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General News

PRONTI: Improving Selection of Test Species in Invertebrate Biological Control

A computer-based tool developed by New Zealand scientists to identify invertebrates for biosafety screening for transgenic plants[1] has been adapted to rank potential nontarget species for testing against proposed entomophagous biocontrol agents. The tool has been tested in case studies on non-native predatory and parasitoid insect species that are already present in New Zealand. It is also being trialled in Canada. This research was carried out within the New Zealand Research Collaboration, Better Border Biosecurity (B3).

The PRONTI (priority ranking of non-target invertebrates) tool comprises a database of species information and a model. A Microsoft Access® database, Eco Invertebase, was compiled from published material for invertebrate species in New Zealand, covering initially (for transgenic plant work) taxonomy, biology, ecology, social/cultural importance and culturing/testing. The model is based on five criteria: (i) direct and indirect hazards from the new organism, (ii) likelihood of exposure of the nontarget species to these hazards, (iii) potential ecological impacts from exposure, (iv) the anthropocentric value of the nontarget species, and (v) how easy the nontarget species is to test. The first two criteria (hazard and exposure likelihood) produce a risk estimate that drives the ranking process.

For each criterion, one or more parameters were selected and quantified by scoring information on relevant species' attributes in the database. 'Uncertainty' is catered for in scoring because data are not always complete or reliable (e.g. a native species may have been little studied). Parameters and criteria can be weighted for importance, and this can be varied to see how rankings change, or if, for example, new information comes to light or priorities change. Equally, new attributes can be added. The reliability of assumptions and decisions can be tested by creating 'dummy' species and assigning them attributes expected to give them a particular placing in the list.

Adapting PRONTI for biological control was facilitated by the similarity between the model's criteria and those used in biological control best practice to select nontarget species for host-specificity testing. Moreover, transgenic organisms and biocontrol agents are regulated in New Zealand by the same legislation (the Hazardous Substances and New Organisms Act 1996) so the regulatory requirements for risk assessment are similar.

Transgenic plants and biocontrol agents do not pose identical risks, so adapting the database involved modifying some parameters; for example, to take account of different mechanisms of resilience (the ability of individuals or populations to mitigate risk). In addition, extra parameters were added to cover attributes relevant for biological control, drawing on published protocols for selecting nontarget species test lists; for example, taxonomic relatedness to the target pest(s) was added as a direct hazard. For biological control purposes, the model uses data on the proposed agent as well as potential target and nontarget species, so data from published literature on each proposed biocontrol agent were also added to Eco Invertebase.

New Zealand biological control scientists have published three case studies to assess PRONTI: (i) For an accidentally introduced generalist predator treated as a hypothetical biocontrol agent, how well do species ranked highly by PRONTI correspond to species that are preyed on in the field?[2] (ii) For a historical (1982) introduction, would PRONTI have identified nontarget species that have been attacked by the introduced agent?[3] (iii) For a recent (2011) introduction, how does the test species list that was arrived at by current best practice compare with PRONTI's species rankings?[4]

Polistes chinensis: *predictions vs field results*

Polistes chinensis is an accidentally introduced generalist predator and unlikely to have been considered for introduction. A theoretical exercise was undertaken to assess it as a hypothetical augmentative biocontrol agent for lepidopteran pests in kiwifruit orchards. Kiwifruit orchards were selected because they form a relatively enclosed system (with shelterbelt barriers to deter wasp emigration) and kiwifruit is New Zealand's leading fruit export.

Data on 340 invertebrate taxa known to occur in kiwifruit orchards were entered in Eco Invertebase (including five lepidopteran pests of kiwifruit). Species highly ranked by PRONTI included the hypothetical pest targets, other Lepidoptera known to be preyed on by *P. chinensis* (together with their relatives), species that shared the targets' food plants, and also species that might suffer both attack and competition (hoverflies).

In a linked field study, *P. chinensis* colonies were introduced into orchards, prey were collected and identified, and PRONTI predictions compared with actual predation records. Analysis of prey indicated that *P. chinensis* fed mostly on Lepidoptera and especially noctuids, but to some extent on other predators (hoverflies and spiders). The authors conclude that the reasonable similarity between model and field results indicates that PRONTI would have correctly identified actual lepidopteran prey either directly or by relatedness to highly ranked species. The study did highlight the difficulties created by absence of complete data; this emerges in other case studies, and also hinders conventional methods of selecting test species.

Microctonus aethiopoides: *predicting nontarget effects*

Microctonus aethiopoides (originally from Morocco) was introduced to New Zealand in 1982 as a biocontrol agent for the lucerne weevil, *Sitona discoideus*. At the time, the biocontrol agent was thought to be specific to the weevil genera *Sitona* and *Hypera*, neither of which have native species in New Zealand, and host-range testing focused on chrysomelid and weevil weed biocontrol agents. Following its release, it has been recorded parasitizing a number of nontarget species, mostly native species from the same subfamily but a different tribe (Leptopiini) to *S. discoideus*.

The study looked at how closely species prioritized (i.e. highly ranked) by PRONTI matched species selected at the time for testing, and whether PRONTI would have predicted the nontarget effects from contemporary evidence; i.e. whether it is a more robust system. Subsequent studies have changed understanding of the host range of *M. aethiopoides* in its native range and of the phylogenetic relationships of relevant weevil groups[5], while values placed on native species have increased. Contemporary (<1982) information for relevant species was input into Eco Invertebase, although current taxonomy was used, and current native species value was included in the PRONTI model.

Of the 82 potential nontarget species in Eco Invertebase that were ranked by PRONTI, all 12 species that have been recorded as attacked by *M. aethiopoides* were in the top 30 species, and ten were in the top 17 – with, as expected, the target *S. discoideus* the top-ranked species. Species selected for testing in 1982 were also included, but only one was prioritized above 30 by PRONTI and, post-release, this species had proved to be a host for *M. aethiopoides*, while the remainder were not. PRONTI was thus highly effective in identifying species at risk, although the authors note that acquired knowledge and changes in test species selection methodology since the 1980s mean current best practice would also have identified at-risk species.

Cotesia urabae: *comparing current best practice*

The final study looked at the introduction in 2011 of *Cotesia urabae* against a noctuid forestry pest, *Uraba lugens*, as a representative of current best practice in test species selection. The aim was to investigate whether PRONTI could improve further on selection methodology. To ensure objectivity, the PRONTI tool was operated only by a scientist who had not been involved in the original test species selection or host-range testing.

The flexibility of PRONTI allowed two noctuid phylogenies to be tested, which might have been critical: taxonomic relatedness had been given greatest weight in both the original test species selection and PRONTI because the parasitoid had been recorded only from *U. lugens* in its native range.

Data for 90 potential nontarget species were entered in Eco Invertebase, including the nine species in the original test list. PRONTI ranked five of these among its top nine species, while a tenth species that has been included in post-release testing was ranked ninth. Post-release testing has found that two species on the original list and in PRONTI's top nine are attacked by *C. urabae*. Lower PRONTI rankings for the other four original test species is attributed to differences in weighting; some were ranked lower because PRONTI gave added weight to a lower risk of exposure, while another is an invasive pest and thus had a low 'value' weighting in PRONTI. This pest was on the original host list, however, as a proxy for a related rare, endemic species, yet the rare species was ranked even lower than the invasive pest by PRONTI because of low testability and high uncertainty (little is known about it). The authors argue this reveals a need to include more information on species relationships in Eco Invertebase. They conclude that the similarities and differences in outputs of the two methods indicate that they have some shared and some different strengths, but PRONTI can handle many more species, rank them all objectively, and organize information to allow rankings to be understood by observers and/or regulatory authorities.

PRONTI in Canada

Two studies are being conducted in collaboration with Dr Peter Mason from Agriculture and Agri-Food Canada. Both involve biocontrol agents released in Canada (*Diadromus pulchellus* and *Trichomalus perfectus*) to control vegetable pests (the leek moth and cabbage seedpod weevil, respectively). These case studies are being conducted in a similar fashion to those described above: the prioritized lists of nontarget species produced by the PRONTI method for the biocontrol agents will be compared with those initially produced for these species before their release. The results will enable the PRONTI method to be assessed for its usefulness under Canadian risk assessment legislation.

PRONTI: a support tool

The case studies have shown how PRONTI is able to rank a wide range and large number of species simultaneously and consistently by comparing them on a set of criteria that draws on data from published literature. This objectivity and transparency is likely to be attractive to regulators. However, adding species information to Eco Invertebase requires considerable resources, while for many species full data are not (yet) available. For investment to be justified, PRONTI needs to be shown to be useful over and above existing methods, and the authors argue that this is the case. They note also that once species are in the database they can be used for any further relevant test species selection models that need to be conducted. PRONTI identifies which species, taxonomic groups, niches, etc., are most at risk and provides a body of information to explain why. Its flexibility allows the effects of different assumptions and priorities to be assessed. These properties allow it to facilitate selection of a set of test species that best represents the range of at-risk species with full appreciation for the uncertainty inherent in the prioritization process.

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[2] Todd, J.H., Barratt, B.I.P., Tooman, L., Beggs, J.R. and Malone, L.A. (2015) Selecting non-target species for risk assessment of entomophagous biological control agents: evaluation of the PRONTI decision-support tool. *Biological Control* 80, 77–88.

[3] Barratt, B.I.P., Todd, J.H. and Malone, L.A. (2016) Selecting non-target species for arthropod biological control agent host range testing: evaluation of a novel method. *Biological Control* 93, 84–92.

[4] Todd, J.H., Barratt, B.I.P., Withers, T.M., Berndt, L.A., Gresham, B., Avila, G.A. and Malone, L.A. (2017) A comparison of methods for selecting non-target species for risk assessment of the biological control agent *Cotesia urabae*. *BioControl* 62, 39–52.

[5] Barratt, B.I.P., Oberprieler, R.G., Barton, D., Mouna, M., Stevens, M., Alonso-Zarazaga, M.A., Vink, C.J. and Ferguson, C.M. (2012) Could research in the native range, and non-target host range in Australia, have helped predict host range of the parasitoid *Microctonus aethiopoides* Loan (Hymenoptera: Braconidae), a biological control agent introduced for *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae) in New Zealand? *BioControl* 57, 735-750.

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Plutella xylostella Management: Balancing Resistant Cultivars with Parasitoid Impact

A study from South Africa provides evidence that the most resistant cabbage cultivars to *Plutella xylostella* are not the best choice when biocontrol agents have a substantial impact on the pest.[1,2]

Plutella xylostella is a global pest of *Brassica* crops, and the use of parasitoids is an important component of its management. In southern Africa, cabbage and other *Brassica* crops are grown and consumed mostly by rural and peri-urban communities to supplement the prevalent maize-based diet; some 132,600 tonnes were harvested in South Africa in 2015. Parasitoids keep *P. xylostella* in cabbage crops below the damage threshold level for a large part of the year (November to May), with a single parasitoid species, *Cotesia vestalis*, contributing more than 80% of this control. Biological control fails in early spring (September–October) and this causes economic damage, although the outbreaks vary in size and duration from year to year. Farmers spray broad-spectrum insecticides to control the outbreaks, which disrupts the recovery of natural enemy populations to levels able to exert biological control. This laboratory study investigated whether choice of cabbage cultivar could be a contributory factor to the varying size and extent of outbreaks and, if so, which cultivars might best help manage the pest and maximize biological control. Two important considerations were investigated: which cultivars best suppress *P. xylostella* populations and which have least impact on *C. vestalis* populations.

According to government data, 51 cultivars of cabbage are commercially cultivated in South Africa; seven of these were selected for the laboratory-based study. In the first part, choice and no-choice tests were conducted with *P. xylostella* to assess oviposition preferences and fitness parameters (development times and survival rates of immature stages, pupal weight, adult female longevity without food) on the seven cultivars. Female moths laid fewest eggs on cvs Leano and Menzania, but this does not make them the best choice. In a monocropping situation, females will lay eggs on any cabbage cultivar, so oviposition preference is less significant in influencing moth population growth than fitness parameters such as larval survival and female fecundity on different cultivars. For example, overall survival of immature stages was lowest on cv. Megaton at c. 45% (some third less than the highest survival rate of c. 67% on cv. Karabo), while female moth longevity, which affects fecundity, was longest for cvs Leano and Megaton. Taken together, the fitness results indicated cv. Megaton as the 'stand-out' cultivar. Growing this cultivar during winter to early spring when biological control fails could mean fewer *P. xylostella*, smaller and shorter pest outbreaks, and less need for spraying. But would this choice hold later in the growing year when biological control is effective against *P. xylostella*, or would the relatively poor nutritional status and quality of host larvae on cv. Megaton impact on parasitoid fitness also?

The potential for bottom-up effects of the cultivars on *C. vestalis* fitness was assessed in the second part of the study. *Cotesia vestalis* does not host-feed as an adult, but is completely reliant on its single host for larval nutrition. The experiments sought to find out whether the cultivar on which the host larva was growing affected the parasitoid's fitness in terms of development times and survival of immature stages, pupal weight, adult longevity/fecundity, F2 generation emergence and sex ratio. Not all parameters are equally significant in a specific system. For example, *C. vestalis* lays most eggs in the first few days post-emergence so fecundity is more significant than female longevity in determining overall fitness – and fecundity was not always related to pupal size either. The number of female offspring is really important, however, because the female parasitoid to host density ratio is a key factor in pest population regulation by a biocontrol agent. The experiments also assessed the effect of the cultivar on parameters affecting the rate at which the parasitoid population grows (net reproductive rate, intrinsic rate of increase), which is critical for biological control because it determines the speed with which the parasitoid population will reach the level needed to suppress the pest.

Mirroring results from some previous studies in other systems, the poor performance of *P. xylostella* on cv. Megaton had a strong negative bottom-up effect on the parasitoid. *Cotesia vestalis* from larvae reared on cv. Megaton had the lowest fecundity and fewest female offspring and, as a result, the lowest rate of population increase. This suggests that although cv. Megaton is effective at suppressing *P. xylostella,* it would be the worst choice out of the seven cultivars for supporting biological control during November to May. Two other cultivars emerged as the best choices: fecundity and number of female offspring were highest for *C. vestalis* on hosts being reared on cvs Beverley Hills and Menzania, and this meant these parasitoids had the highest rates of population increase also. Assuming the results are replicated in the field, growing cvs Beverly Hills and Menzania during the larger part of the year when biological control, notably by *C. vestalis*, provides good control of *P. xylostella* should maximize its effects.

[1] Nethononda, P.D., Nofemela, R.S. and Modise, D.M. (2016) Development, survival, body weight and oviposition rates of *Plutella xylostella* (Linnaeus) (Lepidoptera: Plutellidae) when reared on seven cabbage cultivars. *African Entomology* 24, 162–169.

[2] Nethononda, P.D., Nofemela, R.S. and Modise, D.M. (2017) Bottom-up effects of cabbage cultivars on fitness of a larval parasitoid of *Plutella xylostella* (L.) (Lepidoptera: Plutellidae). *African Entomology* 25, 302–310.

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Advance Orders: a Prediction Tool Facilitates Biocontrol Agent Supply

A study in Karnataka in India developed a tool for predicting *Rastrococcus iceryoides* outbreaks in organic mango crops, so that commercial insectaries can gear up production ready to mass-supply biocontrol agents as soon as they become needed.[1]

Mango is an important commodity crop, and India is a major producer: in 2016/17 it exported some 53,000 metric tonnes of fruit with a value of around US$67 million. Many growers in India are converting to organic production as demand for produce grown without pesticides increases. A survey identified *Rastrococcus* mealybugs as presenting an emerging threat, with the fast-growing pests currently spreading. Infestation, which begins at fruit set, renders fruit unmarketable at harvest. Mealybugs are controlled in organic systems in India by the predator *Cryptolaemus montrouzieri*, which is supplied by commercial insectaries. But the biocontrol companies maintain only small nucleus cultures until orders start to come in. From that point, it takes at least 3–4 weeks to scale up production to meet the level of demand during an outbreak period. Some 20 species of *Rastrococcus* attack mango in India, with *R. iceryoides* causing significant damage. The study investigated whether it was possible for farmers to predict population outbreaks 3–4 weeks before they began, which would allow them to give advance warning to the biocontrol companies. Clearly, the companies cannot sell predators if they have not scaled up production, so having advance notice would increase sales, and the farmers would be able to buy sufficient predators in a timely fashion to contain outbreaks: a win–win situation.

Numbers of mealybugs (confirmed to be *R. iceryoides*) on a random sample of 200 fruit per week were recorded during fruiting seasons from June 2012 to June 2015 in an organic mango orchard at the Indian Council of Agricultural Research – Indian Institute of Horticultural Research in Bengaluru. Meteorological data (maximum and minimum temperatures, morning and afternoon relative humidity, rainfall and wind speed) were also obtained for 1, 2, 3 and 4 weeks before outbreaks. Correlation and regression analyses revealed that only maximum and minimum temperatures showed a significant relationship with mealybug population levels, and this relationship held for all four weeks pre-outbreak. Maximum temperature showed best correlation, so it was used to develop the predictive model. During testing, the model correctly predicted population levels over three seasons, with no significant variation between predicted and observed populations. The model is a user-friendly tool for non-specialists such as extension personnel and farmers. In a situation where early intervention is critical, but biocontrol companies are wary of investing resources unnecessarily, the tool gives all players confidence in predicting outbreaks and scaling up production in advance of an outbreak, leading to improved implementation and results for biological control.

[1] Gujjar, N.R., Verghese, A., Suresh, D.T., Mouly, R. and Joshi, S. (2017 online) Advanced prediction to facilitate biocontrol of the mealybug *Rastrococcus iceryoides* (Hemiptera: Pseudococcidae) in organic mango (Anacardiaceae) orchards. *Canadian Entomologist.* doi:10.4039/tce.2017.42

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Towards Biological Control of Eucalypt Pests in Southeast Asia

The impacts of Australian-origin insects on eucalypt plantations globally is a rapidly increasing problem, characterized by more frequent introductions of new pests and more rapid subsequent inter-country movements. This has led scientists and managers to focus on collaborative efforts for the control and management of these pests.[1] The Biological Control of Eucalypt Pests Alliance (BiCEP) was formed in 2013 to better coordinate research needs internationally for biological control of eucalypt insect pests. BiCEP identified 'the big five' pests (bronze bug, *Thaumastocoris peregrinus*; blue gum chalcid, *Leptocybe invasa*; red gum lerp psyllid, *Glycaspis brimble-*

combei; eucalypt gall wasp, *Ophelimus maskelli*; eucalyptus snout beetles, *Gonipterus* spp.) that required further research work. *Leptocybe invasa* was considered a high priority pest, given its significant impact on industry and smallholder production globally.

The Mekong region

Eucalyptus is widely grown across the Mekong region (Lao People's Democratic Republic [PDR], Cambodia, Thailand and Vietnam) under smallholder, community and industry plantings, where it used for pulp, sawn wood, mulch, construction, fuel and veneer. Trees are living bank accounts, being harvested as needed to finance weddings, funerals or education. Offcuts and prunings are sold or used as firewood, charcoal, and sawdust for mushroom growth.

The Mekong region has undergone a huge period of deforestation in the last 30 years, losing much of its forests to agriculture, fuelwood collection and mining. Governments are now working to stem this forest loss including large scale reforestation projects and plantation expansion. Eucalypts are among the four most important plantation trees in the region, along with *Acacia mangium* and hybrids, *Tectona grandis* (teak) and *Hevea brasiliensis* (rubberwood).[2] These species are exotic to the region and have had long 'honeymoon' periods where exotic pests and diseases have not significantly affected plantation establishment and productivity. However, in the case of eucalypts, invasive Australian insect pests are now becoming major problems, affecting plantation viability.

The blue gum chalcid wasp

Assumed to be native to Australia, *L. invasa* was first detected in the Middle East and the Mediterranean region in 2000 and within ten years had spread to 39 countries across all eucalypt growing continents.[3] Galls produced by the wasp cause stunting and distortion, and in severe cases tree death.[4] Seedlings and trees up to two years of age are particularly vulnerable. Plantations are usually grown as even-age monocultures, often genetically identical (clonal), such that all trees may be susceptible at the same time.

In the Mekong region *L. invasa* has caused severe damage in Vietnam (since 2002), Thailand (2003) and Cambodia and Lao PDR (2007).[5] It is especially damaging to nurseries and young plantations, threatening the expanding eucalypt plantation industry and smallholder growers who rely on eucalypts as a source of income. The *Eucalyptus camaldulensis* × *E. deglupta* hybrid, which is widely grown in commercial and smallholder production in this region, has proven to be particularly susceptible to the wasp. Decreased productivity has reduced the benefits to communities that rely on industry for employment. For smallholder growers (farming lots of 0.5–2 ha), pest pressure has seen a total loss of crop, and many have stopped planting eucalypts altogether.

Management options

There is a limited ability for growers to control *L. invasa* via conventional methods. Chemical control has shown limited effectiveness other than in nurseries and young plantations[6,7] and is costly, short term, unsustainable, and may interfere with existing natural enemy pest control. Additionally, use of many insecticides is prohibited under forest certification scheme (e.g. Forest Stewardship Council) rules. The use of resistant or less susceptible taxa is important in managing damage, but these are less available to private farmers and small growers who are unable to rapidly switch to new genetic material.[7–9]

Biological control has been applied to the management of *L. invasa* in various regions around the world. A search for the natural enemies of *L. invasa* in Australia was initiated in 2003. Four species were subsequently released in Israel: *Selitrichodes kryceri* (Eulophidae), *Quadrastichus mendeli* (Eulophidae); *Megastigmus zvimendeli* and *M. lawsoni* (Torymidae); and another, *Selitrichodes neseri* (Eulophidae), was later released in South Africa. *Quadrastichus mendeli* was re-distributed from Israel into India in 2010, and has recently been collected in the Mekong countries. *Selitrichodes neseri* was redistributed to Brazil in 2015 and most recently to Lao PDR in 2017.

For the Mekong region, priority has been given by governments and industry to develop a biological control programme to protect the eucalypt plantation industry. In response, the Australian Centre for International Agricultural Research (ACIAR) project 'Biological control of galling pests of *Eucalypt* plantations in the Mekong Region' (FST/2012/091) was initiated in 2012. The project is a partnership of researchers from Australia, Lao PDR, Cambodia, Vietnam and Thailand, with the aim of developing effective biological control for *L. invasa* (and other eucalypt pests) to achieve better economic, social and environmental outcomes for rural communities.

Developing a control programme in the Mekong region

The initial task in the ACIAR project was to determine the distribution and abundance of *L. invasa* across the four Mekong countries and search for parasitoids already present. No native parasitoids were found, however the Australian-origin parasitoid *Q. mendeli* was found widely across the region. It is not clear how this parasitoid reached the Mekong, but within a few years of its initial discovery in Lao PDR in 2013 it has become widespread. The distribution and abundance data collected during country surveys indicated that in some regions *Q. mendeli* was providing up to 55% parasitism, though in others it was not yet established or was present in only low densities. Active redistribution of this parasitoid will enhance its spread and impact. Additional agents were sought from among those that had proven successful in controlling the gall wasp elsewhere. Based on its demonstrated specificity, success in establishment and spread, impact following release and ease of rearing, *S. neseri* was selected as an additional biocontrol agent for the Mekong region to complement *Q. mendeli*.

Like *Q. mendeli*, *S. neseri* is an ectoparasitoid developing singly inside the galls of *L. invasa*. The parasitoid was originally collected in Queensland in 2010 by the Forestry and Agricultural Biotechnology Institute (FABI), South Africa.[10] Specimens were imported into quarantine in South Africa and underwent extensive host-range testing against a range of galling species, including representatives from the Acari, Hemiptera, Coleoptera, Diptera and Hymenoptera.[11] Testing confirmed it was unable to initiate galls on *Eucalyptus*, but was a primary parasitoid within galls.[10] The parasitoid was also tested on galled leaves of 17 plants, with oviposition and larval development occurring only on *L. invasa* galls. Parasitism averaged 72% for galls with mature larvae and pupae.[11] Based on these results, *S. neseri* was considered a suitable biocontrol agent and was released in South Africa and subsequently Brazil. The wasp established successfully in both countries and has since also been recorded parasitizing the gall wasp *O. maskelli*, another worldwide eucalypt pest, a new association recorded since its arrival in South Africa.

Selitrichodes neseri was introduced into quarantine in Lao PDR in March 2017. Wasps were hand couriered from FABI in South Africa and introduced into the Haddokkeo Biological Control Facility, Horticulture Research Centre (HRC). A colony has been successfully established in quarantine and is now undergoing further host-specificity testing in preparation for anticipated field release in mid-2018. While *S. neseri* has been shown to be specific to the gall wasps *L. invasa* and *O. maskelli*, additional host testing and biological studies will ensure its safety for release in the Mekong region, and allow for the development of critical skills by project staff. Regional distribution data will be used to identify areas of high pest pressure and low *Q. mendeli* parasitism where *S. neseri* releases will take place.

Capacity building

The primary aim of this project is to deliver a sustainable and effective biocontrol agent for *L. invasa*. However, the project has also created a collaborative multi-country network with an emphasis on building the capacity of all partners in technical and scientific aspects of biological control and forest health research and management. In-country capacity building has focused on the technical aspects of quarantine practice, host testing and insect rearing, including extensive diagnostic training on associated parasitoids and other galling insects.

Australian and Lao colleagues supported plant quarantine staff in developing quarantine and biosecurity policy and procedure for the import of *S. neseri*. During field surveys, colleagues have developed pest checklists for use in meeting phytosanitary and quarantine requirements for trade. Colleagues have liaised with local industry and delivered training on identification of important *Eucalyptus* pests, including disseminating materials in local languages on survey methodology, record keeping and reporting, to improve their capacity to identify pests and provide management options for local growers.

The project supported the construction and equipping of a quarantine-standard biological control facility at the HRC, Haddokkeo, the first of its type in Lao PDR. The facility was approved by the Plant Quarantine Division, Department of Agriculture, Ministry of Agriculture and Forestry in January 2017. The facility is available for use by other groups and can be de-commissioned and used as a regular laboratory, thereby increasing its utility.

For all these successes, there have been challenges throughout. The biggest challenge has not been working across multiple countries or languages, but modifying project activities to accommodate the shift away from planting susceptible varieties by industry. *Leptocybe invasa* pest pressure became so intense that many companies either stopped planting eucalypts altogether, or planted non-susceptible hybrids or other tree species. For the project, this meant less emphasis on assessing the economic impact of *L. invasa* and more on grassroots-community and whole country assessment of the wasp's impact. The project came to focus more on working with local partners to deliver a sound control programme to reduce the impact on productivity, and ultimately livelihoods. Other issues have included extreme temperatures and power failures, which saw one *S. neseri* colony die out, and monsoonal rains that delayed construction of the quarantine facility. Overcoming these challenges has required the experience, input and skill of all members of the project team.

Overview

Eucalyptus plantation forestry is an important contributor to economies in the Mekong region, including trade and employment. This project will enhance the productivity and sustainability of eucalypts, directly benefiting plantation and smallholder growers. Plantations provide strong benefits to regional communities through additional employment opportunities and added income sources. Plantation ventures also provide direct funding to local communities for schools, health and infrastructure. The deployment of biocontrol agents will benefit community forestry as it potentially provides 'free' control in-perpetuity. Effective biological control also provides environmental benefits through lowered usage of pesticides. Although *L. invasa* is currently the key threat to eucalypt plantations in the region, it is only one of a suite of eucalypt insects spreading across the world. This project is increasing the Mekong region's capability to effectively and rapidly respond to these future threats.

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New Rabbit Biocontrol Agent Released around Australia

After eight years of researching, evaluating, planning and preparing, a new rabbit calicivirus strain, known as RHDV1 K5, was officially released around Australia in March 2017 – the first new rabbit biocontrol agent released in 20 years.

More than 600 community sites were registered to take part in the release and were mailed a series of information guides including video tutorials. All packs included instructions on how to collect tissue samples from dead rabbits, and vials and reply-paid envelopes to send samples back. Due to this collection of data, the researchers were able to officially confirm rabbit deaths from RHDV1 K5 at many release sites through laboratory analysis of these samples.

Now, nearly 12 months post release, the research team has been able to confirm through data collection that an average 42% reduction in wild rabbit numbers has been observed at sites where the virus was released, based on coinciding spotlight counts undertaken pre- and post-release.

This is a momentous occasion in Australia's environmental history as it is one of the first invasive animal biocontrol releases where it was very much led through the many hundreds of community groups, producers and land managers who volunteered their time and effort to be involved in releasing and monitoring impact of the virus. It showcases how research, combined with community action, can lead to positive outcomes for agriculture and the environment.

The national project leader Dr Tarnya Cox from NSW (New South Wales) Department of Primary Industries coordinated this massive collaboration and partnership through the Invasive Animals Cooperative Research Centre between all relevant state and territory governments, the Australian Government and industry and research partners such as the CSIRO, Australian Wool Innovation and Meat & Livestock Australia.

What next? Rabbit management in Australia is an ongoing battle to stay on top of the problem and many land managers will be undertaking follow up control this year and in future years. The rabbit biocontrol research team in Australia are also now looking at new solutions to the problem and have recently begun assessing the potential of a rabbit parasite (the protozoan *Eimeria*) as a new biocontrol agent – so watch this space.

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Marsupial Benefits from Rabbit Biocontrol

In Australia, the discovery in New South Wales of a small predatory marsupial thought to have been locally extinct for a century is being attributed to the long-term impact of biological control by the rabbit calicivirus. A University of New South Wales team from the 'Wild Deserts' project discovered a single animal in Sturt National Park in the west of the state in late 2017. Once widely distributed across Australia's sandy desert environments, rabbits and introduced predators had precipitated a decline in crest-tailed mulgara populations by the early twentieth century.

An earlier study found the mulgara was one of several mammals to be benefitting from rabbit biological control in parts of South Australia, where its populations were making a strong recovery (see *BNI* 37(2) June 2016). Release of the calicivirus in 1995 had greatest impact in arid areas. The fall in rabbit populations allowed ground cover to increase, while reductions in rabbit populations meant fewer prey for introduced predators such as cats and foxes, whose populations have also fallen, and this in turn means mulgara suffer less competition for small rodent prey.

The Wild Deserts team plan to eradicate rabbits, cats and foxes from two 20-km^2 fenced areas in Sturt National Park, and then reintroduce a number of mammals that have been locally extinct for 90 years. The finding of a crest-tailed mulgara during monitoring of the project area gives a boost of confidence that this and other native mammal populations can recover. It also underlines the importance of rabbit biological control as a strategic conservation tool.

Source: University of New South Wales.
Web: https://newsroom.unsw.edu.au/

Contact: Rebecca West (Rebecca.west@unsw.edu.au) and Reece Pedler (r.pedler@unsw.edu.au), University of New South Wales.

New Book on Biological Control

Biological Control: Ecology and Applications by George E. Heimpel and Nicholas J. Mills has been published by Cambridge University Press in 2017. While there are some good introductory texts on the topic of biological control, this is a more advanced treatment of the subject, suitable for advanced undergraduates, graduate students and researchers in general. The book includes sections on theoretical population ecology, invasion biology and evolutionary biology that explain how the process of biological control can be used to address fundamental hypotheses as well as how it can be used to suppress populations of harmful organisms safely and effectively. The book features case studies and advances from biological control of invertebrate and vertebrate pests, weeds and plant pathogens. The result is a comprehensive text on biological control that takes a fundamental as well as an applied outlook.

Web: www.cambridge.org/us/academic/subjects/life-sciences/entomology/biological-control-ecology-and-applications?format=HB#eL5hr6ZzA0rFBwzE.97

ISBCW 2018 in Switzerland

The XVth International Symposium on Biological Control of Weeds (ISBCW) will be held on 26–31 August 2018 at Engelberg in Switzerland. This is always an excellent event with stimulating keynotes, and topical oral and poster sessions and workshops. Themes include: (i) Target and agent selection, (ii) Novel methods to determine efficacy and environmental safety of agents, (iii) Making classical biological control more predictive: moving from ecological to evolutionary processes, (iv) Regulations for agent release and access to genetic resources, (v) Post-release monitoring and evaluation, (vi) Social and economic assessments of biological control, (vii) Integrated weed management and restoration, (viii) Opportunities and constraints for classical weed biocontrol in developing countries and (ix) in developed countries, and (x) Bioherbicides. Abstracts are invited by 31 March. A programme for up to six evening workshops on more specific themes was being developed as BNI went to press. Please visit the website or email for more information.

Email: info@isbcw-2018.com
Web: www.isbcw-2018.com/

BioControl Special Issue

'Biological control: achievements and opportunities' is the theme of the February 2018 issue of *BioControl*, edited by Jacques Brodeur and Russell Messing. The catalyst for the issue was a workshop organized by the International Organisation for Biological Control at Engelberg in Switzerland in March 2015. This was convened to examine wide-ranging impediments to greater uptake of biological control worldwide, draw together ideas from participants on how to address challenges, and develop an action plan. The outcomes are encapsulated in this issue. Biological control is described as a thriving, collaborative, international scientific discipline, but dependent on public education and support. Reviews of classical biological control, augmentative biocontrol, vector-borne disease biocontrol and integrated weed management take different approaches and identify obstacles, strengths, needs and opportunities in these sectors. The role of ecological theory in some biological control successes and technological advances in understanding evolution of biocontrol agents are discussed. Promising roles for national extension partners and social science approaches in enhancing uptake are explored. Best practices for use and exchange of invertebrate biocontrol agents to meet Nagoya Protocol requirements are explained. Summing up, limitations to biological control uptake are identified, and a range of recommendations emphasise the need for improved communication with all stakeholders about the economic, environmental and social successes and benefits of biological control.

Web: https://link.springer.com/journal/10526/63/1/page/1