Evaluating and Regulating Biological Control Agents: A North American Perspective

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EPPO / COST - SMARTER / IOBC / IBMA / CABI
WORKSHOP ON EVALUATION AND REGULATION OF BIOLOGICAL CONTROL AGENTS
23-24 November 2015
North American history ...

Entomophagous biological control agents

- **United States** – first release in 1888: *Cryptochetum iceryae* against *Icerya purchasi* (cottony cushion scale) in citrus; *Rodalia cardinalis* was released in 1889
- **Canada** – first release in 1885: *Trichogramma minutum* against *Nematus ribesii* (imported currantworm); 1910 *Mesoleius tenthredinis* against *Pristiphora erichsonii* (larch sawfly)
- **Mexico** – first release in 1922: *Lixiphaga diatraeae* against *Diatraea saccharalis* (sugarcane borer)

Phytophagous biological control agents

- **United States** – first release in 1945: *Chrysolina hyperici* against *Hypericum perforatum* (Klamath weed, St. John’s wort)
- **Canada** – first release in 1951: *C. hyperici* against *H. perforatum*
- **Mexico** – first release in 1977: *Neochetina eichhorniae* against *Eichhornia crassipes* (water hyacinth)
… North American history …

**United States**

- **1957** - Subcommittee on Biological Control of Weeds established [U.S. Department of the Interior’s (USDI) Bureau of Reclamation, Bureau of Land Management, and Fish and Wildlife Service; and from the U.S. Department of Agriculture’s (USDA) Forest Service and Agricultural Research Service].

- **1971** - name changed to Working Group on Biological Control of Weeds. **Canadian and Mexican comments were invited because the Working Group knew that an introduced organism recognizes no political boundaries and its introduction needed to be considered on a continental basis.** [+ Environmental Protection Agency, Cooperative State Research, Education, and Extension Service (now the National Institute of Food and Agriculture), and the U.S. Army Corps of Engineers].

- **1987** - the Working Group was replaced by the Technical Advisory Group (TAG). Then and now, TAG functions under USDA-APHIS Plant Protection and Quarantine (APHIS-PPQ) [membership is voluntary and now **must** be in accordance with the Federal Advisory Committee Act]:
  - Executive Secretary from APHIS-PPQ (not a voting member);
  - TAG Chair is elected by its members for a 3-year, renewable term;
  - Membership is indefinite until members retire or their agencies name someone else.
... North American history ...

**Canada**

1962 – informal, reciprocal review of biocontrol of weeds proposals between the United States and Canada [Canada Department of Agriculture].

1982 – Workshop in Biocontrol of Weeds in Regina, Saskatchewan recommended the formation of a standing committee – Biocontrol of Weeds Review Committee

1987 – Biocontrol of Weeds Review Committee
   Initially the review was done by the Deputy Minister of Agriculture. This was clearly an inappropriately high level. It was then passed to the Director General who rapidly transferred the responsibility to the Coordinator level.

1992 – Biological Control Review Committee
   - Chair, Director level
   - Chair, Expert appointed (1998)
   - Membership is ad hoc, except for Pest Management Regulatory Agency (PMRA) and Canadian Food Inspection Agency (CFIA) Risk Assessment Unit and always includes taxonomists.
... North American history

Mexico

1980 - Regulation of the Plant and Animal Health Act: with regard to plant health

National Biological Control Reference Centre (NBCRC) makes decision to release or not based on requirements set out in Articles 101 and 102 of the Plant Health Act, and additional supporting technical information based on the RSPM 12

NBCRC may consult with the National Consultative Phytosanitary Advisory Group (NCPAG) Biological Control Committee
Current situation in North America

Regulated under Plant Protection Legislation

Regulatory agencies

- Canadian Food Inspection Agency
- Sanidad Vegetal
- USDA-Animal and Plant Health Inspection Agency

Petition reviews done by

- Biological Control Review Committee (BCRC) [Canada]
- National Committee for Biological Control Review (NCBCR) [Mexico]
- Technical Advisory Group (TAG), weed agents only [U.S.A.]
Challenge: Non-harmonized regulatory requirements ...

**Canada**
- Petitioner sends petition package to National Manager of IASDP (see IASDP.AADG.BC)
- IASDP reviews petition to determine if it is aligned with Plant Health Programs
- IASDP forwards petition to REIs for review
- REIs contact petitioner to advise them that petition must be resubmitted
- Chair of BCRC forwards Committees recommendations to REIs
- If BCA is approved, list of approved BCAs is updated by IASDP accordingly

**Mexico**
- Application by the importer to the General Director of Foreign Vegetal Health
- The SCBCR reviews a copy of the import application, addressing the requirements set out in Articles 101 and 102 of the Plant Health Act, and additional supporting technical information
- The decision to send to the interested parties
- Invasive Alien Species and Domestic Programs Section (IASDP) Plant Health & Biosecurity Directorate (PHBD) Regulatory Entomologists (REIs) Biological Control Review Committee (BCRC) Biological Control Agents (BCA)
- Invasive Alien Species and Domestic Programs Section (IASDP)
- Plant Health & Biosecurity Directorate (PHBD)
- Regulatory Entomologists (REIs)
- Biological Control Review Committee (BCRC)
- Biological Control Agents (BCA)

**United States**
- TAG-BCAW Process – Release Petition
  1. Conducts more research
  2. Submits petition
  3. Elects to submit application to APHIS
- TAG-BCAW Member of SMEs
  1. Reviews and evaluates
  2. Synthesizes comments from SMEs
  3. Submits comments and recommendations
- TAG Chair
  1. Considers recommendations
  2. Submits TAG recommendation to APHIS-PPO, Petitioner and others
- (L) APHIS Process [see workflow 5 – 16]
Solution: Harmonized International Standards

- Food and Agriculture Organization (global)
  [ISPM No. 3 – 1996, revised 2005]

- North American Plant Protection Organization (3 countries)

“These guidelines are intended to assist a researcher in drafting a petition .... A standardized petition will also assist reviewers and regulators ....”
North American guidelines ...


- ... 1983 ... Bulletin of the Entomological Society of America 29(3): 55–61
Guidance documents

USA

TAG manual
• first published in 2000, revised in 2013
• Intended as a ‘one-stop’ reference for information on procedures for importing and assessing biological control agents for weeds.

Canada

Guide for Importation and Release of Arthropod Biological control Agents
• first published in 2006, revised in 2016
• Intended as a reference for petitioners on information requirements, includes example petitions
Results

Petitions Reviewed

Petition quality is generally high

> 90 biocontrol agent species introduced into Canada against > 17 weeds
> 283 biocontrol agent species introduced into Canada against > 85 arthropod pests
However, there are challenges

- Changing attitudes
- Endangered species
- Taxonomy – mixed cultures, species complexes
- Perception of Risk
- Politics
Changing attitudes

Rhinocyllus conicus

- Host range testing demonstrated polyphagy but all thistles considered weeds when released in 1968 against nodding thistle: impact was significant
- In 2000, USDA-APHIS revoked all permits for interstate shipment of R. conicus
Threats to endangered species

*Cactoblastis cactorum*
- Introduced into Carribbean Islands (1957-1970) to control complex of cactus spp.
- Adventive (same bioregion) in Florida (1989) where endangered *Opuntia* cacti are present
- In 2009 found in Mujeres, Mexico about 10 miles offshore from Cancun but eradicated – significant threat to desert ecosystems and commercial *Opuntia* production

[Image: Cactoblastis cactorum moth female.jpg]

[Image: Prickly Pear.jpg]
Taxonomy
Cryptic insect species

*Aphthona lacterosa*

Morphological similarity but molecular (CO1) studies identified three clades (Roehrdanz et al 2009)

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Changing plant classifications

Toadflax

“The genus *Linaria* was traditionally placed in the Scrophulariaceae (Figwort) family ... Revisions based on molecular phylogenetic analyses indicated that *Linaria* would be more appropriately included within the expanded Plantaginaceae (Plantain) family ...”

http://rstb.royalsocietypublishing.org/content/royptb/365/1539/423/F1.large.jpg
Perception of risk

What is impact?
The debate rages on ...

Differential Host-Finding Abilities by a Weed Biocontrol Insect Create Within-Patch Spatial Refuges for Nontarget Plants

Haley A. Catton, Robert C. Lalonde, and Rosemarie A. De Clerck Floate

Behavior

ABSTRACT Many modern weed biocontrol insects exhibit transient “spillover” nontarget herbivory when and where insects are in high density, such as following biocontrol releases, or around dense target weed infestations. Understanding spatial patterns of herbivory is important for predicting efficacy and safety of biocontrol, as refuges from herbivory can buffer plants from population-level impacts. Here, we demonstrate that differential host-finding and arrestment behaviors by an oligophagous biocontrol insect lead to spatial refuges from nontarget herbivory around insect release points within mixed patches of target and nontarget plants. We created transient insect outbreaks by releasing large numbers of M. cruciferae Fällin (Coleoptera: Curculionidae) into naturally occurring rangeland patches of the nontarget plant H. micrantha (Eastwood) J. L. Gentry with varying densities of its target weed, Cynoglossum officinale L., and monitored spatial patterns of herbivory around release points after 4-7 wk. In complement, we conducted a mark-release-recapture (MBR) experiment to compare M. cruciferae’s target and nontarget host-finding and arrestment behaviors. For rangeland releases, 85% of nontarget herbivory occurred within 4.55 m of release points, independent of target plant density. Target herbivory occurred throughout our evaluation radii (up to 14 m), where maximum density of diffusing M. cruciferae was 1/10 of that in the nontarget herbivory radius. In the MBR experiment, more weevils were recaptured on C. officinale (but not H. micrantha) than expected by chance. M. cruciferae’s lack of specialized nontarget host-finding and arrestment behaviors means that spatial refuges from herbivory are created for H. micrantha just meters away from sources of high weevil density.

KEY WORDS weed biocontrol, mark-release-recapture, nontarget herbivory, spatial refuge, within-patch scale
Politics

United States

- 1957 - Subcommittee on Biological Control of Weeds established [U.S. Department of the Interior’s (USDI) Bureau of Reclamation, Bureau of Land Management, and Fish and Wildlife Service; and from the U.S. Department of Agriculture’s (USDA) Forest Service and Agricultural Research Service].

- 1962 - an informal, reciprocal review of proposals between the U. S. and Canada.

- 1969 - the membership of the Subcommittee was expanded to include subject matter experts in plant taxonomy, ornamentals, and plant quarantine. At that time, the Bureau of Reclamation dropped its membership.

- 1971 - name changed to Working Group on Biological Control of Weeds. Canadian and Mexican comments were invited because the Working Group knew that an introduced organism recognizes no political boundaries and its introduction needed to be considered on a continental basis. [Environmental Protection Agency, Cooperative State Research, Education, and Extension Service (now the National Institute of Food and Agriculture), and the U.S. Army Corps of Engineers].

- 2015 - Political boundaries still define decisions!
Meeting the challenges ...

Entomophagous BCAs

- Non-target testing methods poorly understood
- Methodologies developed & case studies accumulating

Solutions

- RSPM 12 initially (2000) did not include section on host range testing
  - But needed to provide a statement on potential non-target impacts
- Revised RSPM 12 (2015) includes section on host range testing
... Meeting the challenges ...

Deposition of Reference specimens
- A condition of release was that reference (voucher) specimens be deposited in National Collections
- But unable to track that this was done

Solutions
- RPSMs 7 and 12 (2015) include “Pre-release compliance” section, includes letters that verify deposition of reference specimens of released populations

7. Pre-Release Compliance
7.1 Reference specimens (10 or more) must be deposited in the National Collection of the permitting country in advance of approval for release. The specimens should be of good condition for DNA extraction and with clear labels, indicating collection locality, latitude and longitude, date of collection, name of collector and any other pertinent information.

A letter explaining that the specimens are biological control agents and are being donated to the National Collection as part of the conditions under which release will be granted should accompany the specimens when they are submitted. A copy of the letter should be included in the submission to the permitting NPPO.

7.2 Information on the planned location and timing of the first release(s) should be included in the submission. Note: a letter confirming the release date and location should be provided to the NPPO within 3 months after release.
... Meeting the challenges ...

Movement of approved commercial biocontrol agents

- In United States, implementation of Homeland Security measures impeded movement of commercial biocontrol agents among NAPPO countries

Solutions

NAPPO Regional Standards for Phytosanitary Measures (RSPM)

RSPM 26 Certification of commercial arthropod biological control agents moving into NAPPO member countries

The Secretariat of the North American Plant Protection Organization
1431 Merivale Road, 3rd Floor, Room 140
Ottawa, Ontario, Canada K1A 0Y9
July 23, 2012
... Meeting the challenges ...

Taxonomic consistency

- Commercial agents marketed under ‘old’ taxonomic names, very confusing

Solution

- Appendix added to RPSM 26 that provides correct taxonomic names and synonyms used by industry

- Appendix is updated annually

Galendromus occidentalis (Nesbitt) [=Metaseiulus occidentalis (Nesbitt); =Typhlodromus occidentalis (Nesbitt)] (MESOSTIGMATA: Phytoseiidae)
... Meeting the challenges

**Submission quality**

- Guidance on preparation of petitions for entomophagous agents needed
  - Incomplete information
  - ‘nothing known’ answers

**Solution**

- Workshop

- Discussion of needs
  - Testing protocols for predators
  - Retrospective studies of well-known agents as examples
Successful biological control of leafy spurge

- *Hyles euphorbiae* released in 1965; *Aphthona cyparissiae* & *A. flava* released in 1982; *A. nigriscutus* released in 1983; *A. czwalinae* released in 1985; *A. lacterosa* released in 1990

- *Aphthona nigriscutus* & *A. lacertosa* most successful

- Current work includes relocation of established populations and assessing population dynamics

R. Bourchier, AAFC Lethbridge
Successful Biological Control of cereal leaf beetle


- *Tetrastichus julis* most successful, widespread, up to 95% parasitism

- Current work includes: introduction of *T. julis* into areas newly invaded by cereal leaf beetle (e.g. Canadian prairies, northwestern USA); monitoring impact and dispersal of *T. julis*; developing a bioclimatic model to predict regions capable of sustaining *T. julis*

P. Mason, AAFC Ottawa
Successful Biological Control of houndstongue

- *Mogulones crucifer* released in 1997; *Longitarsus quadriguttatus* released in 1998
- *Mogulones crucifer* most successful, near 100% establishment
- Current work includes: assessing genetic variation and impacts of invasive plants; examining impact of climate change on current and potential invasive plants; developing novel screening, release and enhancement strategies for biocontrol agents

R. De Clerck-Floate, AAFC Lethbridge
Successful Biological Control of lily leaf beetle


- *Tetrastichus setifer* most successful, widespread, up to 100% parasitism

- Current work includes: introduction of *T. setifer* into areas newly invaded by lily leaf beetle (e.g. western Canada); monitoring dispersal of *T. setifer* to lily leaf beetle on novel plant hosts; developing a bioclimatic model to predict dispersal of *T. setifer*, release of *L. errabundus* in Canada

Photos by A.M. Brauner, AAFC

P. Mason, AAFC Ottawa
‘Successful’ Biological Control of leek moth

- **Diadromus pulchellus** released in 2010

- *Diadromus pulchellus* has successfully overwintered, population appears to have established

- Current work includes: introduction of *D. pulchellus* into areas newly invaded by leek moth; monitoring dispersal of *D. pulchellus*; testing host range hypotheses; developing post-release monitoring protocols; developing a bioclimatic model to predict dispersal of *D. pulchellus*; evaluation of additional candidate agents

P. Mason, AAFC Ottawa

Photos by A.M. Brauner, AAFC
‘Successful’ Biological Control of emerald ash borer


- *Oobius agrili* parasitism of EAB eggs in 75% of sampled trees; *Tetrastichus planipennisi* parasitism in 92% of sampled trees, up to 21% parasitism of EAB larvae

- Current work: monitoring impact and dispersal of agents; introduction of *S. galinae*; biology and impact of the native *Phasgonophora sulcata*

P. Mason, AAFC Ottawa
Recommendations from the North American experience
1. Bioregions approach

Bioregions of North America (Ricketts et al. 1999) http://www.ebcc.info/wpimages/Bioregions-EBCC3.gif
2. Harmonized International Standards

- Food and Agriculture Organization (global) [ISPM No. 3 – 1996, revised 2005]


- European Plant Protection Organization (50 countries) [PM6.2 (2)]
3. Host range testing

Fig. 3.1. Model for developing a list of non-target species for testing with potential biological control agents. The target species is at the centre of the model. Concentric rings of increasing radius indicate decreasing risk, and, therefore, testing priority. The three axes – taxonomy, geography and ecology/ethnobiology – must be considered together to optimize the predictive power of the phylogenetic hypothesis represented in the taxonomy axis.

Taxonomy and Biological Control ...
4. Benefits and Risks assessment
Thanks!