Evaluating and Regulating Biological Control Agents: A North American Perspective

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Ottawa, Ontario

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

NAPPO
North American Plant Protection Organization
Organización Norteamericana de Protección a las Plantas

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

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

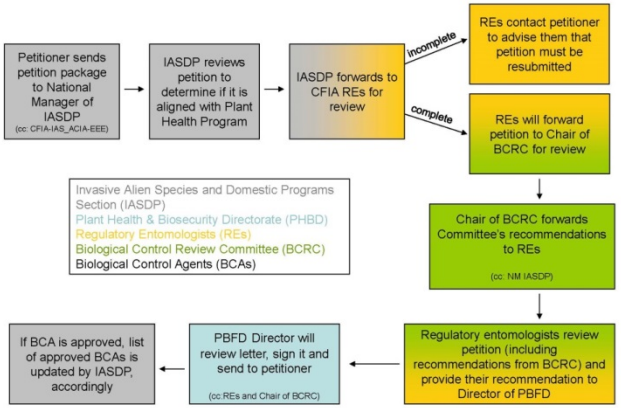
- Canadian Food Inspection Agency
- Sanidad Vegetal
- USDA-Animal and Plant Health Inspection Agency

Petition reviews done by

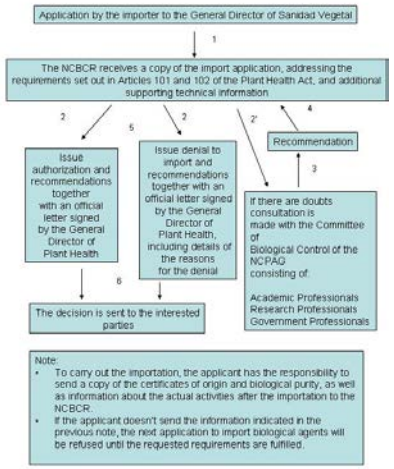
- Biological Control Review Committee (BCRC) [Canada]
- National Committee for Biological Control Review (NCBCR) [Mexico]
- Technical Advisory Group (TAG), weed agents only [U.S.A.]

Challenge: Non-harmonized regulatory requirements …

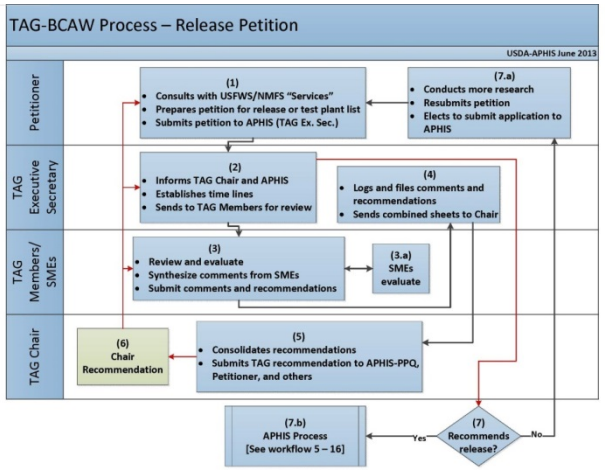
Canada



Mexico



United States



Solution: Harmonized International Standards

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

- North American Plant Protection Organization (3 countries)
  [RSPM No. 7- 1998, revised 2001 2007, 2008, 2015]
  [RSPM No. 12 - 2000, revised 2006, 2008, 2015]

"These guidelines are intended to assist a researcher in drafting a petition …. A standardized petition will also assist reviewers and regulators …."

North American guidelines …

- Klingman, Dayton L.; Coulson, Jack R. 1982. **Guidelines for introducing foreign organisms into the United States for the biological control of weeds.** Weed Science 30: 661–667.
- … 1983 … Bulletin of the Entomological Society of America 29(3): 55–61

GUIDELINES ON PROPOSALS TO INTRODUCE FOREIGN ORGANISMS INTO THE UNITED STATES FOR THE CONTROL OF WEEDS

I. General summary of procedures
II. Selection of target weeds
III. Introduction into quarantine facilities within the continental United States
IV. Testing in domestic quarantine facility
V. Release into the field within the continental United States

Suggested Format for Documentation in Support of Proposal for Release of an Organism for Weed Control

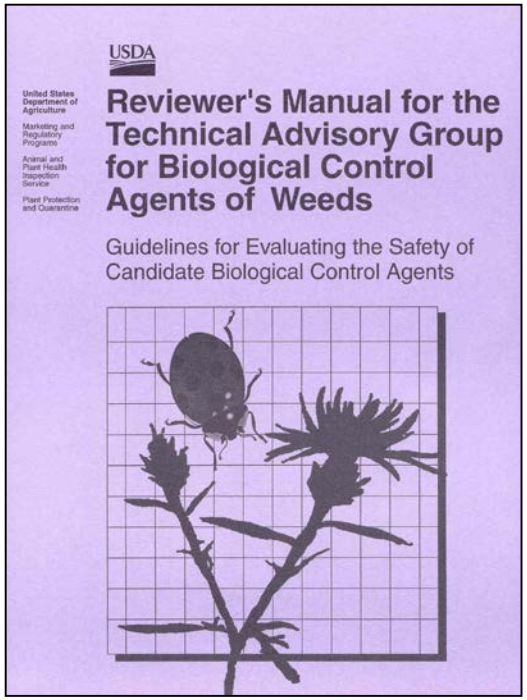
I. Introduction
II. Taxonomic position of biological control organism
III. Geographic distribution
IV. Host plants
V. Life history
For arthropods
For plant pathogens
VI. Mortality factors
VII. Effects of organism on host plant
VIII. Potential - control value
IX. Host-specificity experiments
For arthropods
For plant pathogens
X. Discussion
XI. Summary
XII. Illustrations
XIII. Bibliography

Guidance documents

USA

TAG manual

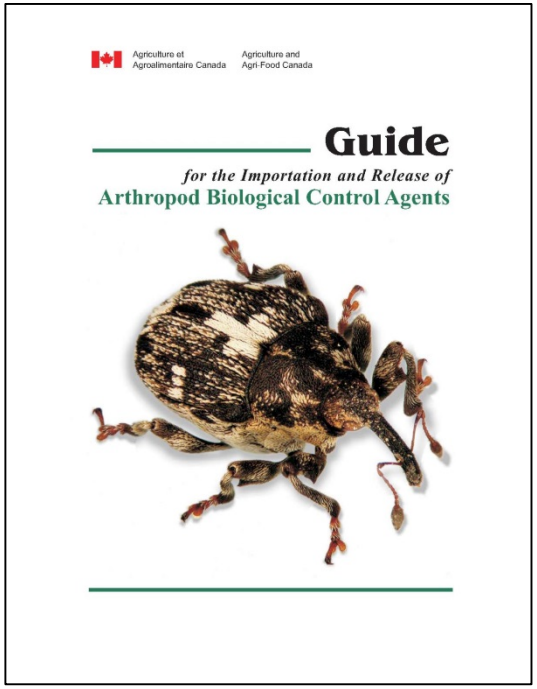
- first published in 2000, revised in 2013
- Intended as a 'one-stop' reference for information on procedures for importing and assessing biological control agents for weeds.



Canada

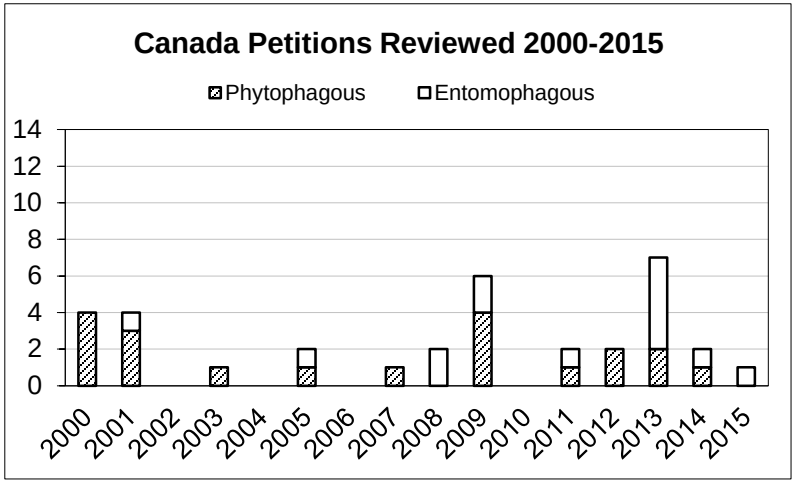
Guide for Importation and Release of Arthropod Biological control Agents

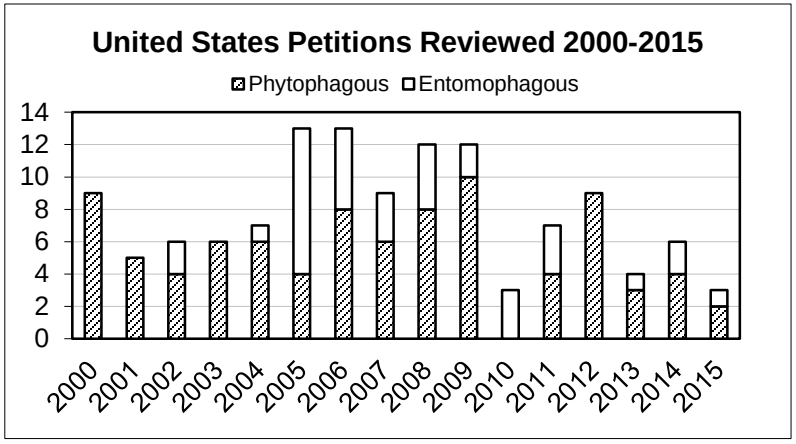
- first published in 2006, revised in 2016
- Intended as a reference for petitioners on information requirements, includes example petitions



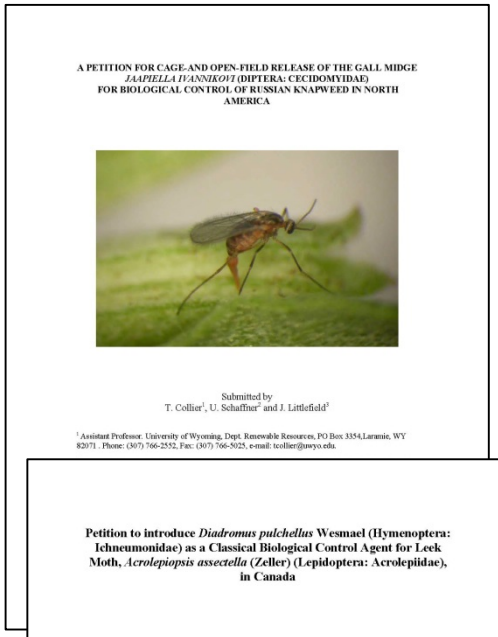
Results

Petitions Reviewed





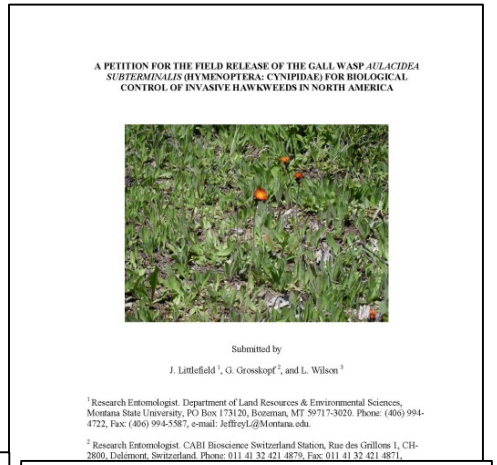
Petition quality is generally high



A PETITION FOR CAGE-AND OPEN-FIELD RELEASE OF THE GALL MIDGE *JAAPIELLA IVANNIKOVI* (DIPTERA: CECIDOMYIDAE) FOR BIOLOGICAL CONTROL OF RUSSIAN KNAPWEED IN NORTH AMERICA

Submitted by
T. Collier[1], U. Schaffner[2] and J. Littlefield[3]

[1] Assistant Professor. University of Wyoming, Dept. Renewable Resources, PO Box 3354,Laramie, WY 82071 . Phone: (307) 766-2552, Fax: (307) 766-5025, e-mail: tcollier@uwyo.edu.



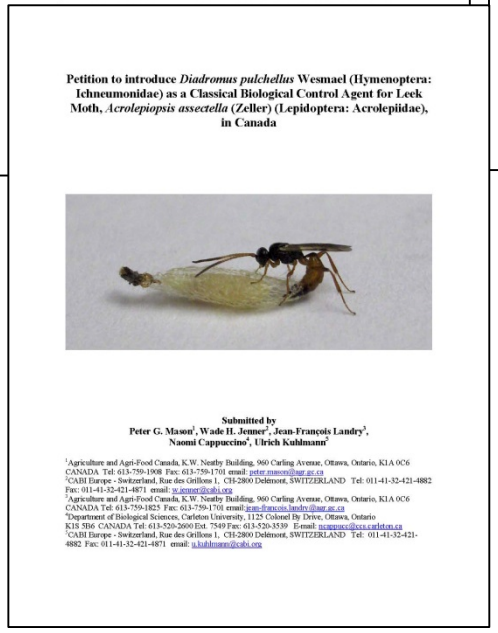
A PETITION FOR THE FIELD RELEASE OF THE GALL WASP *AULACIDEA SUBTERMINALIS* (HYMENOPTERA: CYNIPIDAE) FOR BIOLOGICAL CONTROL OF INVASIVE HAWKWEEDS IN NORTH AMERICA

Submitted by

J. Littlefield [1], G. Grosskopf [2], and L. Wilson [3]

[1] Research Entomologist. Department of Land Resources & Environmental Sciences, Montana State University, PO Box 173120, Bozeman, MT 59717-3020. Phone: (406) 994-4722, Fax: (406) 994-5587, e-mail: JeffreyL@Montana.edu.

[2] Research Entomologist. CABI Bioscience Switzerland Station, Rue des Grillons 1, CH-2800, Delémont, Switzerland. Phone: 011 41 32 421 4879, Fax: 011 41 32 421 4871.



Petition to introduce *Diadromus pulchellus* Wesmael (Hymenoptera: Ichneumonidae) as a Classical Biological Control Agent for Leek Moth, *Acrolepiopsis assectella* (Zeller) (Lepidoptera: Acrolepiidae), in Canada

Submitted by
Peter G. Mason[1], Wade H. Jenner[2], Jean-François Landry[3], Naomi Cappuccino[4], Ulrich Kuhlmann[5]

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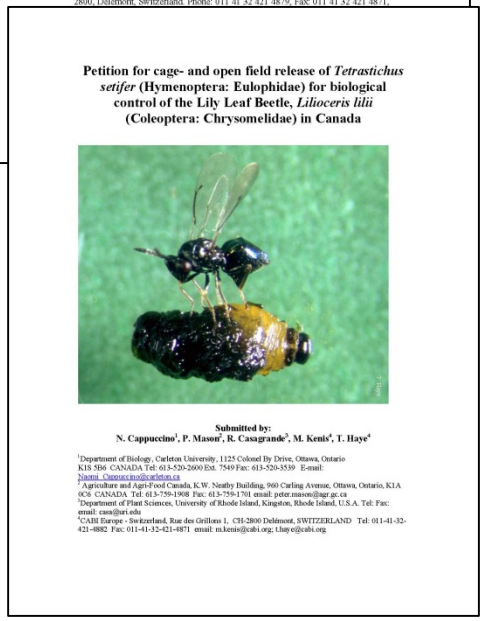
[3]Agriculture and Agri-Food Canada, K.W. Neatby Building, 960 Carling Avenue, Ottawa, Ontario, K1A 0C6 CANADA Tel: 613-759-1825 Fax: 613-759-1701 email:jean-francois.landry@agr.gc.ca
[4]Department of Biological Sciences, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario K1S 5B6 CANADA Tel: 613-520-2600 Ext. 7549 Fax: 613-520-3539 E-mail: ncappucc@ccs.carleton.ca
[5]CABI Europe - Switzerland, Rue des Grillons 1, CH-2800 Delémont, SWITZERLAND Tel: 011-41-32-421-4882 Fax: 011-41-32-421-4871 email: u.kuhlmann@cabi.org



Petition for cage- and open field release of *Tetrastichus setifer* (Hymenoptera: Eulophidae) for biological control of the Lily Leaf Beetle, *Lilioceris lilii* (Coleoptera: Chrysomelidae) in Canada

Submitted by:
N. Cappuccino[1], P. Mason[2], R. Casagrande[3], M. Kenis[4], T. Haye[4]

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[3]Department of Plant Sciences, University of Rhode Island, Kingston, Rhode Island, U.S.A. Tel: Fax: email: casa@uri.edu
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>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

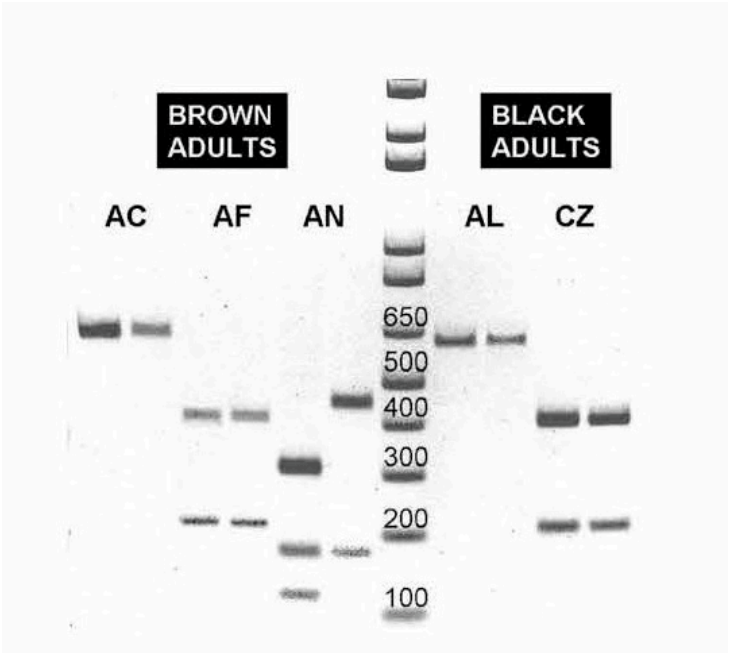
- Introduced into Carribbean Islands (1957-1970) to control complex of cactus spp.
- Adventive (same bioregion) in Florida (1989) where endangered *Opuntia* cacti are present
- In 2009 found in Mujeres, Mexico about 10 miles offshore from Cancun but eradicated – significant threat to desert ecosystems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

Taxonomy

Cryptic insect species

Aphthona lacterosa

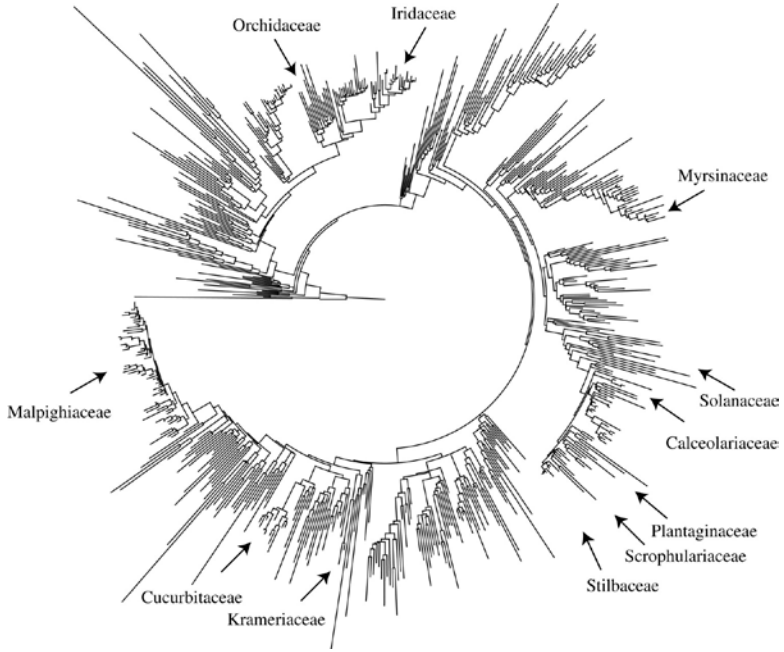
Morphological similarity but molecular (CO1) studies identified three clades (Roehrdanz et al 2009)



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 …"



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Perception of risk

What is impact?

The debate rages on …

BEHAVIOR

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

HALEY A. CATTON,[1,2] ROBERT G. LALONDE,[1] AND ROSEMARIE A. DE CLERCK-FLOATE[3]

Environ. Entomol. 43(5): 1333–1344 (2014); DOI: http://dx.doi.org/10.1603/EN14041

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 *Mogulones crucifer* Pallas (Coleoptera: Curculionidae) into naturally occurring rangeland patches of the nontarget plant *Hackelia 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 (MRR) experiment to compare *M. crucifer*'s target and nontarget host-finding and arrestment behaviors. For rangeland releases, 95% of nontarget herbivory occurred within 4.25 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. crucifer* was 1/10 of that in the nontarget herbivory radius. In the MRR experiment, more weevils were recaptured on *C. officinale* (but not *H. micrantha*) than expected by chance. *M. crucifer*'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.

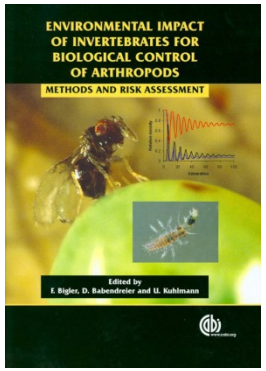
- 1969 - the membership of the Subcommittee was **expanded to include subject matter experts in plant taxonomy, ornamentals, and plant quarantine**. At that time, the Bureau of Reclamation dropped its membership.

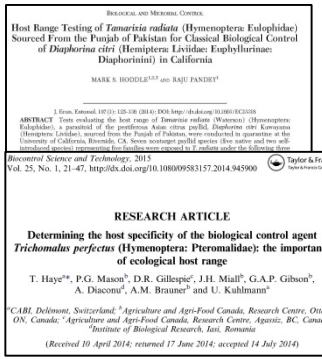
- 1971 - name changed to Working Group on Biological Control of Weeds. **Canadian and Mexican comments were invited because the Working Group knew that an introduced organism recognizes no political boundaries and its introduction needed to be considered on a continental basis**. [+ Environmental Protection 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 …

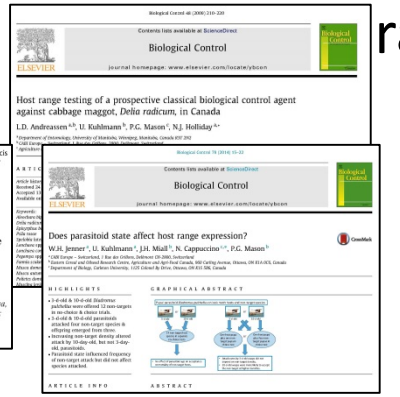
Entomophagous BCAs

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




Host Range Testing of *Tamarixia radiata* (Hymenoptera: Eulophidae) Sourced From the Punjab of Pakistan for Classical Biological Control of *Diaphorina citri* (Hemiptera: Liviidae: Euphyllurinae: Diaphorinini) in California

MARK S. HOODLE and RAJU PANDEY


Biological Control

Host range testing of a prospective classical biological control agent against cabbage maggot, *Delia radicum*, in Canada

L.D. Andreassen, U. Kuhlmann, P.G. Mason, N.J. Holliday

Biocontrol Science and Technology, 2015
Vol. 25, No. 1, 21–47. http://dx.doi.org/10.1080/09583157.2014.945900

RESEARCH ARTICLE

Determining the host specificity of the biological control agent *Trichomalus perfectus* (Hymenoptera: Pteromalidae): the importance of ecological host range

T. Haye, P.G. Mason, D.R. Gillespie, J.H. Miall, G.A.P. Gibson, A. Diacono, A.M. Brauner and U. Kuhlmann

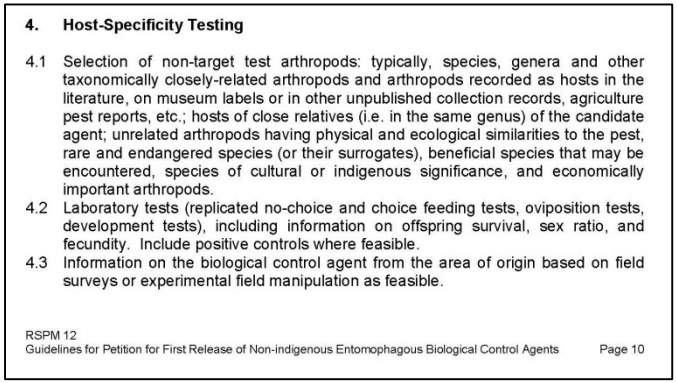
Biological Control

Does parasitoid state affect host range expression?

W.H. Jenner, U. Kuhlmann, J.H. Miall, N. Cappuccino, P.G. Mason

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


4. Host-Specificity Testing

4.1 Selection of non-target test arthropods: typically, species, genera and other taxonomically closely-related arthropods and arthropods recorded as hosts in the literature, on museum labels or in other unpublished collection records, agriculture pest reports, etc.; hosts of close relatives (i.e. in the same genus) of the candidate agent; unrelated arthropods having physical and ecological similarities to the pest, rare and endangered species (or their surrogates), beneficial species that may be encountered, species of cultural or indigenous significance, and economically important arthropods.

4.2 Laboratory tests (replicated no-choice and choice feeding tests, oviposition tests, development tests), including information on offspring survival, sex ratio, and fecundity. Include positive controls where feasible.

4.3 Information on the biological control agent from the area of origin based on field surveys or experimental field manipulation as feasible.

RSPM 12
Guidelines for Petition for First Release of Non-indigenous Entomophagous Biological Control Agents Page 10

… 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.

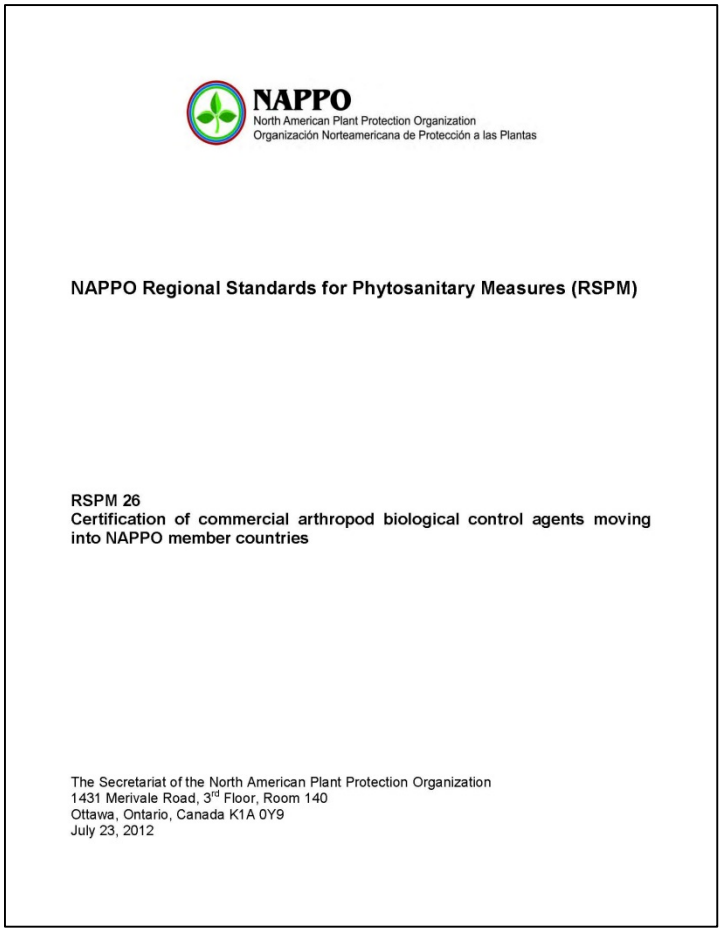
7.2 Information on the planned location and timing of the first release(s) should be included in the submission. Note: a letter confirming the release date and location should be provided to the NPPO within 3 months after release.

… 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
North American Plant Protection Organization
Organización Norteamericana de Protección a las Plantas

NAPPO Regional Standards for Phytosanitary Measures (RSPM)

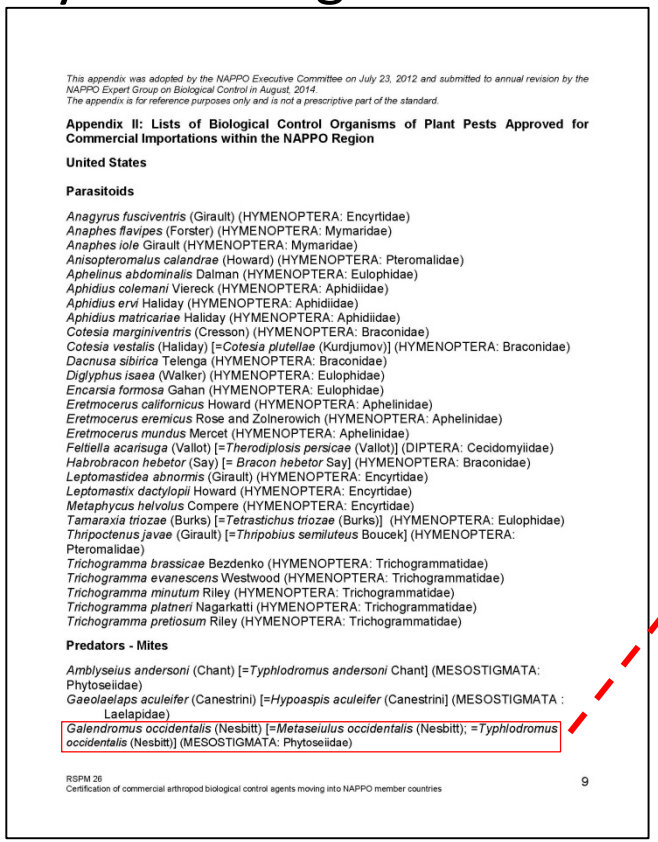
RSPM 26
Certification of commercial arthropod biological control agents moving into NAPPO member countries

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



This appendix was adopted by the NAPPO Executive Committee on July 23, 2012 and submitted to annual revision by the NAPPO Expert Group on Biological Control in August, 2014.
The appendix is for reference purposes only and is not a prescriptive part of the standard.

Appendix II: Lists of Biological Control Organisms of Plant Pests Approved for Commercial Importations within the NAPPO Region

United States

Parasitoids

Anagyrus fusciventris (Girault) (HYMENOPTERA: Encyrtidae)
Anaphes flavipes (Forster) (HYMENOPTERA: Mymaridae)
Anaphes iole Girault (HYMENOPTERA: Mymaridae)
Anisopteromalus calandrae (Howard) (HYMENOPTERA: Pteromalidae)
Aphelinus abdominalis Dalman (HYMENOPTERA: Eulophidae)
Aphidius colemani Viereck (HYMENOPTERA: Aphidiidae)
Aphidius ervi Haliday (HYMENOPTERA: Aphidiidae)
Aphidius matricariae Haliday (HYMENOPTERA: Aphidiidae)
Cotesia marginiventris (Cresson) (HYMENOPTERA: Braconidae)
Cotesia vestalis (Haliday) [=*Cotesia plutellae* (Kurdjumov)] (HYMENOPTERA: Braconidae)
Dacnusa sibirica Telenga (HYMENOPTERA: Braconidae)
Diglyphus isaea (Walker) (HYMENOPTERA: Eulophidae)
Encarsia formosa Gahan (HYMENOPTERA: Eulophidae)
Eretmocerus californicus Howard (HYMENOPTERA: Aphelinidae)
Eretmocerus eremicus Rose and Zolnerowich (HYMENOPTERA: Aphelinidae)
Eretmocerus mundus Mercet (HYMENOPTERA: Aphelinidae)
Feltiella acarisuga (Vallot) [=*Therodiplosis persicae* (Vallot)] (DIPTERA: Cecidomyiidae)
Habrobracon hebetor (Say) [= *Bracon hebetor* Say] (HYMENOPTERA: Braconidae)
Leptomastidea abnormis (Girault) (HYMENOPTERA: Encyrtidae)
Leptomastix dactylopii Howard (HYMENOPTERA: Encyrtidae)
Metaphycus helvolus Compere (HYMENOPTERA: Encyrtidae)
Tamaraxia triozae (Burks) [=*Tetrastichus triozae* (Burks)] (HYMENOPTERA: Eulophidae)
Thripoctenus javae (Girault) [=*Thripobius semiluteus* Boucek] (HYMENOPTERA: Pteromalidae)
Trichogramma brassicae Bezdenko (HYMENOPTERA: Trichogrammatidae)
Trichogramma evanescens Westwood (HYMENOPTERA: Trichogrammatidae)
Trichogramma minutum Riley (HYMENOPTERA: Trichogrammatidae)
Trichogramma platneri Nagarkatti (HYMENOPTERA: Trichogrammatidae)
Trichogramma pretiosum Riley (HYMENOPTERA: Trichogrammatidae)

Predators - Mites

Amblyseius andersoni (Chant) [=*Typhlodromus andersoni* Chant] (MESOSTIGMATA: Phytoseiidae)
Gaeolaelaps aculeifer (Canestrini) [=*Hypoaspis aculeifer* (Canestrini] (MESOSTIGMATA : Laelapidae)
Galendromus occidentalis (Nesbitt) [=*Metaseiulus occidentalis* (Nesbitt); =*Typhlodromus occidentalis* (Nesbitt)] (MESOSTIGMATA: Phytoseiidae)

RSPM 26
Certification of commercial arthropod biological control agents moving into NAPPO member countries
9

Galendromus occidentalis (Nesbitt) [=*Metaseiulus occidentalis* (Nesbitt); =*Typhlodromus occidentalis* (Nesbitt)] (MESOSTIGMATA: Phytoseiidae)

Solution

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

… Meeting the challenges

Submission quality

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

Solution

- Workshop

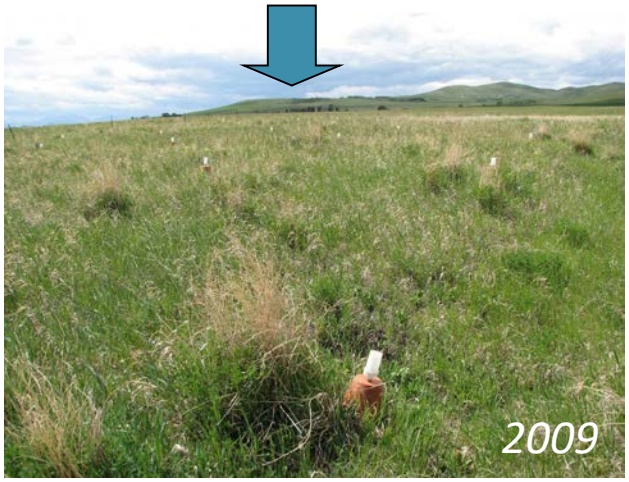
- Discussion of needs
  - Testing protocols for predators
  - Retrospective studies of well-known agents as examples

Successful biological control of leafy spurge

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

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

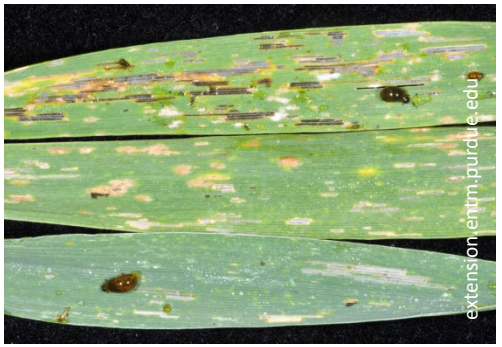
- Current work includes relocation of established populations and assessing population dynamics



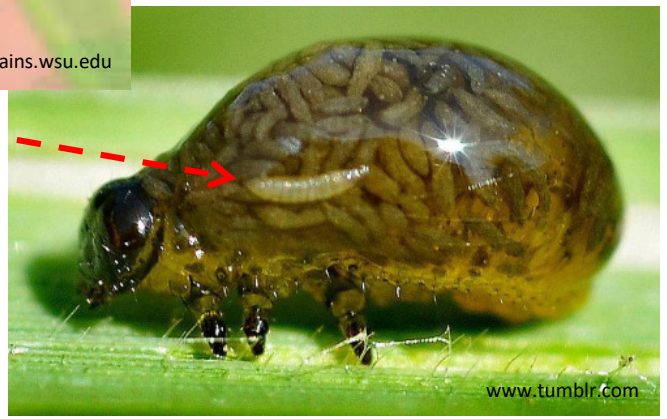
R. Bourchier, AAFC Lethbridge

Successful Biological Control of cereal leaf beetle

- *Tetrastichus julis* released in 1967 (1974 in Canada); *Diaparsis carinifer* released in 1967, *Lemophagous curtus* released in 1969, *Anaphes flavipes* released in 1966
- *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*



Tetrastichus julis

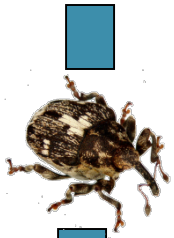


P. Mason, AAFC Ottawa

Successful Biological Control of houndstongue

- *Mogulones crucifer* released in 1997; *Longitarsus quadriguttatus* released in 1998
- *Mogulones crucifer* most successful, near 100% establishment

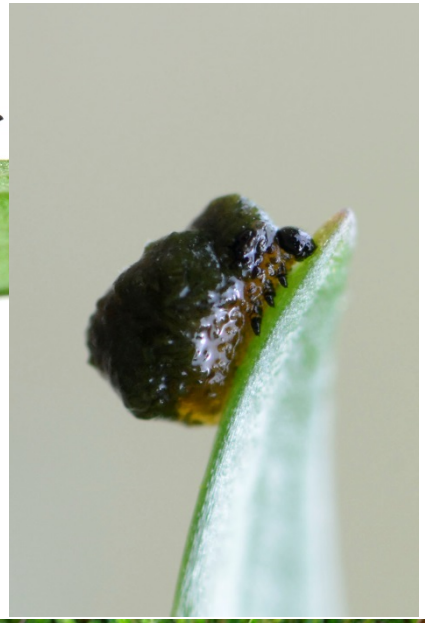
- Current work includes: assessing genetic variation and impacts of invasive plants; examining impact of climate change on current and potential invasive plants; developing novel screening, release and enhancement strategies for biocontrol agents



R. De Clerck-Floate, AAFC Lethbridge

Successful Biological Control of lily leaf beetle

- ***Tetrastichus setifer*** released in 1999 (2010 in Canada); ***Diaparsis jucunda*** released in 2003, ***Lemophagous errabundus*** released in 2003
- *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



Tetrastichus setifer

P. Mason, AAFC Ottawa

Photos by A.M. Brauner, AAFC

‘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

Diadromus pulchellus

Photos by A.M. Brauner, AAFC

P. Mason, AAFC Ottawa

‘Successful’ Biological Control of emerald ash borer

- *Tetrastichus planipennisi* released in 2007 (2013 in Canada); ***Spathius agrili*** released in 2007, ***Oobius agrili*** released in 2007 (2015 in Canada) – all established

- *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*

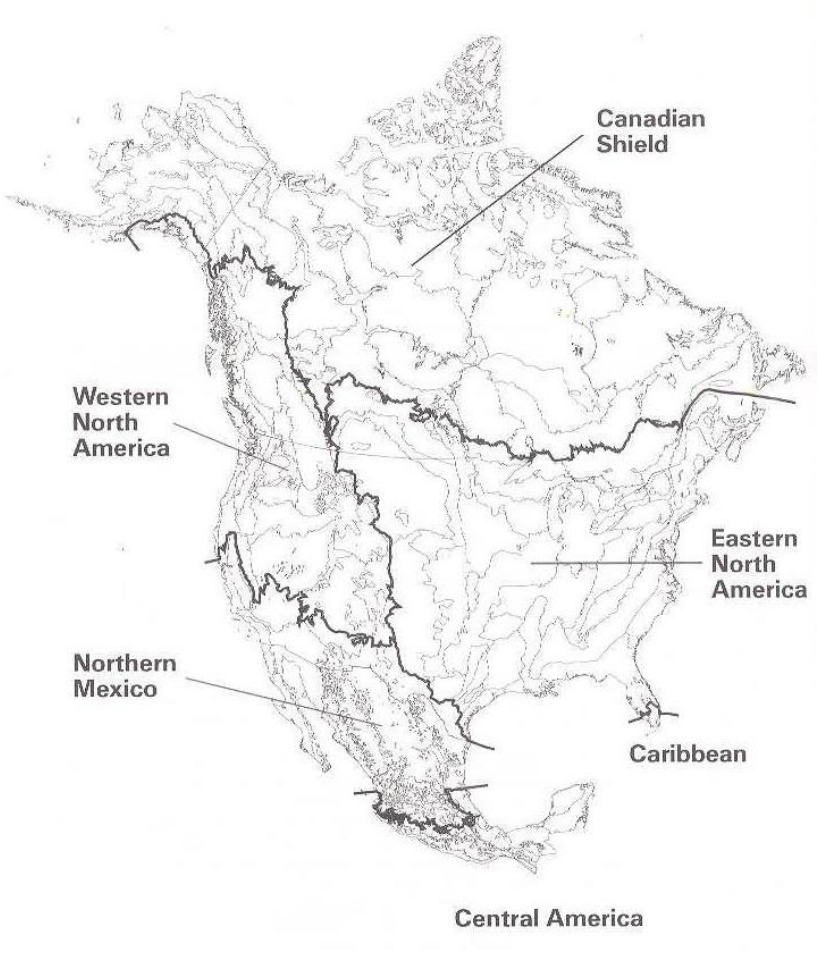
Agrilis planipennis

Tetrastichus planipennisi

P. Mason, AAFC Ottawa

Recommendations from the North American experience

1. Bioregions approach



Bioregions of North America (Ricketts *et al*. 1999)

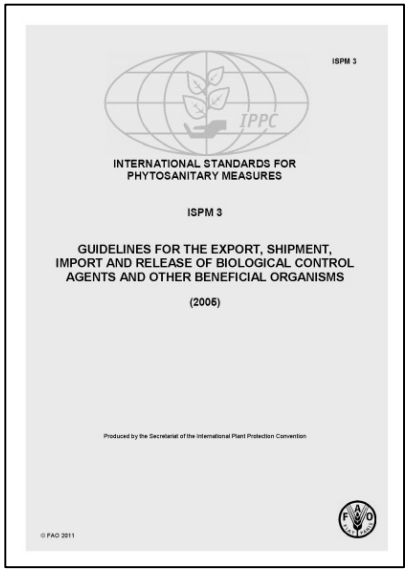
http://www.ebcc.info/wpimages/Bioregions-EBCC3.gif

2. Harmonized International Standards

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

- North American Plant Protection Organization (3 countries)
  [RSPM No. 7- 2001, revised 2006, 2014]

- European Plant Protection Organization (50 countries)
  [PM6.2 (2)]


ISPM 3

IPPC

INTERNATIONAL STANDARDS FOR PHYTOSANITARY MEASURES

ISPM 3

GUIDELINES FOR THE EXPORT, SHIPMENT, IMPORT AND RELEASE OF BIOLOGICAL CONTROL AGENTS AND OTHER BENEFICIAL ORGANISMS

(2005)

Produced by the Secretariat of the International Plant Protection Convention

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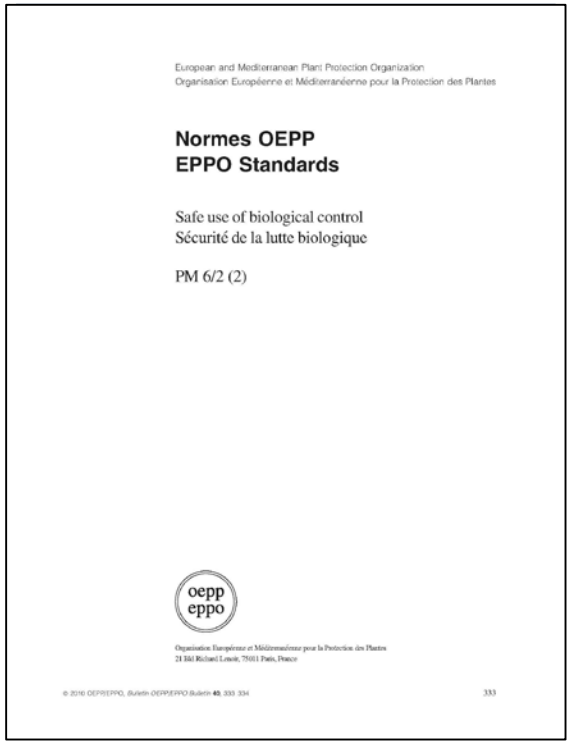
European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes

Normes OEPP
EPPO Standards

Safe use of biological control
Sécurité de la lutte biologique

PM 6/2 (2)

oepp
eppo

Organisation Européenne et Méditerranéenne pour la Protection des Plantes
21 Blvd Richard Lenoir, 75011 Paris, France

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3. Host range testing

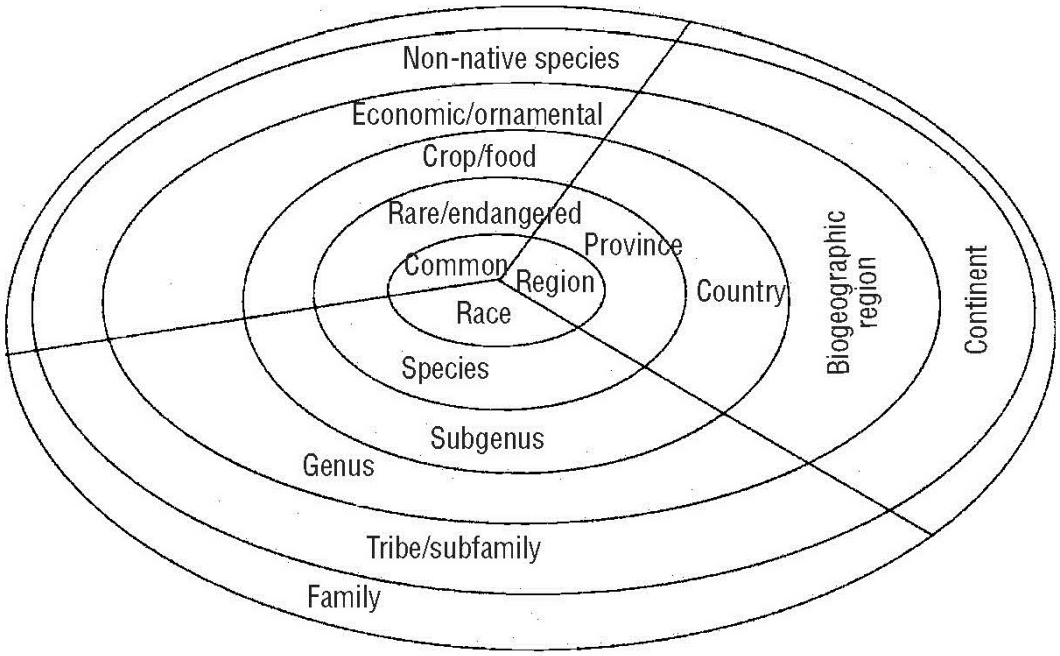
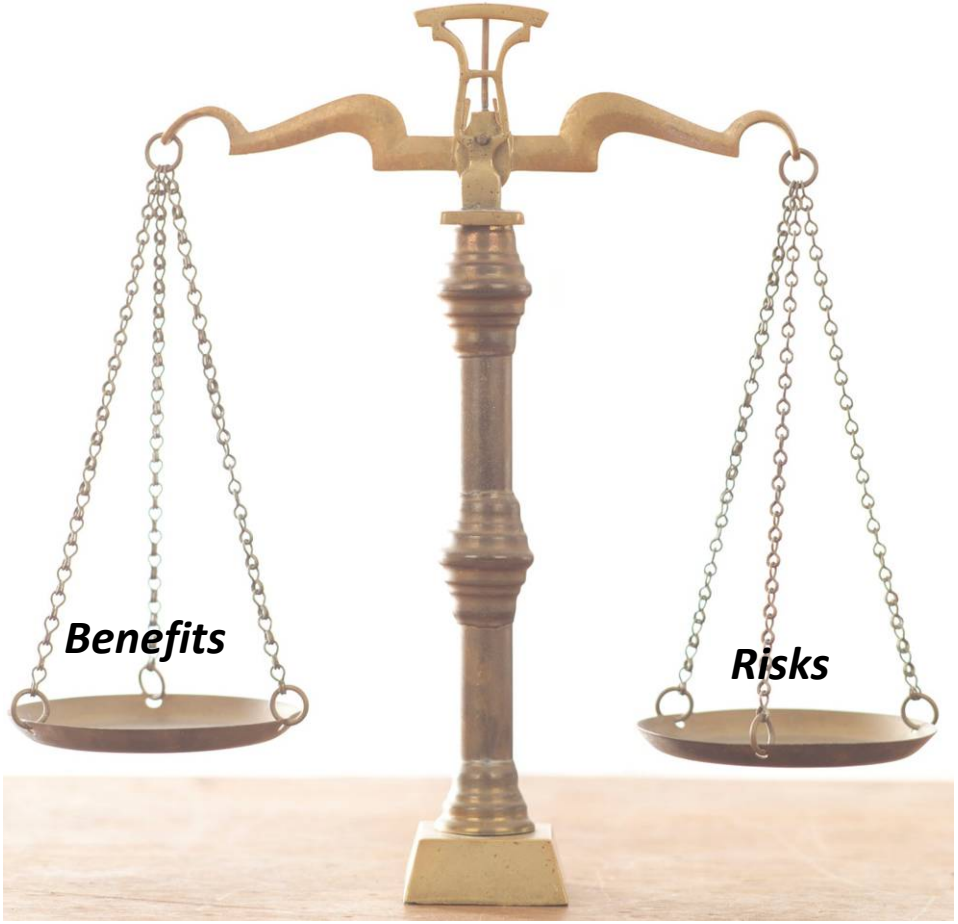


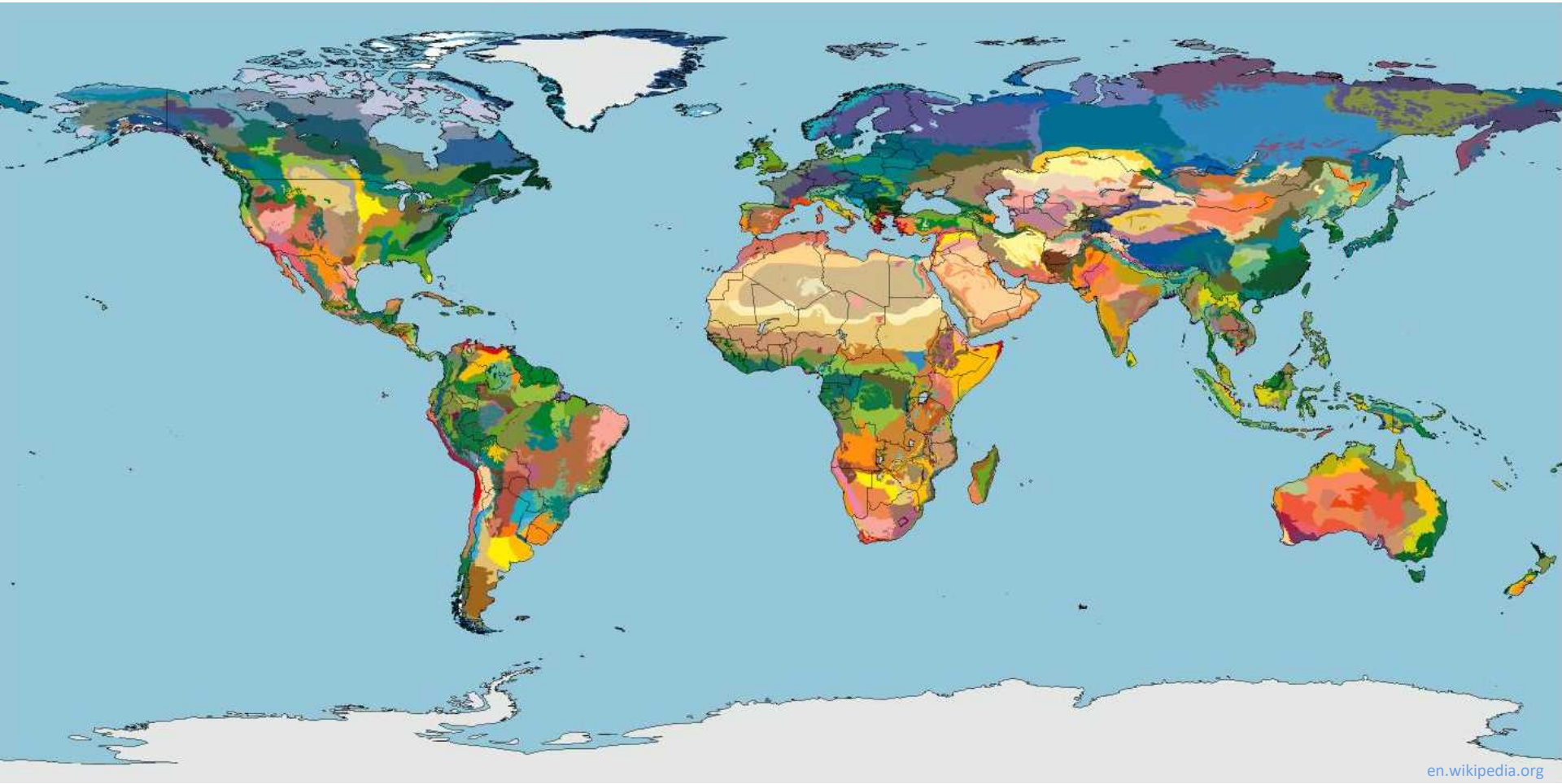
Fig. 3.1. Model for developing a list of non-target species for testing with potential biological control agents. The target species is at the centre of the model. Concentric rings of increasing radius indicate decreasing risk, and, therefore, testing priority. The three axes – taxonomy, geography and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

J.T. Huber, S. Darbyshire, J. Bissett and R.G. Foottit. 2002.
Taxonomy and Biological Control …

4. Benefits and Risks assessment



Thanks!



Canada