Classical Biological Control for the management of Weeds

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www.cabi.org

KNOWLEDGE FOR LIFE
Content

• CABI
• Biocontrol types
  • Inundative
  • Classical
• The age of Serendipity
• Japanese knotweed showing process
• Azolla weevil “baby steps”
• Other current targets
• Conclusion
in brief

- CABI provides scientific expertise and information about agriculture and the environment
- Activities include: scientific publishing, development projects and research, and microbial services
- Established in 1910
- Not-for-profit
- Owned by 48 member countries
We work on behalf of 48 member countries

* UK Overseas Territories.  **Associate Member
Global reach

We have 400+ staff across 21 locations worldwide
Our Capabilities in Europe vs weeds

- 36 scientists in 3 centres
- 3 quarantine suites
- 8 laboratories
- 10 glasshouse chambers
- Dozens of field cages
- 20 students
- >30 projects

Globally >800 years of experience in IAS – and rising!!
Recognised globally as leaders in biological control
Broom in New Zealand – Unfair advantage

Photo S. Fowler
Biological options

Native weed

Bioherbicide/
Inundative

Exotic weed

Classical
biocontrol
The Inundative Approach

• Used in high value horticulture, agriculture, golf courses to reduce chemical input/ combat resistance

• Or where conflicts of interest would exclude classical natural control

Better described as COMMERCIAL as applied like a chemical product from a bottle with a label and a user and is formulated.
Classical Biological Control

Uses co-evolved, and highly specific natural enemies from the area of origin of the plant to provide self-sustaining control. Often after a single release.

7,108 introductions of about 2,685 species of biological control agents have been made.
The Enemy Release Hypothesis

In their introduced range exotic plant species should experience;

“a decrease in regulation by herbivores and other natural enemies, resulting in an increase in distribution and abundance”.

The Theoretical Process

Graph courtesy of APIS
Eichhornia crassipes – Water Hyacinth
The real sequence of events

Graph courtesy of APIS
Recent project vs Water Hyacinth in the Guadiana river in Spain

€23,000,000
Is it Effective?

Clewley et al (2012) - The effectiveness of classical biological control of invasive plants

- Meta-analysis of 61 published studies (2000-2011)
- *Biocontrol agents significantly reduced: plant size (28 ± 4%), plant mass (37 ± 4%), flower and seed production (35 ± 13% and 42 ± 9%, respectively) and target plant density (56 ± 7%).*
- *Non-target plant diversity significantly increased (88 ± 31%)*

Culliney (2005) reviewed the economics from 32 projects for which adequate data existed.

- *The ratios varied considerably around a mean of over 200: 1 (range = 2.3: 1 to 4,000: 1)*
- *All were positive*
Is It Safe?

Over 1,300 releases of weed biocontrol agents around the world

>400 agents against 150 target weeds

A century of research

Any non-target effects are predictable by the vigorous safety testing

An International code of conduct

12 examples of “non-target” effects – all but one predicted at the time or predictable by the science applied to day
Weed CBC activity in Europe

<table>
<thead>
<tr>
<th>Country</th>
<th>Recipient</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>0</td>
<td>48</td>
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<tr>
<td>Finland</td>
<td>0</td>
<td>5</td>
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<td>France</td>
<td>0</td>
<td>111</td>
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<tr>
<td>Germany</td>
<td>0</td>
<td>46</td>
</tr>
<tr>
<td>Greece</td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td>Italy</td>
<td>0</td>
<td>71</td>
</tr>
<tr>
<td>Portugal</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Spain</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Sweden</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>UK</td>
<td>2</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>381</td>
</tr>
</tbody>
</table>
CBC Activity in Europe

Insect BCA history

In Europe there have been more than 300 releases of 176 predators and parasitoids against insects with very little regulation / Pest Risk Analyses.
The age of serendipity
Opuntia ficus indica invasion of Calderona Natural Park
2007

Espadán Natural park.

2012

Calderona Natural park. 92,5ha occupied by Opuntia
Biological control
Common ragweed

Ambrosia artemisiifolia

- Worst agricultural, environmental and social weed in EU
- COST SMARTER - Sustainable management of Ambrosia artemisiifolia in Europe
- Action will promote and coordinate classical and inundative BC activities among European labs and experts from Non-COST countries

Photo: H Mueller Schäerer

www.cabi.org/isc
Ambrosia beetle

Recently landed in Italy and spreading rapidly

Not the one we would have chosen first

But it is devastating Ambrosia on the way

Air monitoring data already showing significant reduction in airborne pollen load

Images ex COST SMARTER
Japanese knotweed
A consortium of Sponsors came together in 2003 to sponsor the programme.
The Japanese team in their temperate glasshouse with stock plants
186 species of phytophagous arthropod recorded from Japanese knotweed in Japan.

Many insects feeding on most parts

- Leaf feeders (123)
- Sap suckers (39)
- Stem borers (12)
- Leaf rollers (7)
- Other (5)
A process of elimination
Allantus luctifer

Machiatella itadori

Gallerucida bifasciata (for Europe)

Lixus impressiventris

All pictures: CABI UK
Aphalara itadori
Only 2mm as an adult

Eggs can just be seen with the naked eye
Centrifugal phylogenetic method:
More closely related species more likely to be attacked than more distantly related ones
Test Plant List

- 90 species and varieties
- representatives from 19 families.
- 37 plants natives including all native Polygonaceae
- 23 species introduced to the UK,
- 3 species native to Europe,
- 13 ornamental
- 10 economically important UK species
Bar chart showing mean egg count on those plants that did receive eggs in multiple choice oviposition tests. (+/- 1SE).

The 78 spp. that did not receive eggs are excluded.
Nymph transferred
% survival over time

- Fallopia japonica
- Rheum Glaskin's
- Fallopia dumetorum
- Fallopia esculentum
- Fallopia convolvulus
- Oxyria digyna
- Polygonum arenastium
- Rumex hydrolapatholium
- Reum palmatum
- Fallopia baldschuanica
- Fallopia dibotrys
- Persicaria polystachya
- Fallopia conoilliana
- M. complexa
<table>
<thead>
<tr>
<th><strong>Pest Risk Analysis</strong>&lt;br&gt;Necessary to free it from PHQL</th>
<th><strong>W&amp;C Act application for release</strong>&lt;br&gt;Necessary to release an animal</th>
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<tr>
<td>Based on Eppo template</td>
<td>Brand new version for Wales &amp; England</td>
</tr>
<tr>
<td>Internal Govt iterative review</td>
<td>Internal Govt iterative review</td>
</tr>
<tr>
<td></td>
<td>ACRE Committee review</td>
</tr>
<tr>
<td>External Peer review</td>
<td>External Peer review</td>
</tr>
<tr>
<td>Public consultation (3 months)</td>
<td>Public consultation (3 months)</td>
</tr>
<tr>
<td>Chief Scientist advice</td>
<td>Chief Scientist advice</td>
</tr>
<tr>
<td>Ministerial decision for Sec. of State</td>
<td>Ministerial decision for Sec. of State</td>
</tr>
<tr>
<td>Release from PH quarantine licence</td>
<td>W&amp;C license to release</td>
</tr>
</tbody>
</table>

EU Standing Committee on Plant Health Informed along the way
5 Year monitoring programme + contingency plan!

Phase 1 (2010) more of a safety test
8 pairs of release and control sites
3 recordings /season + 1 winter sample
Latest results

• Field cage results in 2014 prove direct and indirect safety of release
• Still no sustained populations in the field
• Release plan now includes riparian sites which should increase likelihood of success
• New stock from Japan will be compared with old rearing colony
• Canada and USA have petitioned for release
Himalayan balsam seedling infected with aecia of *P. komarovii var. glanduliferae* - India
Approval of the PRA

The PRA was presented to the SCPH on the 26th June in Brussels

Accepted by FERA and DEFRA

Defra Ministers approved the release of the rust in July

Released at first site 26th August

<table>
<thead>
<tr>
<th>Site</th>
<th>County</th>
<th>Habitat</th>
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</thead>
<tbody>
<tr>
<td>Sunningdale</td>
<td>Berkshire</td>
<td>Woodland</td>
</tr>
<tr>
<td>Silwood park</td>
<td>Berkshire</td>
<td>Woodland</td>
</tr>
<tr>
<td>Coldvreach Mill</td>
<td>Cornwall</td>
<td>Riparian</td>
</tr>
</tbody>
</table>
Baby Steps – Azolla weevil
Biological control of Azolla

Azolla filiculoides

- Hugely successful biocontrol in S. Africa, no EU congenerics
- Weevil *Stenopelmus rufinasus* already present in mainland Europe-potential to augment existing weevil populations for Azolla biocontrol
- CABI partner in the European RINSE project (Reducing the Impacts of Non-native Species in Europe) - 8 other partners from France, England, Belgium and the Netherlands
- Demonstration trials of *S. rufinasus* on Azolla could be an important first step for weed biocontrol in mainland Europe.
- Great potential in Southern Europe
European Union, Interreg IV 2 Seas Programme funding

9 partners from France, England, Belgium and the Netherlands

Awareness and management of INNS

CABI conducting demonstration trials with the Azolla weevil
Azolla weevil workshop at CABI, Egham UK
## Differing requirements by country

<table>
<thead>
<tr>
<th>UK</th>
<th>Netherlands</th>
<th>Belgium</th>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Ordinarily resident”</td>
<td>Formal Risk Assessment required</td>
<td>“Naturally occurring”</td>
<td>Proof of residency required</td>
</tr>
<tr>
<td>No restrictions to rearing and redistribution (England &amp; Wales)</td>
<td>Pest Risk Assessment followed by water authority authorised trials with ‘native’ weevils</td>
<td>Rearing and redistribution of native stock to sites with permission of land managers/local authorities</td>
<td>Collection and formal ID of weevils in France followed by rearing and regulated releases at limited sites</td>
</tr>
</tbody>
</table>
Before

7 weeks later

After
<table>
<thead>
<tr>
<th>Species</th>
<th>Form</th>
<th>Origin</th>
<th>EU distribution</th>
<th>Genus native?</th>
<th>Conflict</th>
<th>BC history</th>
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<tbody>
<tr>
<td>Buddleja davidii</td>
<td>Ph</td>
<td>China</td>
<td>Temperate</td>
<td>No(^b)</td>
<td>O</td>
<td>Yes</td>
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<tr>
<td>Fallopia japonica</td>
<td>Ge</td>
<td>Japan</td>
<td>Temperate</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Acacia dealbata</td>
<td>Ph</td>
<td>Australia</td>
<td>Mediterranean</td>
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<td>O</td>
<td>Yes(^d)</td>
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<td>Azolla filiculoides</td>
<td>Hy</td>
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<td>Temp/Med</td>
<td>No(^b)</td>
<td>No</td>
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<tr>
<td>Ailanthus altissima</td>
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<td>China</td>
<td>Temp/Med</td>
<td>No(^e)</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Impatiens glandulifera</td>
<td>He</td>
<td>India</td>
<td>Temperate</td>
<td>Yes</td>
<td>O</td>
<td>No</td>
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<tr>
<td>Rhododendron ponticum</td>
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<td>S Europe</td>
<td>Temp/Med</td>
<td>Yes</td>
<td>O</td>
<td>Yes</td>
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<tr>
<td>Robinia pseudoacacia</td>
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<td>Temperate</td>
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<td>F</td>
<td>No</td>
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<tr>
<td>Senecio inaequidens</td>
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<td>S Africa</td>
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<td>No</td>
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</tr>
<tr>
<td>Carpobrotus edulis</td>
<td>Ch</td>
<td>S Africa</td>
<td>Temp/Med</td>
<td>No(^e)</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Heracleum mantegazzianum</td>
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<td>W Asia</td>
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<td>No</td>
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<tr>
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<td>Mediterranean</td>
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<td>No</td>
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<td>Hy</td>
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<td>Temp/Med</td>
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<td>Ludwigia peploides</td>
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<td>S America</td>
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<td>No</td>
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<td>Crassula helmsii</td>
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<td>Australasia</td>
<td>Temperate</td>
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<td>No</td>
<td>No</td>
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<td>Elodea canadensis</td>
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<td>No</td>
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<td>Myriophyllum aquaticum</td>
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<td>Solidago canadensis</td>
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<td>N America</td>
<td>Temperate</td>
<td>Yes</td>
<td>No</td>
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</tr>
</tbody>
</table>
Biocontrol of Floating pennywort

*Hydrocotyle ranunculoides*

- Part of EU WFD project group funded by Defra
- Only 1 native *Hydrocotyle* sp. in Europe
- *Listronotus elongatus* weevil is most promising agent, no non target development
- Draft PRA should be submitted in 2015
- 2 other potential agents: *Puccinia hydrocotyles* rust and fly, *Hydrellia* sp. ex Argentina
- Opportunities for EU piggy-backing, esp. Netherlands, France and Belgium, Germany

*Eugaurax* sp. pupae
Australian swamp stonecrop

- Semi aquatic plant, native to Australia and New Zealand – introduced to UK in 1911
- Forms dense mats, outcompeting native species and altering habitat for native species
- Difficult to control using conventional methods
- Project initiated in 2009/2010
- Test plant list produced – 41 species including natives, *Crassula aquatica* and *Crassula tillaea*
Advantages of weed CBC

- Based on scientifically sound principles and protocols
- 100+ year history
- Sustainable
- Cost effective
- Environmentally benign
- Efficacious
- Good safety record
Disadvantages of CBC

- Restricted to control of exotics
- Potentially long lag phase
- No eradication
- Irreversible
- Perceived as expensive due to long research phase
- Potential conflict of interest
- No guarantee of success and hard to predict impacts
In Summary

• Biological control is a tried and tested approach to some of the worst weeds in the world
• It has a very good safety record and any non-target attack is predictable
• Efficacy is harder to predict
• The political, regulatory and consumer drivers mean that there should be a lot more classical biocontrol in Europe in future
• This tool cannot be ignored when considering species for inclusion in the list of spp of EU Concern re the Invasive Species Regulation
Thank You
Many thanks

RINSE partners:

Norfolk County Council

inbo

RATO vzw

VAL D'AUTHIE

inagro

Bournemouth University

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