Improved New Organism Decision-making for Invasive Species and Biological Control

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OECD CO-OPERATIVE RESEARCH PROGRAMME : BIOLOGICAL RESOURCE MANAGEMENT FOR SUSTAINABLE AGRICULTURAL SYSTEMS
Theme 2: “Sustainability”
OECD Fellowship Duration: December 13, 2011 to April 14, 2012 (18 weeks)
Host Supervisor: Dr Kim Hoelmer, USDA ARS European Biological Control Laboratory, Montpellier, France

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Non-scientific Summary
Insect host range affects risk assessment for biological control agents of weeds and invasive insects, including the cost benefit analyses that are used for determining government responses to new incursions, and for justifying biological control introductions against weeds. This project had three objectives, starting with an examination of scientific contradictions between predictions and field experience with insect host range, a consideration of dilemmas involving prediction of insect host range, and an examination of machine vision for experimentally studying insect behaviour and host choice. These objectives were met and several publications were produced. The study confirmed that insect host range is predictable from laboratory-based predictions following appropriate protocols, based on field experience with 512 agents released against weeds worldwide.

Executive Summary
An OECD Fellowship entitled “Improved New Organism Decision-making for Invasive Species and Biological Control” was undertaken between December 13, 2011 and April 14, 2012 by Dr DM Suckling, Biosecurity Group Leader at Plant and Food Research, New Zealand. The Fellowship was hosted by Dr Kim Hoelmer, at the USDA-Agricultural Research Service European Biological Control Laboratory, Montpellier, France. The project, funded under Theme 3 (“Sustainability”) was successful at meeting the objectives:

Objective 1 - Improved host range prediction. A review of laboratory and field studies was undertaken, with a particular focus on contradictory outcomes between laboratory and field results. Three scientific manuscripts were completed.

Objective 2 - Improved host range policy. The work used the framework provided by the successful New Zealand HSNO Act (1996), and a new approach to assessing magnitude of ecological impact based on a framework from invasive
species was developed. An essay for “AgScience” explored the notion of “significance”, which has a wider meaning than the purely statistical term.

Objective 3 - Machine vision recording of host range experiments. Experimental methods were developed for host range analysis that may help to increase productivity and reliability of host range tests.

The main achievements were:

1. The review of non-target impacts was successfully completed together with USDA colleague Dr Réne Sforza, including the construction of a database with 129 cases of non-target impacts on plants from weed biological control. An additional review of the benefits of weed biological control was completed, along with a manuscript on the host range of painted apple moth.

2. An improved framework was developed for assessing the magnitude of non-target impacts of biological control agents, based on impacts caused by invasive species. The team at USDA and the OECD Fellow also learned a lot from each other during the exchange, and new methods were developed together.

3. An additional collaborative project was funded by the USDA APHIS which extended the visit to Montpellier for three weeks, and new collaborations were established with two Italian research groups. The project involves the development of female moth attractants for the invasive European grape vine moth, *Lobesia botrana*, and field trials were established in France and Italy.

4. Five seminars on biosecurity were presented to research audiences at four Italian universities. One Italian PhD student was invited to New Zealand for six months, and a joint research plan developed. A final project seminar was held at the USDA-ARS during a workshop. An international workshop on invasive species was attended.

5. A French student (License Professionnelle “Agriculture raisonnée et certification environnementale”) was supervised for three months with NZ funding and the methods were established at the USDA ARS for future use.

6. A further six scientific publications were completed during the fellowship.

Conclusions

Risk

- Plant host range has been predictable with a few exceptions in Classical Biological Control
- Non-target impacts are mostly not important to plant populations
- Biosafety record for weed biocontrol is > 99%
- Avoidable errors are less likely in future
- Frequent literature citation of the non-target risks may be overstating actual risks

Benefit

- Risk of failing to achieve benefits is greater than non-target risks
• Taxonomy and testing remains critical, odds of achieving benefits are improving
• NZ has had massive benefits from Classical Biological Control of weeds
• Improved methods are still needed

1 Relevance:
• to the Cooperative Research Programme objectives
• to the Theme; and
• to agricultural and food policy

This project is part of “Sustainability” theme because it involved an assessment of host range for invasive and valued beneficial biological control species, and new perspectives and knowledge on host plant choice. Improved knowledge of this topic will underpin better definitions of insect host range for decision support (i.e. to eradicate or not ?), and it is expected that methods enabled here will contribute to better understanding of non-target impacts of putatively beneficial insects (possible weed biocontrol agents).

Failure to make the right decisions on new organisms in a timely fashion can have long-term consequences for the sustainability of both productive and natural ecosystems. The costs of existing pests do not decrease when new pests are added to the system, costs simply mount up. Such costs can be due to economic, environmental, social or even cultural factors, and become a major burden that limits future opportunities, such as sustainable production with reduced pesticide usage. Because pesticides (here insecticides and herbicides) are typically amongst the least sustainable inputs into productive ecosystems, avoidance of such long-term consequences is highly desirable in the interests of ensuring food security. This argument has successfully formed the basis for approvals of biological control introductions in many countries (e.g. www.epa.govt.nz).

The work is highly relevant to Theme 3, because biosecurity is critical to the long term sustainability of our productive and natural ecosystems. Expanding expertise in insect host range is likely to lead to a range of new solutions for biosecurity. This project has helped to build new skills, understanding and methods with relevance to biosecurity and weed management, in order to better combat pests and reduce such threats to sustainability. The proposed new framework for risk assessment based on ecological outcomes will be presented to the Environmental Protection Authority of New Zealand, and published in a peer reviewed scientific journal, as well as in a popular article through a scientific society. It is recommended that a simple five step scale be used to better communicate the risk of consequences from both action (biological control) and no action (ongoing impacts from invasive species).

2 Objectives of the project

The high level purpose of the project was to review insect host range from the perspective of non-target impacts from biological control agents for weeds, and invasive species such as the painted apple moth, which was eradicated from New Zealand based on host range testing and field observation of host use including native and valued plants.
The three specific objectives were

1. **Objective 1 Improved host range prediction.** A review of laboratory and field studies was undertaken, with a particular focus on contradictory outcomes between laboratory and field results. Three manuscripts were completed.

2. **Objective 2 Improved host range policy.** The work used the framework provided by the successful New Zealand HSNO Act (1996), and a new approach to assessing magnitude of ecological impact of biological control agents was developed based on a framework from invasive species. An essay explored the notion of “significance”, which has a wider meaning than the purely statistical term.

3. **Objective 3 Machine vision recording of host range experiments.** Experimental methods were developed for host range analysis that may help to increase productivity and reliability of host range tests. Work is ongoing.

### 3 Major achievements

3.1. The review of non-target impacts of weed biological control was successfully achieved, with updating of the number of agents released globally, for the first time since 1998 (now 512), the construction of a database with 159 cases of plants receiving non-target impacts and assignment of adverse effects on a five step scale (minimal to massive) for 129 cases, and the completion of a manuscript entitled “How Bad are Observed Non-Target Impacts from Weed Biocontrol?” This included the development of text descriptors supporting a logical framework for assessment of potential adverse non-target ecological effects from biological control agents. The research team at USDA and the OECD Fellow also learned a lot from each other during the exchange, and new methods were developed together.

3.2. A retrospective analysis of the benefits of previous weed biological control agents in New Zealand was completed, using a five step scale used in risk assessment (minimal to massive). It was identified that two cases of massive benefit had been achieved, with other cases of major or moderate benefit.

3.3. A manuscript on host range testing of the painted apple moth was completed, involving 122 plant provenances from 79 species. This insect was the subject of a $65M eradication campaign in Auckland, New Zealand from 1999-2007 that was based on the assessment of risk to NZ native and valued plants included in this manuscript.

### 4 Conclusions

**Risk**

- Plant host range has been predictable with a few exceptions in Classical Biological Control. The exceptions are relatively unimportant.
- Non-target impacts are mostly not important to plant populations, but the exceptions were predictable.
- Biosafety record for weed biocontrol is > 99%, only four organisms of 512 caused direct non-target effects.
• Avoidable errors are less likely in future, due to the application of improved scientific methods.
• Frequent citation of the risks may be overstating things, mainly from two insects.

Benefit
• New Zealand has had massive benefits from Classical Biological Control of weeds.
• The risk of failing to achieve benefits with ongoing damage from invasive plants is greater than non-target risks for classical biological control done with best practice.
• Improved methods are still needed to improve productivity.
• Taxonomy and testing remains critical, but the odds of success are improving with improved ecological knowledge.

5 Follow-up:
Several publications were produced that specifically cite the OECD in the Acknowledgements:

5.1 Suckling, D.M. and Sforza, R. How bad are ecological non-target impacts from weed biocontrol? Submitted: Journal of Applied Ecology

Summary
1. A review focussed on non-target impacts from organisms deliberately introduced for the biological control of weeds has confirmed that insect host range can be predicted. The magnitude of direct non-target impact from 38 biocontrol agents on 129 plants was retrospectively categorized using a risk management framework for ecological impacts (minimal, minor, moderate, major, massive).
2. The vast majority of agents introduced for classical biological control of weeds (>99% of 512 agents released) have had no significant adverse effects on non-target plants thus far; four have had adverse direct impact on non-target plant populations. Of these, two were not approved introductions. Six examples of moderate indirect impact with minor habitat modification were noted and one was moderate to major in scale, with effects likely on ecosystem processes.
3. Most direct non-target impacts (91%) were categorized as minimal or minor in magnitude with no adverse long-term impact on non-target plant populations, but a few cacti and thistles are affected at moderate (n=3), major (n=7) to massive (n=1) scale. The impacts on cacti were not from a deliberate introduction, but rather unforeseen spread from the Caribbean to mainland North America.
4. About 8% of biocontrol agents released caused non-target impacts, of which 1% were categorized as massive.
5. Potentially massive direct impacts are resulting from two agents (Cactoblastis cactorum on native cacti and Rhinocyllus conicus on native thistles), but these introductions would not be permitted today as the risk was foreseeable and more balanced societal attitudes exist to cactus and thistle biodiversity.
6. Synthesis and applications. Our analysis shows that weed biological control has a historical biosafety track record of >99% and fewer non-target impacts can be expected in future because of improved science and incorporation of societal values. Failure to use biological control represents a significant opportunity cost from the certainty of ongoing adverse impacts from invasive weeds. It is recommended that a simple five step scale be used to better communicate the risk of consequences from
both action (biological control) and no action (ongoing impacts from invasive species).

5.2 Suckling, D.M. Benefits from biological control of weeds in New Zealand range from negligible to massive: a retrospective analysis. Submitted: Biological Control

Abstract

Recent concern highlighting non-target impacts in classical biological control of arthropods and weeds has heightened awareness of these risks but raised the risk of obscuring beneficial effects. This review applied a retrospective assessment of the benefits from weed biological control in New Zealand. While it is arguably too early to assess the impact from many new organisms (n=20), the fate of organisms released earlier (n=33) has been assessed according to the modern criteria for judging beneficial effects used by New Zealand’s Environmental Protection Authority (negligible, minimal, minor, moderate, major and massive). Cases with negligible benefit (n=12) included failures to establish self-sustaining populations, while cases with minimal benefit (n=11) included some where predation reduced the realised benefit of established organisms. The remaining cases offered massive (n=2), major (n=1), moderate (n=5) or minor (n=2) benefit. Suppression of ragwort (Senecio jacobaea) and St Johns wort (Hypericum perforatum) were considered to be massive in magnitude, offering long term ecosystem benefits of controlling invasive weeds. Improved clarity around risk and benefit could help improve the quality of debate on biological control, and the five step scale used in New Zealand may prove more widely useful elsewhere.


Abstract

1. Host selection for any organism is an evolutionary rationalisation of performance and environment, so predicting hosts of a polyphagous defoliator in a new ecosystem can be particularly challenging. A wide host range, including herbivory observed on novel native and introduced species was a contributing factor in the decision to commence a successful NZ$65 million eradication programme against painted apple moth (Teia anartoides) in Auckland (1999-2007).
2. This study aimed to investigate potential host plants using larval no-choice tests to predict the risk of uncontrolled impact of the insect in New Zealand.
3. Laboratory tests were carried out on a total of 79 native and introduced plant species with 122 provenances. Plants were defined as potential hosts if any female larvae developed through to the pupal stage (24/79 species) but a smaller subset of plants were probable physiological hosts with >10% survival.
4. The list includes the known Australian host range plus additional plants, including predicted sporadic or more common attack of New Zealand native broom, lemon, apple, cherry, sycamore, Douglas fir, larch, gorse and broom.
5. Field observations of populations with significant numbers of larvae on New Zealand karaka and grey mangrove were in contradiction of the laboratory results, which would suggest that they could be significant hosts but were not predicted as such.
6. Synthesis and applications. A degree of uncertainty remains over the potential ecological impact of painted apple moth in New Zealand, had it not been eradicated. The possible reasons for disagreement between putative laboratory and field host ranges are discussed, but this study highlights the difficulty in defining host range in polyphagous species.
5.4 Suckling D.M. Understanding “Significance” and Ecological Impacts. Proposed for “AgScience”.

The term “significance” is explored in this essay because of its importance to legislation involving hazardous substances and new organisms, administered by the Environmental Protection Authority. “Significance” is a widely used term in science where a precise and statistical definition is applied, often with 95% or higher probability of an outcome ($P<0.05$). The word is also used in various environmental policy settings such as the HSNO Act (1996), where an application for bringing a new organism or hazardous substance into New Zealand may be considered to have “national significance”. Significance also appears under Section 36 of the HSNO Act, concerned with minimum standards. Significance is a highly context-specific concept, and its interpretation can provide a real challenge to decision-makers in the boundary zone between science and society.

5.5 Additional publications prepared and submitted during the Fellowship


Proposed ongoing collaboration with the USDA ARS is under discussion, with a possible proposal for a follow up visit to New Zealand being investigated.

6) Satisfaction

The OECD Fellowship conformed entirely to my expectations, and provided me with a wonderful opportunity to collaborate with an excellent team at the USDA-ARS European Biological Control Laboratory, and to live in the south of France for the first time since childhood. This presented me with a chance to renew and expand my French language skills, which was valuable as bilingualism is important to me.

The OECD fellowship directly expanded my technical knowledge of insect host range by exposing me for an extended period to experts in weed biological control, and this ultimately included interactions with New Zealand and Australian experts who provided reviews of manuscripts.
I was also able to develop and expand cooperation with Italian researchers, and now have an ongoing project with them on female moth attractants on an invasive species.

My positive outlook towards other people and opportunities, enhanced by previous experience, has expanded my range of collaborators, and this will include a visiting Italian PhD student in my lab in 2012-13.

No practical problems were encountered, beyond those associated with normal research, and these were solved thanks to the excellent hospitality provided by Dr Kim Hoelmer and the staff at USDA-ARS EBCL.

- Please suggest any improvements in the fellowship Programme

The application process was clear and not overly burdensome, with clear guidelines. Permission was granted for the visit to other labs during the fellowship which offered an opportunity to reach a wider audience and established wider cooperation, which was excellent. The administration of the funding was straightforward. No improvements are recommended.

7) Advertising the Cooperative Research Programme

I learned about the latest round in an email call for proposals, as a former recipient.

I have been aware of the OECD Fellowship scheme for some years, having hosted two and been a recipient once previously, and I have seen posters also. In order to make the scheme more visible, I have been careful to mention it widely during my seminars and emails to colleagues, as well as acknowledging the scheme in several scientific publications. I will do some further follow up in New Zealand.

- Any issues you would like to record?

I have no issues to record. I will be happy to be an advocate for the scheme.