Formulation development research and field application trials in New Zealand have shown that the widespread and facultative pathogenic fungus *Sclerotinia sclerotiorum* has potential as a bioherbicide against Californian thistle (*Cirsium arvense*) and giant buttercup (*Ranunculus acris*) in pastures (Hurrell & Bourdôt 1993; Verkaaik et al. 2004; Bourdôt et al. 2006b).

It has also proven effective in greenhouse studies against a range of additional pasture weed species including the annual thistles nodding thistle (*Carduus*

Winged thistle 26 days after application of* Sclerotinia sclerotiorum*.

***Nodding thistle 26 days after application of* Sclerotinia sclerotiorum.**

***Californian thistle 26 days after application of* Sclerotinia sclerotiorum.**

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nutans), slender-winged thistle (*C. pycnocephalus*), winged thistle (*C. tenuiflorus*) and Scotch thistle (*Cirsium vulgare*), and ragwort (*Senecio jacobaea*).

Such a bioherbicide would be suitable for pastoral production systems aiming to reduce chemical herbicide use. But technical challenges associated with cost-effective commercial scale-up remain to be solved.

In addition, the fungal pathogens *Fusarium tumidum* and *Chondrostereum purpureum* have been the subject of research as potential woody weed bioherbicides (Bourdôt et al. 2006a; Ramsfield 2006). *C. purpureum* is currently being tested on a wide range of NZ's woody weeds by scientists in Scion and AgResearch as part of the FRST-funded research programme Undermining Weeds.

Furthermore, recent studies carried out by AgResearch scientists funded by Meat & Wool New Zealand have resulted in the discovery of several naturally occurring fungal pathogens on Californian thistle in New Zealand that are potential bioherbicides. One of these is being researched currently in farm-scale trials throughout New Zealand. This fungus is thought to be involved in the demise of the thistle when mown during rainfall, a phenomenon frequently reported by farmers. The farm-scale trials, along with controlled-environment studies, aim to optimise the effect of mowing Californian thistle in the rain.

The other fungus discovered on Californian thistle (a new international record) is the subject of a new collaboration between AgResearch and Agriculture and Agri-Food Canada. This collaboration is aiming to develop a commercially viable bioherbicide for use against Californian thistle in NZ and Canadian pastures and possibly also for arable crops.

To date none of these plant pathogens has been developed as a commercially available bioherbicide in New Zealand. This is in part because of their variable field efficacy (Bourdôt et al. 2007) and/or because of the technical problems associated with production scale-up. In addition, the social mandate for biological alternatives to synthetic herbicides in New Zealand remains weak in comparison to that in other countries such as Canada where government targets to reduce herbicide use have been set (Bailey et al. 2009 – in press).

Acknowledgements

I thank the New Zealand Foundation for Research Science and Technology (Undermining Weeds programme [C10X0811]), Landcare Research, Dairy InSight, EnCoate NZ Limited and Meat & Wool New Zealand for funding, and Geoff Hurrell, AgResearch, for technical support.

Giant buttercup 26 days after application of* Sclerotinia sclerotiorum*.

Gorse plant 12 months after cutting and application of* Chondrostereum purpureum *showing dead plant with fruiting bodies of the fungus.

Gorse population in Gebbies Valley, the site of* Chondrostereum purpureum *experiment.

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Biocontrol

Reflecting on 25 years of biocontrol in Southland

By Jesse Bythell
Biosis Ecological Consulting Company
jesse@biosis.co.nz

In the summer of 1984 Wallace County Council noxious plant officer Peter Ayson was carrying out a routine ragwort inspection on a property near Colac Bay, Southland. The ragwort was so thick and tall it felt more like steering a boat through a yellow sea rather than driving a truck across a paddock. Naturally, this property immediately came to Peter's mind when the Department of Scientific and Industrial Research (DSIR) asked if the Wallace County Council would be interested in using biological control insects to combat ragwort. So began Southland's 25 year involvement with biological control agents.

The first biocontrol agent to be used in Southland was the cinnabar moth (*Tyria jacobaea*) in 1984. These moths were released without fanfare by Peter Ayson and Mr and Mrs Blakie on their Colac Bay dairy farm. The following year the ragwort flea beetle (*Longitarsus jacobaea*) was also released on the farm and over the years these two insect populations prospered and provided many thousands of insects for release onto new properties. The Blakies have since sold the farm, and although there is still some ragwort present, it is at a level that that can be tolerated.

To date, 28 biocontrol agents have been introduced in Southland, resulting in 378 primary releases (see Table 1, on next page for list of agents and their status). Approximately 36% of sites have established or are recovered (i.e. showing early signs of establishment). New releases and remote sites make up 22% of sites which have not yet been monitored, and the status of about 9% of sites is uncertain. Not all populations are successful and about 10% of sites have failed to establish. A further 20% have been destroyed; usually sites are destroyed by accident when land is sold or the landowner forgets exactly where the insects are located. Not all biocontrol agents in Southland have been as successful and biocontrol may not be the best solution for all property types.

The ultimate aim of classical biocontrol is to enable agents to naturalise and spread to wherever their hosts are present. Once we "kick start" the process by making the first releases, the agents form self-sustaining populations which remain year after year knocking back their hosts. Many years of carrying out releases at carefully selected sites is starting to pay off. Self-established populations of broom twig miner moth, broom psyllid, ragwort flea beetle and the gorse spider mite are now cropping up across Southland. When agents reach this stage, the focus shifts to carrying out releases in remaining areas where the agent in question is not yet present.

Over the years the organisations administering biocontrol have changed in Southland. Today Environment Southland employs contractors Peter Ayson and Jesse Bythell, part-time to monitor and release biocontrol agents.

Biocontrol is now gaining wider support in the Southland community and in 2008 the Te Anau Biocontrol Group was formed. The group aims to help facilitate the distribution of biocontrol agents in the Te Anau Basin and surrounding area. The group's membership consists of private landowners and staff from Environment Southland and the Department of Conservation. In spring the group plans to release two new broom agents: the broom shoot moth (*Agonopterix assimilella*) and the broom leaf beetle (*Gonioctena olivacea*). The money to purchase these agents came from Land Information New Zealand and the Meridian Energy Community Fund.

During the last 25 years the focus has remained on combating broom, gorse, ragwort and thistles. To date, gorse has remained the toughest nut to crack, but agents for ragwort and broom have made great progress and new thistle agents are showing early promise. There is no doubt that it is a difficult task to maintain momentum and support for projects which can take more than a decade to come to fruition. However, because of the determination and commitment shown by many people over the years, Southland is now benefiting from an array of effective and well-established biocontrol agents. It will be exciting to see what the future holds for the biological control of weeds in Southland.

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Table 1: Summary of all biocontrol agents released in Southland since 1984

				Status of release sites					
	First released	Total number of sites per agent	Overall agent status	Established	Recovered	Status uncertain	Not yet monitored	Site destroyed	Failed
Broom agents									
Broom leaf beetle	2007	1	Uncertain			1			
Broom psyllid	1995	30	Established	10	2		16	2	
Broom seed beetle	1995	22	Established	6	1	3	3	7	2
Broom shoot moth	2009	1	Not yet monitored				1		
Broom twig miner moth*	1987	32	Established	12	2		16	2	
Gorse agents									
Gorse colonial hard shoot moth	2002	2	Uncertain						
Gorse pod moth	1992	14	Established	2	1	1		7	3
Gorse soft shoot moth	1990	11	Uncertain			2	5	3	1
Gorse spider mite	1989	49	Established	49					
Gorse thrips	1990	14	Established	2		1		9	2
Hieracium agents									
Hieracium gall midge	2006	8	Established	3	4		1		
Hieracium gall wasp	2000	5	Uncertain	1	1	2		1	
Old man's beard agents [1]									
Old man's beard leaf fungus	1997	4	Sites destroyed					4	
Old man's beard leaf miner	1996	2	Sites destroyed					2	
Ragwort agents									
Cinnabar moth	1984								
Ragwort crown boring moth	2007	1	Uncertain			1			
Ragwort flea beetle	1985	137	Established	22	14	18	30	30	23
Ragwort plume moth	2006	4	Established	1	1	1	1		
Thistle agents									
Californian thistle flea beetle	1995	1	Failed						1
Californian thistle gall fly	1997	9	Uncertain				2	4	3
Californian thistle leaf beetle	1992	3	Failed						3
Californian thistle stem miner	2009	1	Not yet monitored				1		
Californian thistle weevil	1992	2	Failed					1	1
Green thistle beetle	2007	11	Established	2	1		8		
Nodding thistle crown weevil[2]	1989	4	Established	1				2	1
Nodding thistle gall fly[2]	1994	6	Uncertain		1	3		2	
Nodding thistle recepticle weevil[2]	1986	3	Established	1				1	1
Scotch thistle gall fly	2000	1	Uncertain			1			
		378		112	28	34	84	77	41
Percentage of all sites				**29.6%**	**7.4%**	**9.0%**	**22.2%**	**20.4%**	**10.8%**

[1] Old man's beard is now an eradication weed in the Southland RPMS and biocontrol efforts are no longer appropriate

[2] Nodding thistle is a containment weed in the Southland RPMS and biocontrol efforts are no longer appropriate

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biological control

THE FIRST 25 YEARS

Gwyn at Environment Southland

biological weed control
doesn't mean much to some
but for Keith and Peter, 25 years ago
when this work was begun
they have certainly struggled
and there has been a number of failures
but like those persistent pest plants abound
these two blossom each year - like your dahlias
they've fought the cursed gorse
they've fought the prolific broom
they've targeted the thistles and the ragwort
which multiply with the spring/summer bloom
there's also been the clematis
and the old mans beard at large
darwin's barberry and blackberries
seem to think they are the one's in charge
so now it's over to the insects
which have been imported especially for the weeds
they've been released throughout Southland

where they will fulfil their entire needs
yes, free board and lodgings
a continuous supply of food
their hours are simply dawn to dusk
then at night – hanky-panky – if they're in the mood
these insects need to multiply
to build a vital workforce

and as the years roll on by
future generations will wonder 'what was that pest plant gorse'
to assist with the biological control
Jesse has now joined the ranks
hopefully in just another 25 years
it'll be native grasses and trees over Southland and it's river banks
to Peter, Keith and Jesse - we know you won't want a fuss
'weeds are like people, we may all be different
but you sure gotta dig us' (taken from Keith's email address)

Gwynn
February 2009

Biocontrol

Buddleia leaf weevil off to a promising start in New Zealand

Michelle Watson & Toni Withers
Forest protection,
Scion,
Rotorua

The buddleia leaf weevil was first released in New Zealand in 2006, the first release of this species as a biocontrol agent for the pest plant buddleia (*Buddleja davidii*) in the world.

Buddleia is an invasive weed of Chinese origin, common in exotic and indigenous forests in New Zealand. It colonises disturbed sites and riverbeds, competing with tree crops, shading waterways and displacing native pioneer species. The weed is estimated to cost the forestry industry between $0.5 and $2.9 million annually in control costs and loss of production. In addition, councils, the Department of Conservation and other landowners and managers incur ongoing expenses associated with managing this pest plant.

Buddleia plants with their distinctive purple blooms.

The weevil has two damaging life stages: both the larva and the adult feed on the surface of buddleia leaves causing leaves to shrivel and drop.

Five release sites were initially chosen in commercial forests in the central North Island, where buddleia was abundant. One thousand weevils were released at each site over a four month period and we closely monitored them for three seasons between 2006 and 2009. We are delighted to report that the weevil has established at all sites, having now survived two winters and vastly increased in numbers. At one site near Ohope it has spread at least 1km during this time. The weevils have shown a great ability to damage the buddleia plants, with up to 98% defoliation of some plants. Defoliated plants enter winter with no green leaves, yet appear able to re-sprout again in spring. We are unsure what

Buddleia leaf weevil larvae, left and adult, right, showing the damage the two life stages does to the host plant's leaves.

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Buddleia at Kinleith Forest prior to the first release in October 2006, left, and in April 2009, above. Note: the green bush in the foreground is a hebe.

impact this level of damage will have on buddleia growth and reproduction. But as we hoped, the weevil appears to be well suited to the New Zealand climate, although the greatest impact on buddleia was generally seen at the warmer sites.

In order to widely distribute the agent throughout New Zealand where buddleia is found, a further 18 releases of 250, and in a few cases 500, adult weevils were made from 2007 to 2009, from the Far North to Tauranga, Taumaranui, Upper Hutt, Bishopdale and Kaikoura. These releases have resulted in populations being recorded at all sites the following summer. Of note, has been the severe defoliation of buddleia seen at the Tauranga release site only 17 months after the release was made.

The buddleia leaf weevil overwinters as adults, sheltering within leaf litter and, on more sunny days, they can be seen feeding on leaf tips. At most sites in New Zealand very few to no larvae are likely to be present between June and the end of August. Because of this we expect that releases made in mid-spring will have the greatest probability of establishment. This timing allows numbers of weevils to build up in the new site before the following winter. While the optimum number of weevils needed for successful establishment is unknown, it is clear that a release of 250 adults has been sufficient in a wide range of climates. Further work will be undertaken to better understand minimum release numbers.

We are excited about the potential of this weed biocontrol agent to begin to suppress this pest plant throughout New Zealand.

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Biocontrol

Factors behind *Microctonus* species' success against weevil pests in NZ

Pip Gerard, Craig Phillips, Mark McNeill, Barbara Barratt & Stephen Goldson
Entomologists in Biocontrol, Biosecurity and Bioprocessing
AgResearch

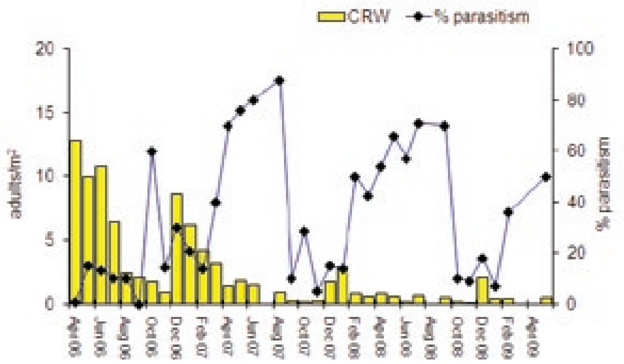
Introduction

Ideally, pests and diseases that threaten New Zealand's primary industry and natural ecosystems are stopped at the border or are detected early enough for authorities to carry out successful eradication programmes. However, when exotic species are able to escape detection and build up to pest levels, other management options have to be employed. Classical biocontrol is an attractive option for the suppression of forage pests in New Zealand. The introduced natural enemy usually spreads over large areas, including inaccessible sites. Once established it is self-perpetuating and freely available to all. Cosmetic damage is of no consequence in forages so the low pest populations that survive in successful biocontrol programmes are tolerable.

Three forage pest biocontrol programmes have been founded on the successful introductions of tiny parasitic braconid wasps from the genus *Microctonus*.

- A Moroccan strain of *M. aethiopoides* was introduced via Australia into New Zealand in 1982 (Stufkens et al. 1987) and has successfully suppressed the lucerne weevil (*Sitona discoideus*) to below damage thresholds in lucerne (Kean & Barlow 2001).
- *Microctonus hyperodae*, which was imported from South America and released in 1991 (McNeill et al. 2002), is now contributing to the control of Argentine stem weevil (*Listronotus bonariensis*) throughout New Zealand.
- The Irish strain of *M. aethiopoides* was released in 2006 for the control of the clover root weevil (*Sitona lepidus*) in NZ pastures (Gerard et al. 2007). Within 18 months, parasitism exceeded 85% at all four initial release sites, and by winter 2009 at North Island sites not affected by the 2008 drought, weevil suppression was clearly evident and parasitism was detected over 60km into surrounding farmland.

In all cases, it is the weevil adult that is attacked, not the more damaging larvae which are relatively inaccessible below ground (*Sitona* spp.) or inside plant tillers (Argentine stem weevil). The *Sitona* spp., in particular, produce a large number of eggs and a high proportion of eggs and newly hatched larvae are lost through predation (e.g. ants), desiccation and competition for larval feeding sites. Therefore adult mortality may have no impact on the establishment of damaging larval populations. In spite of this challenge, these *Microctonus* biocontrol introductions have all been successful. What underlies this success?



Graph showing the annual seasonal abundance of the clover root weevil (CRW) declining over a three year period against the seasonal percentage parasitism by wasps from the genus* Microctonus*. at Patoka, one of the first four release sites.

Wasp attributes

All three *Microctonus* spp have the same mode of action against their hosts. The wasp injects eggs into the abdomens of host weevils. This quickly renders female weevils sterile, breaking the weevil life cycle. The host weevil dies after the wasp larvae complete development and emerge to pupate in the soil and litter. While the wasps do fly and can be dispersed by wind, long distance dispersal is likely also as eggs and larvae in dispersing hosts.

Specific population models have been developed for the first two species listed above which suggest reasons for their success as biocontrol agents (Barlow et al. 2002). A model for the species in New Zealand using observed parasitism levels of 47% predicted sustained suppression of the pest to below economic thresholds. Field testing 10 years later indicated that this was realised, though at lower levels of parasitism (40%). This is because in New Zealand a small proportion of Moroccan *M. aethiopoides* atypically continues

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developing among later emerging hosts within the lucerne crop rather than arresting their development over summer inside the bulk of adult weevil population that leaves the crop to aestivate elsewhere. This allows several generations of the wasp to build up in the crop and "ambush" weevils returning from the aestivating sites in autumn before they can start laying eggs.

Modelling of Argentine stem weevil in New Zealand ryegrass pastures also suggested that it was successfully controlled by *M. hyperodae*. Here a suppression level of 75% was associated with a higher parasitism level of about 75%. This appears to be due to the high searching efficiency of the wasp, synchrony between host and wasp, more generations of wasps per year than of hosts, and a large summer-autumn peak of weevils allowing wasp build up going into winter. The introduction of two strains of *M. hyperodae* that have slightly different seasonalities contributed to this success because each strain quickly became dominant in the parts of NZ to which it was most suited (Phillips et al. 2008).

Both *M. hyperodae* and the Irish *M. aethiopoides* reproduce asexually (only females develop from unfertilised eggs). Therefore these biocontrol agents can start searching for weevils immediately on emergence and can persist at lower densities than might be possible if they needed to find a mate. The discovery of the female-only strain of *M. aethiopoides* from Ireland that had closely co-evolved with clover root weevil was pivotal to the success of the biocontrol programme. After extensive searching, a European strain of *M. aethiopoides* had been identified as the best candidate, but research showed mating between the European and Moroccan strains produced hybrids with poor efficacy against target hosts. Therefore if an introduction of a sexual European strain had proceeded, it could have disrupted the existing biocontrol of lucerne weevil.

Clover root weevil (**Sitona lepidus*****) is sized up by its natural enemy, the parasitoid wasp,* Microctonus aethiopoides.**

The Irish *M. aethiopoides* is possessed with another key attribute contributing to its success in that, unlike the other two *Mictoctonus* that produce only a single wasp per weevil, it can produce multiple progeny from a single host. This flexibility to lay one or more eggs per host gives it ability optimise oviposition, enabling it to produce relatively more (but smaller) offspring per host when host availability is low, and fewer (but larger and more fecund) progeny when hosts are abundant. This ability means it can survive a bottleneck of host availability in spring, multiply rapidly through several generations in summer when adult weevils are most abundant, and during the autumn achieve peak parasitism in the weevil generation that produces the damaging winter larval population.

Ecosystem attributes

The NZ pastoral ecosystem has also contributed to the success of the biocontrol programmes. Forage crops and pastures are usually perennial systems that permit stable host-prey relationships, although there can be some disturbance through grazing, mowing, and climatic events such as drought and flood. There is also little use of pesticides because of the cost of treating large areas combined with stringent international controls on residues in farm produce. As a result there is minimal likelihood of biocontrol disruption through pesticide impacts. The introduced *Microctonus* biocontrol agents have always caused far higher levels of weevil parasitism in NZ than in the places they were collected from, probably because they have no specialised natural enemies such as hyper-parasites here as they do overseas (e.g. Goldson et al, 1997). Therefore they established in an environment where they have no specialised natural enemies, abundant hosts, little competition, and for *M. hyperodae* and the Irish *M. aethiopoides*, a host-habitat continuum throughout NZ.

Robust risk assessment

While insect biology and ecosystem attributes were crucial to the success of the biocontrol programmes, the measures of success have changed as awareness of potential negative impacts of biocontrol introductions has grown. It is now known that the Moroccan *M. aethiopoides* parasitises a number of native and exotic non-target weevils, especially broad-nosed weevils in the subfamily Entiminae (Barratt 2004). While there is no evidence of a significant adverse impact on these weevil populations, the knowledge of this unexpected wide host range contributed to increased concern in New Zealand about the potential impacts of all new biocontrol agents on non-target species (e.g. Barratt et al. 2000), including a new *M. aethiopoides* strain. Because of

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this concern, at AgResearch's request, in December 2004 the Minister for the Environment prescribed *M. aethiopoides* to be a "risk species". As a result all strains, with the exception of the Moroccan strain, are considered to be "new organisms" and as such require a HSNO Act approval. Therefore host range tests were carried out in quarantine with a number of NZ species which have taxonomic and ecological affiliations with clover root weevil (Goldson et al. 2005). The case made to ERMANZ was based on the comparative data on host-specificity testing between the Moroccan and Irish strains of *M. aethiopoides* which indicated that the latter is likely to have a narrower host range.

Expertise and resources

The success of a biocontrol programme depends on the team involved, its network of collaborators, and the resources available. The three *Microctonus* programmes had team members in common. The expertise gained in the research associated with the lucerne weevil biocontrol programme provided the knowledge basis that facilitated the Argentine stem weevil programme, which in turn assisted all aspects of the research and implementation of the search, introduction and release of the clover root weevil biocontrol.

By their nature, classical biocontrol programmes require substantive funding for at least 6 to 10 years from initiation to implementation. For the lucerne weevil, the biocontrol programme was funded by the government through DSIR and MAFTech. However, changes in research funding policies in the 1990s meant that AgResearch researchers were encouraged to set up and run the commercial production, marketing and distribution of *M. hyperodae* (McNeill et al. 2002). The clover root weevil programme was initiated after the implementation of the competitive funding system and would not have been possible without long-term funding from FRST, DairyNZ, Meat & Wool New Zealand and their industry predecessors. With the economic restrictions associated with the current funding systems, the AgResearch team had to apply considerable kiwi ingenuity to achieve their goals. This was highlighted during the search phase when the team set up temporary bases in the USA, UK and France, and obtained free use of laboratory facilities and multiple weevil and natural enemy samples through the support of collaborators in University of California, IGER, Teagasc, DARD, USDA and the EU COST Action 814 programme.

Conclusion

The success of these three *Microctonus* introductions is due to the favourable combination of effective biocontrol agents, New Zealand pastoral ecosystem attributes, and commitment by researchers and funders from initiation to delivery on-farm. The expertise developed through these series of introductions has contributed to New Zealand researchers being recognised as leaders in biocontrol research, in particular in predicting host range and non-target impacts of agents.

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News

Government and locals work together to fight marine pests

The potential for marine pest species to harm the unique marine environment of the top of the South Island is being minimised through the work of a new partnership between central and local government, the eight iwi of the area through their customary fisheries forum, community and industry interests.

This collaboration, known as the Top of the South Marine Biosecurity Partnership, was formally launched in Nelson in August and is a pilot programme for achieving regionalised protection of the marine environment and local marine-based industries.

While initially co-ordinated by MAF Biosecurity New Zealand (MAFBNZ), the partnership includes representation from the three local councils (Marlborough District, Tasman District and Nelson City), iwi through the Te Tau Ihu Customary Forum, the Ministry of Fisheries, Department of Conservation, the local aquaculture industry and port companies.

The local government authorities have made a financial commitment to the programme, each contributing $20,000 a year for the next two years, with MAFBNZ matching this contribution.

The parties, with diverse interests, have agreed on a strategy with priority actions, starting with the contracting of local company Mincher Campbell Ltd to undertake co-ordination and advocacy work.

Co-ordinator Russ Mincher said that in the first instance he and partner Al Campbell would get to know local interests involved with the area's coastal waters, identify the high-value areas to protect, develop local surveillance programmes to look out for new marine pest species and begin to identify those activities that pose a risk of spreading marine pests.

"There is a lot to protect in this region. As well as its unique environmental attributes, the area has a large coastline enjoyed for its recreational opportunities and which is used by a significant aquaculture industry," Russ Mincher said.

"Marine pest species, such as the locally prolific sea squirt, *Didemnum vexillum*, can damage the very environment we value here. This new partnership is an exciting initiative to protect what's at stake".

Mr Mincher said one of the key actions local boat owners must embrace was that it was vital the hulls of moored boats were kept clean and well antifouled.

Those familiar with the marine life of the Marlborough/Nelson/Tasman areas are encouraged to report anything unusual they see to MAFBNZ's pest and disease hotline: 0800 80 99 66.

Uptake of Check, Clean, Dry message continues to grow

The Check, Clean, Dry communications programme is gearing up again as the fishing season and the busy summer months approach.

The aim of the programme is to get waterway users to always Check, Clean, Dry equipment and clothing between waterways to help slow the spread of didymo and other freshwater pests. The programme is co-ordinated nationally by MAFBNZ, in partnership with Department of Conservation, Fish & Game NZ, regional councils, affected industry and iwi. Partners are instrumental in implementing the programme in the field, including distributing collateral and carrying out advocacy work on waterways and at events, particularly over the summer months. This approach has proven to be very successful over the past few years.

MAFBNZ's 2009 audience research shows that:

- 97 percent of fresh waterways users recall seeing some information, advertising or giveaway from the programme
- 94 percent of fresh waterways users know the phrase Check, Clean, Dry
- Nine out of 10 fresh waterways users say they have considered how they can slow the spread of didymo.
- Eight out of 10 fresh waterways users are familiar with what they need to do to help slow the spread of didymo.
- Seven out of 10 fresh waterways users now always check, clean, dry and another two out of ten say they sometimes do.
- Year-on-year, we have increased the percentages of freshwater users who say they think about how they can stop the spread of didymo, they have taken an action to do so, and they always check, clean, dry.

Most fresh waterway users are familiar with the concept of check, clean, dry in relation to didymo, and the communications programme is now focusing on broadening the message to include other freshwater pests.

For more information about the Check, Clean, Dry communications programme see www.biosecurity.govt.nz or contact Matthew Thorpe at matthew.thorpe@maf.govt.nz

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