Classical Biological Control for the management of Weeds

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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

CABI

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**

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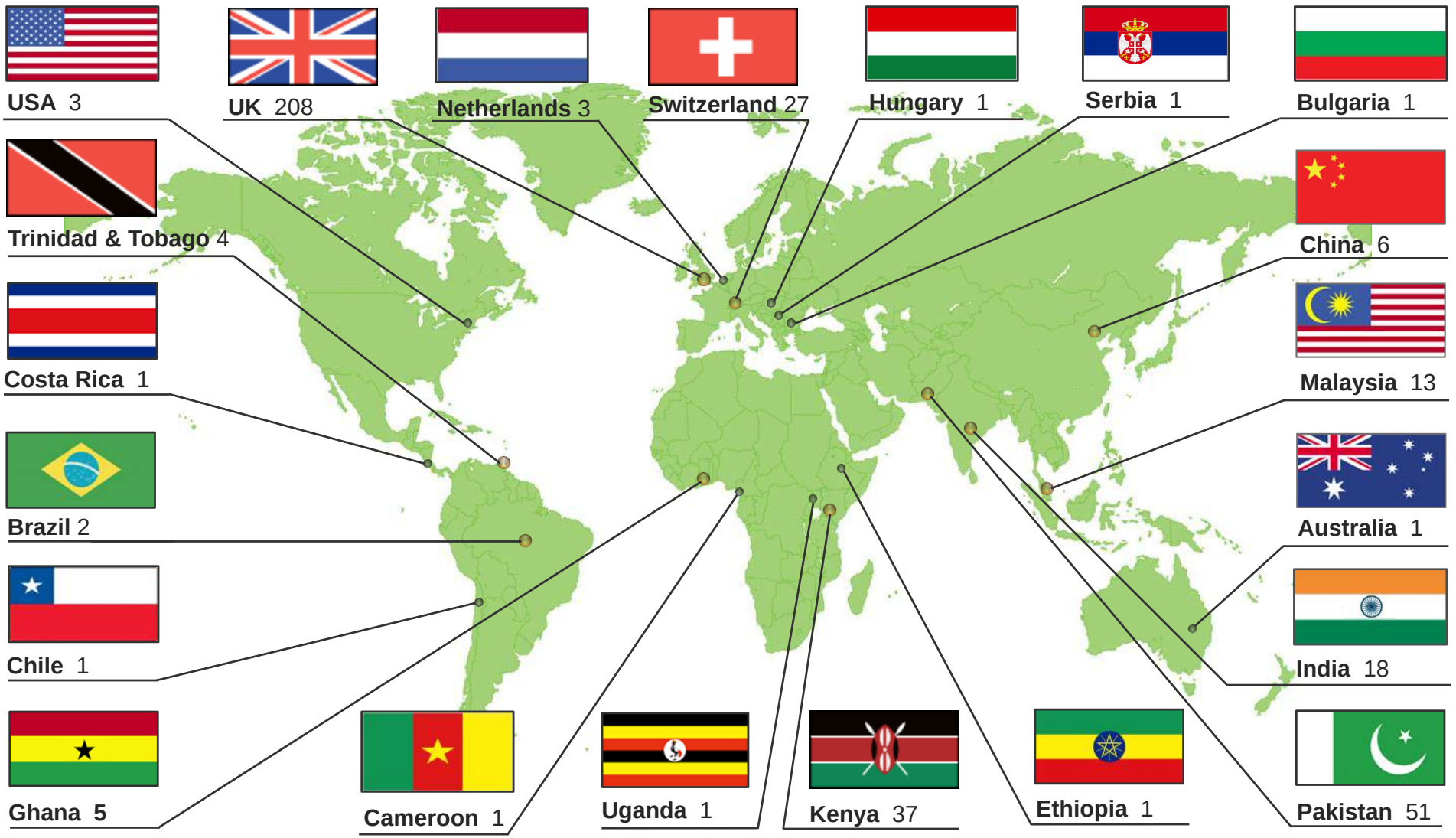
We work on behalf of 48 member countries

* 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

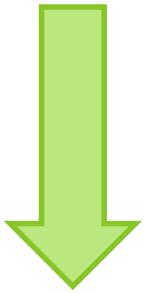
Globally >800 years of experience in IAS – and rising!!

Recognised globally as leaders in biological control

Broom in New Zealand – Unfair advantage

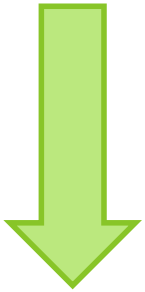
Biological options

Native weed



Bioherbicide/
Innundative

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.

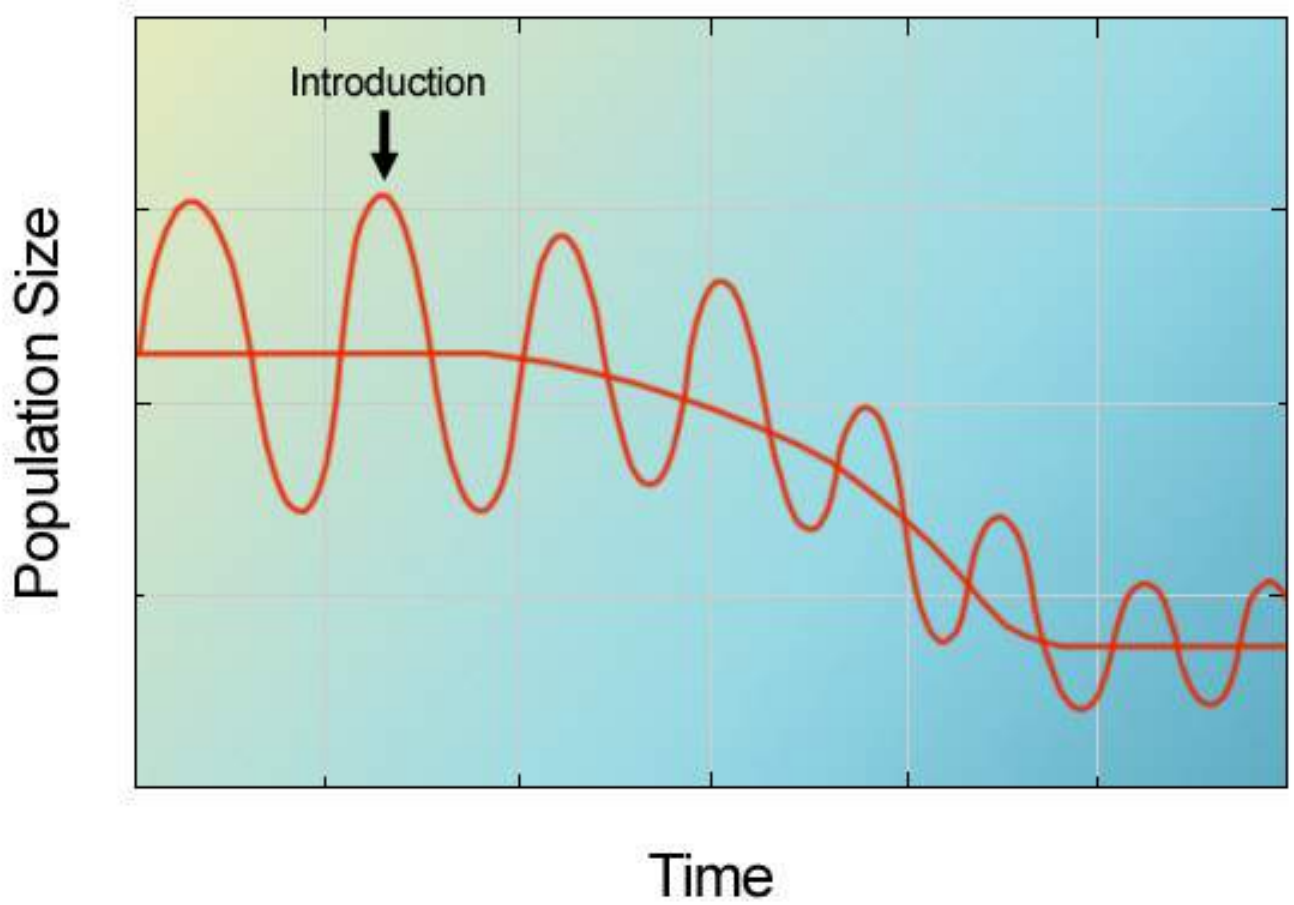
The Enemy Release Hypothesis

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".

Keane, R.M. and Crawley, M.J. (2002) 'Exotic plant invasions and the enemy release hypothesis', *Trends in Ecology & Evolution* **17** (4): pp.164-170.

The Theoretical Process

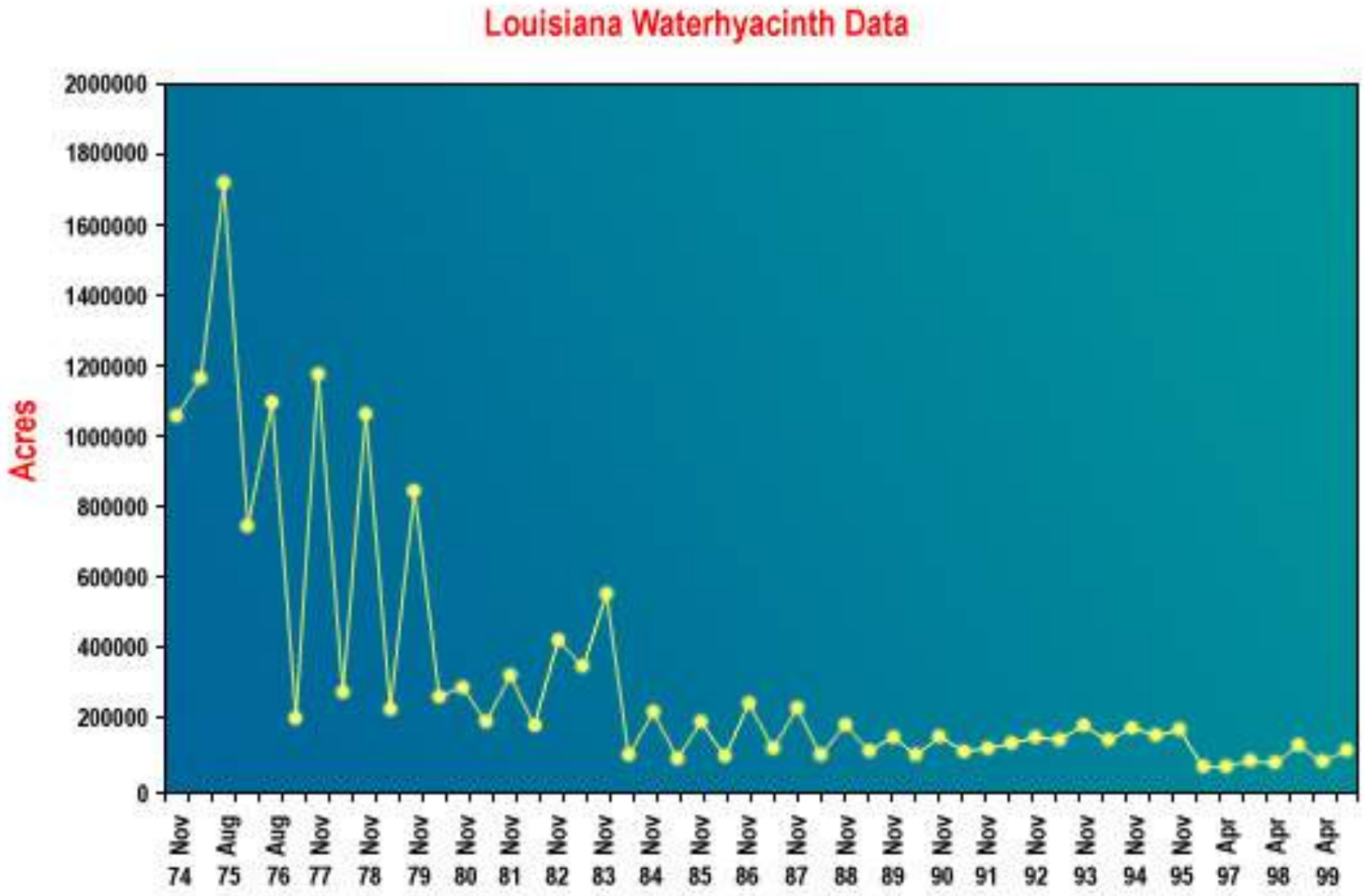


Graph courtesy of APIS

Eichornia crassipes – Water Hyacinth

Neochetina eichhorniae
Mottled water hyacinth weevil
Copyright 1997 USDA-ARS

The real sequence of events



Graph courtesy of APIS

Recent project vs Water Hyacinth in the Guadiana river in Spain

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

Country	Recipient	Source
Austria	0	48
Finland	0	5
France	0	111
Germany	0	46
Greece	0	29
Italy	0	71
Portugal	0	18
Spain	0	9
Sweden	0	3
UK	2	41
Total	1	381

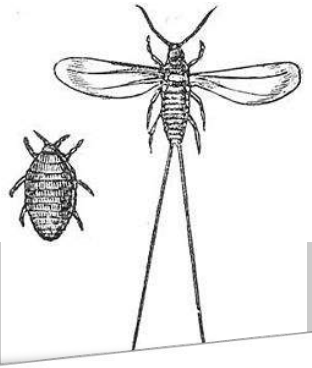
CBC Activity in Europe

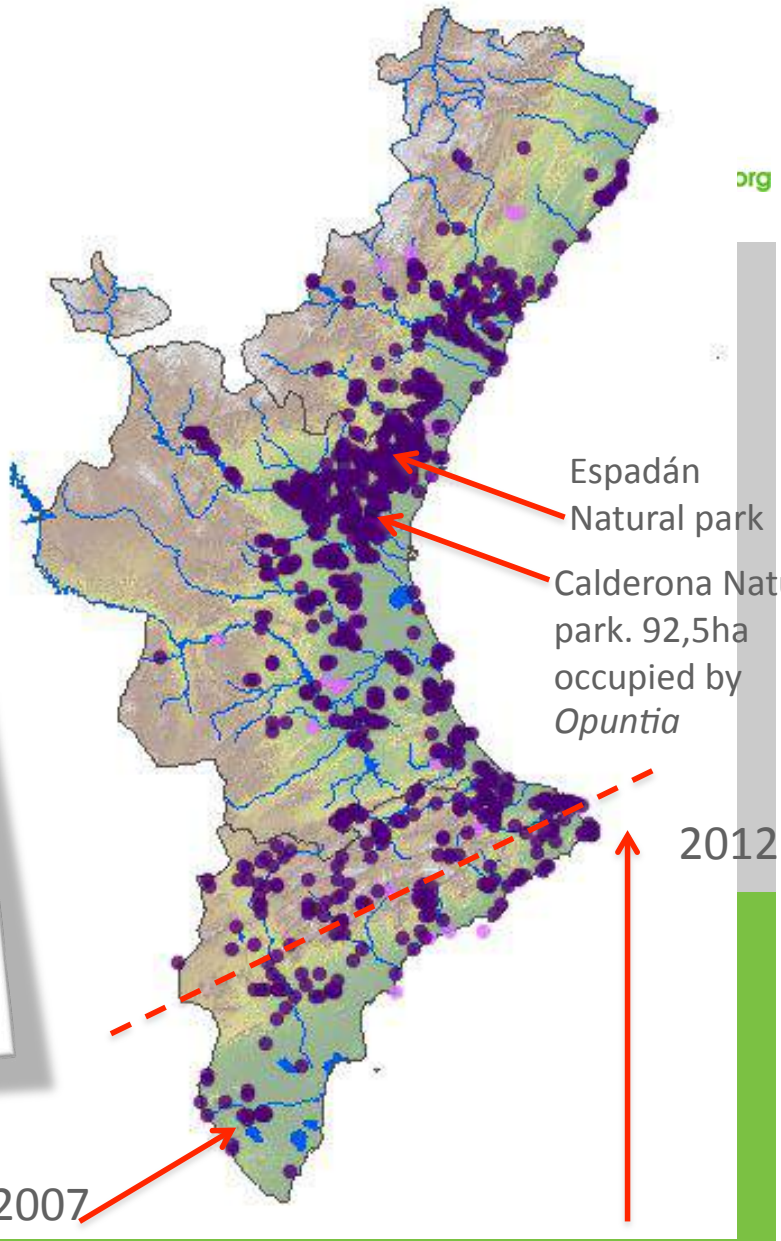
Insect BCA history

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





Slide - Vincente Del Torro

Biological control Common ragweed

Photo: H Mueller Schaerer

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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

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

British Waterways

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Department for Environment Food and Rural Affairs

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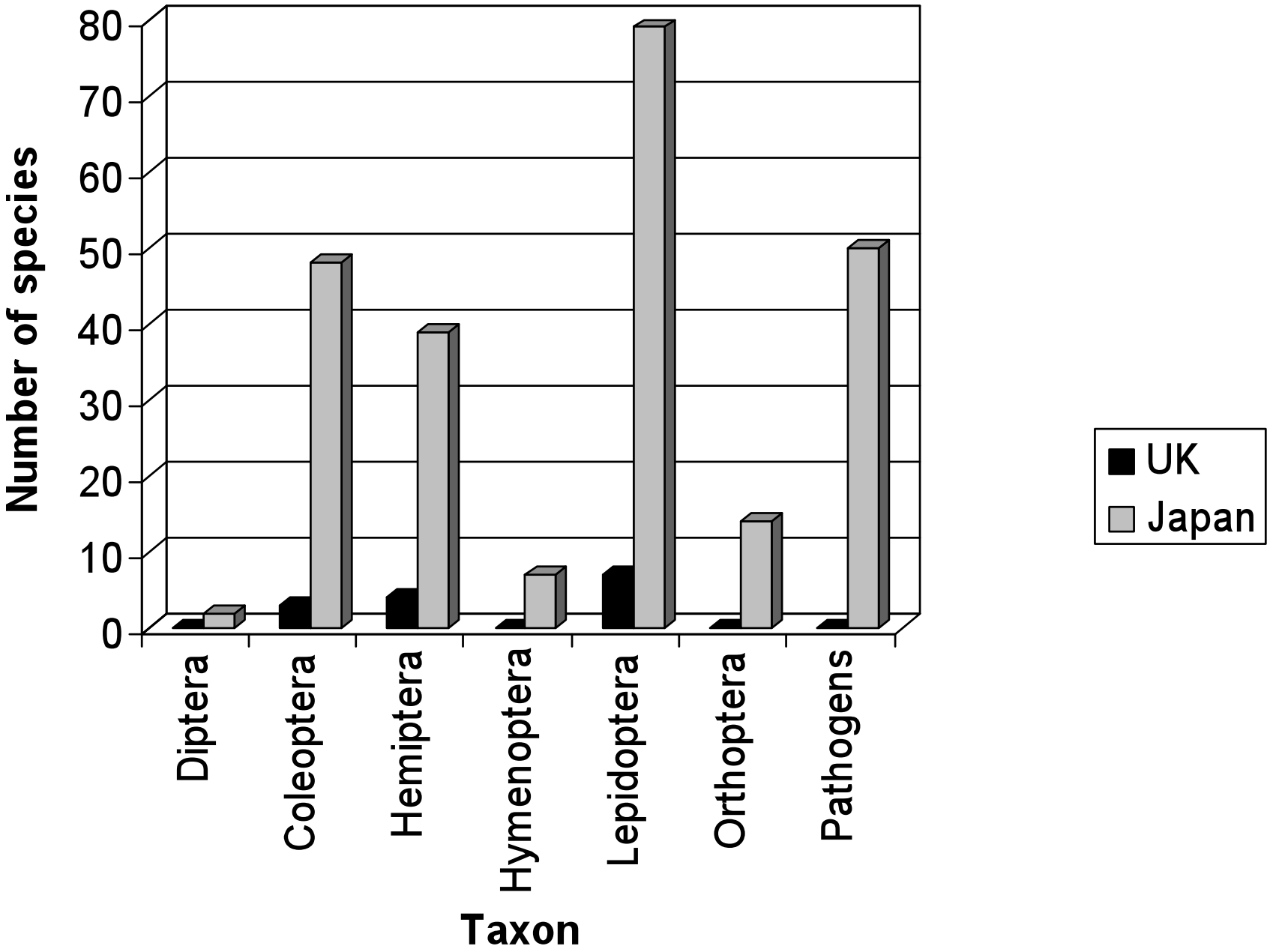
Network Rail

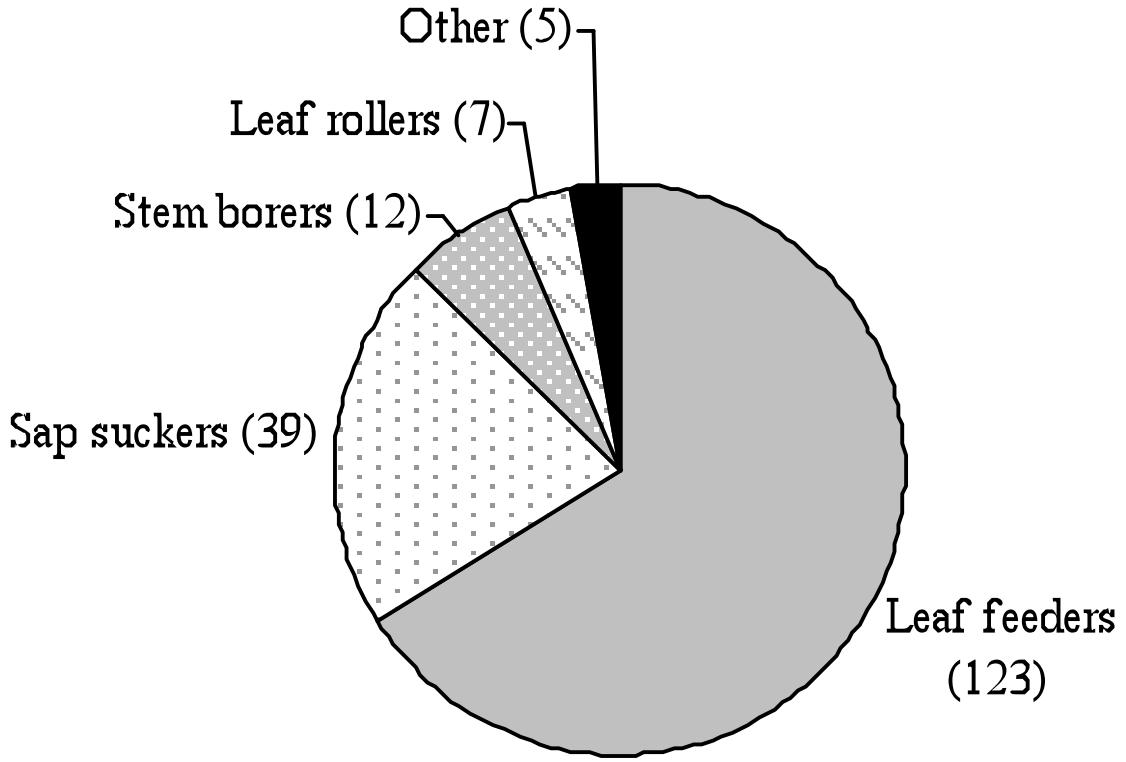
South West of England
Regional Development Agency

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

The Japanese team in their temperate glasshouse with stock plants

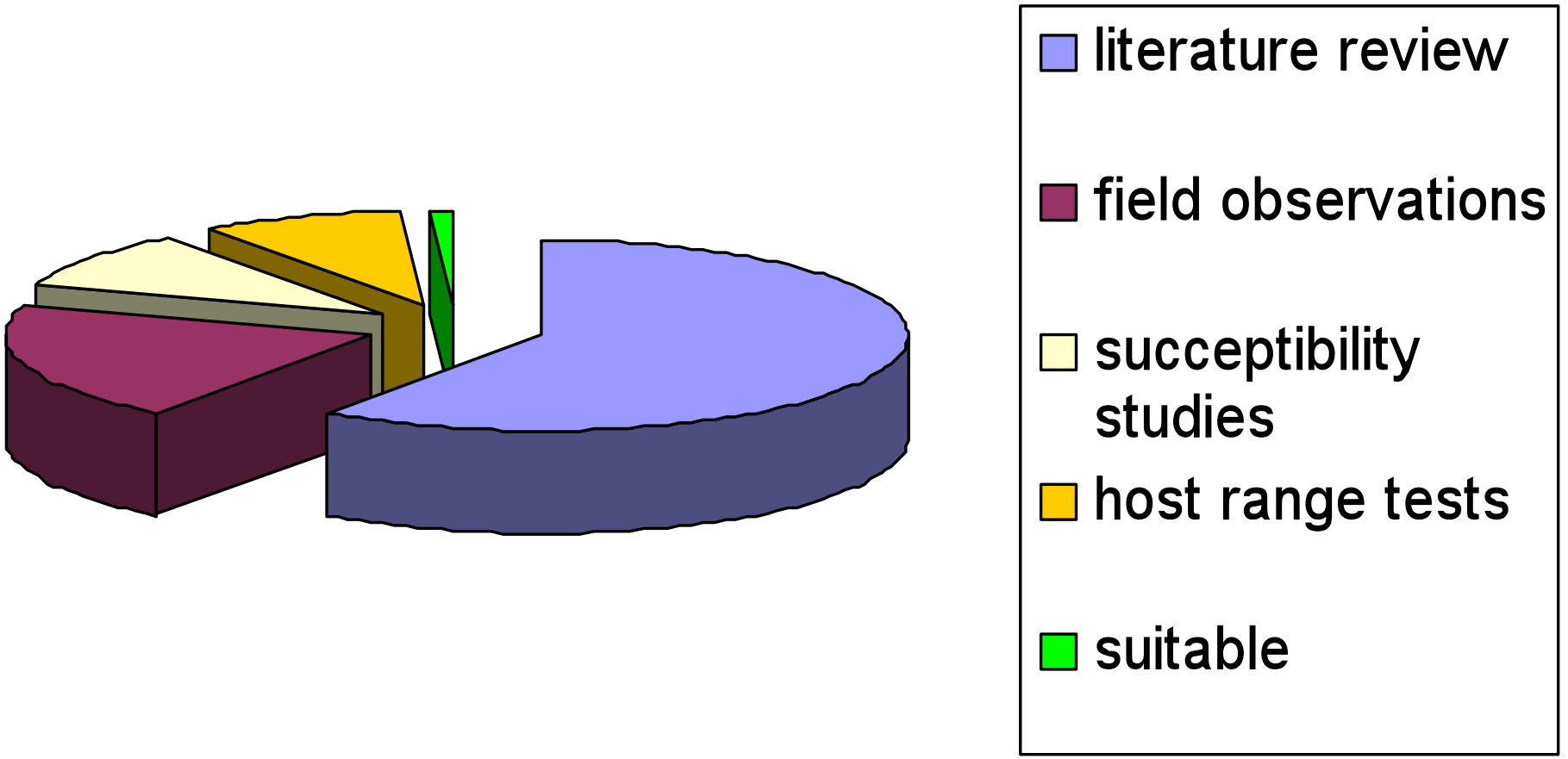

Number of species
80
70
60
50
40
30
20
10
0
Diptera
Coleoptera
Hemiptera
Hymenoptera
Lepidoptera
Orthoptera
Pathogens
Taxon
UK
Japan

Many insects feeding on most parts



186 species of phytophagous arthropod recorded from Japanese knotweed in Japan.

A process of elimination



Gallerucida bifasciata

Allantus luctifer

REJECTED

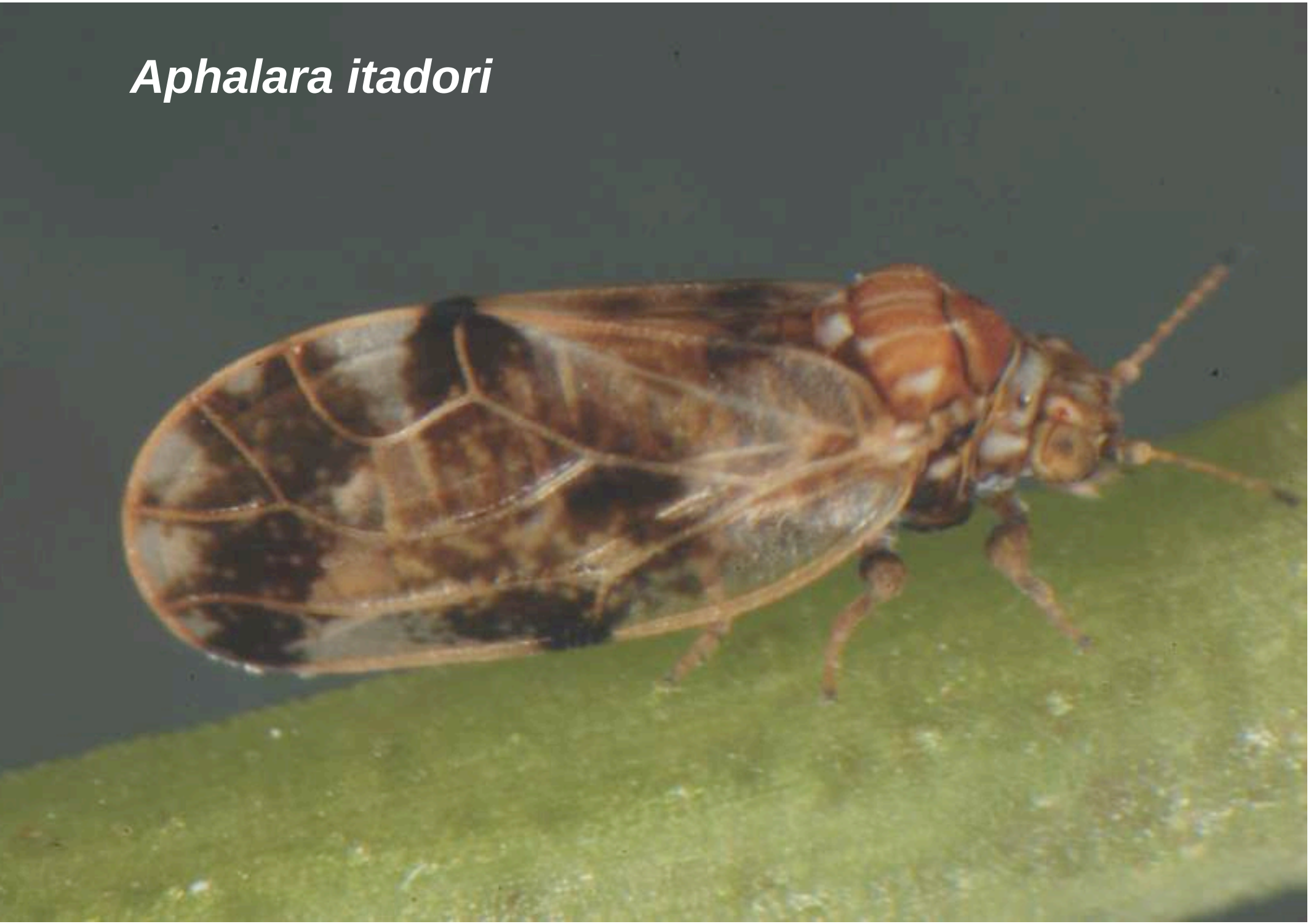
(for Europe)

All pictures: CABI UK

Machiatella itadori

Lixus impressiventris


NOTICE
AUTHORISED
PERSONS ONLY

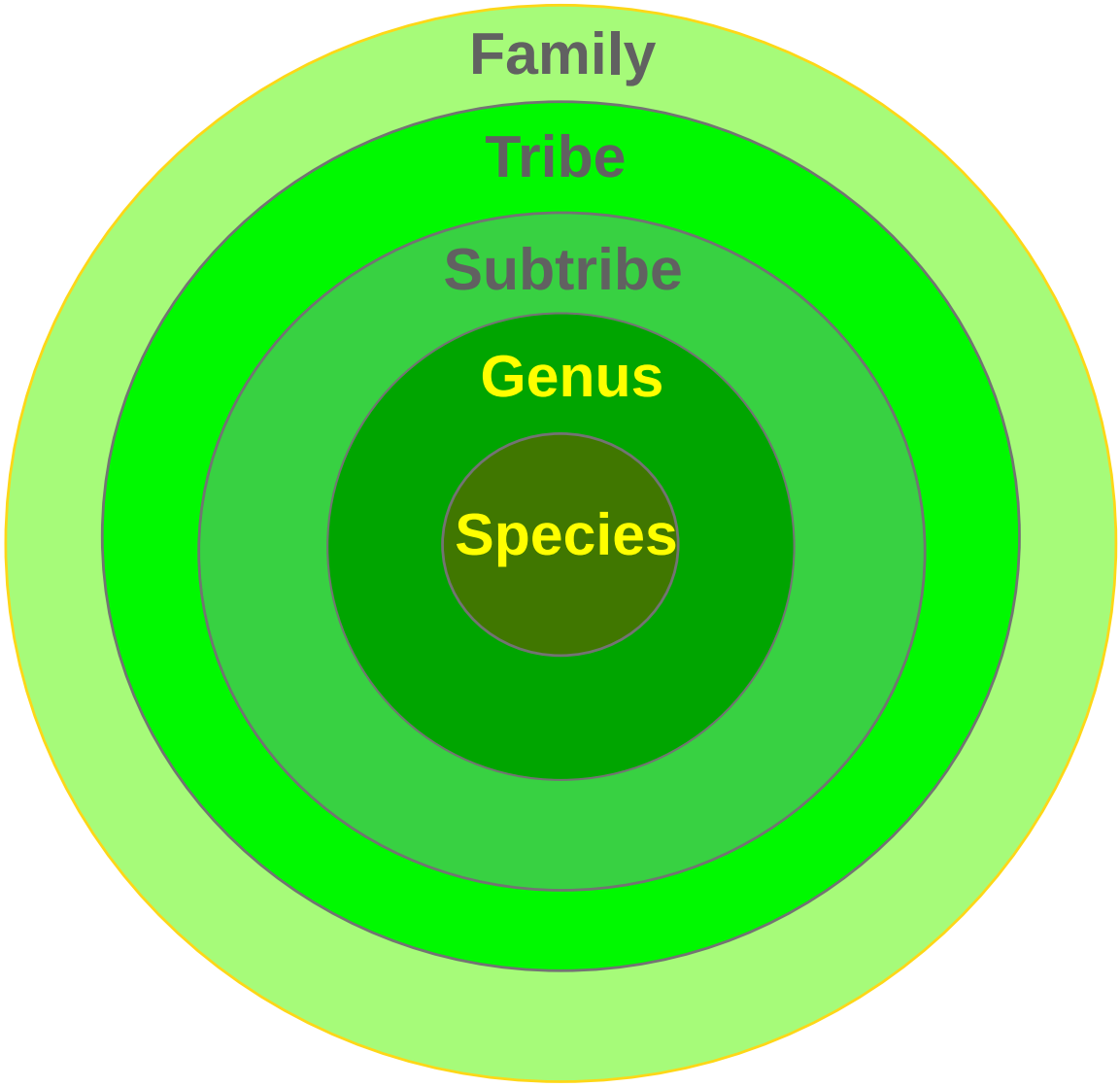

Aphalara itadori

Only 2mm as an adult

Eggs can just be seen with the naked eye

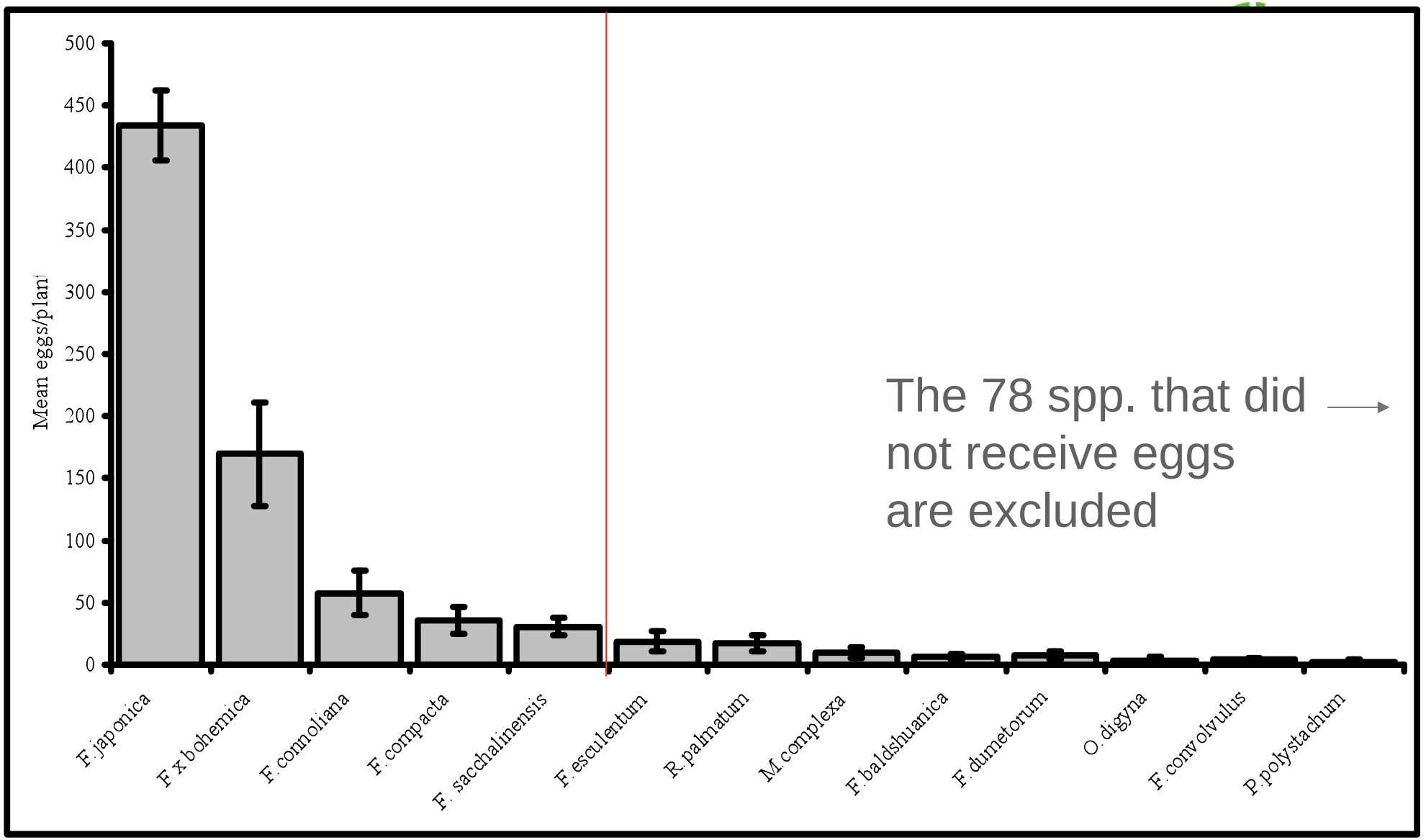
Centrifugal phylogenetic method:

More closely related species more
likely to be attacked than more distantly related ones



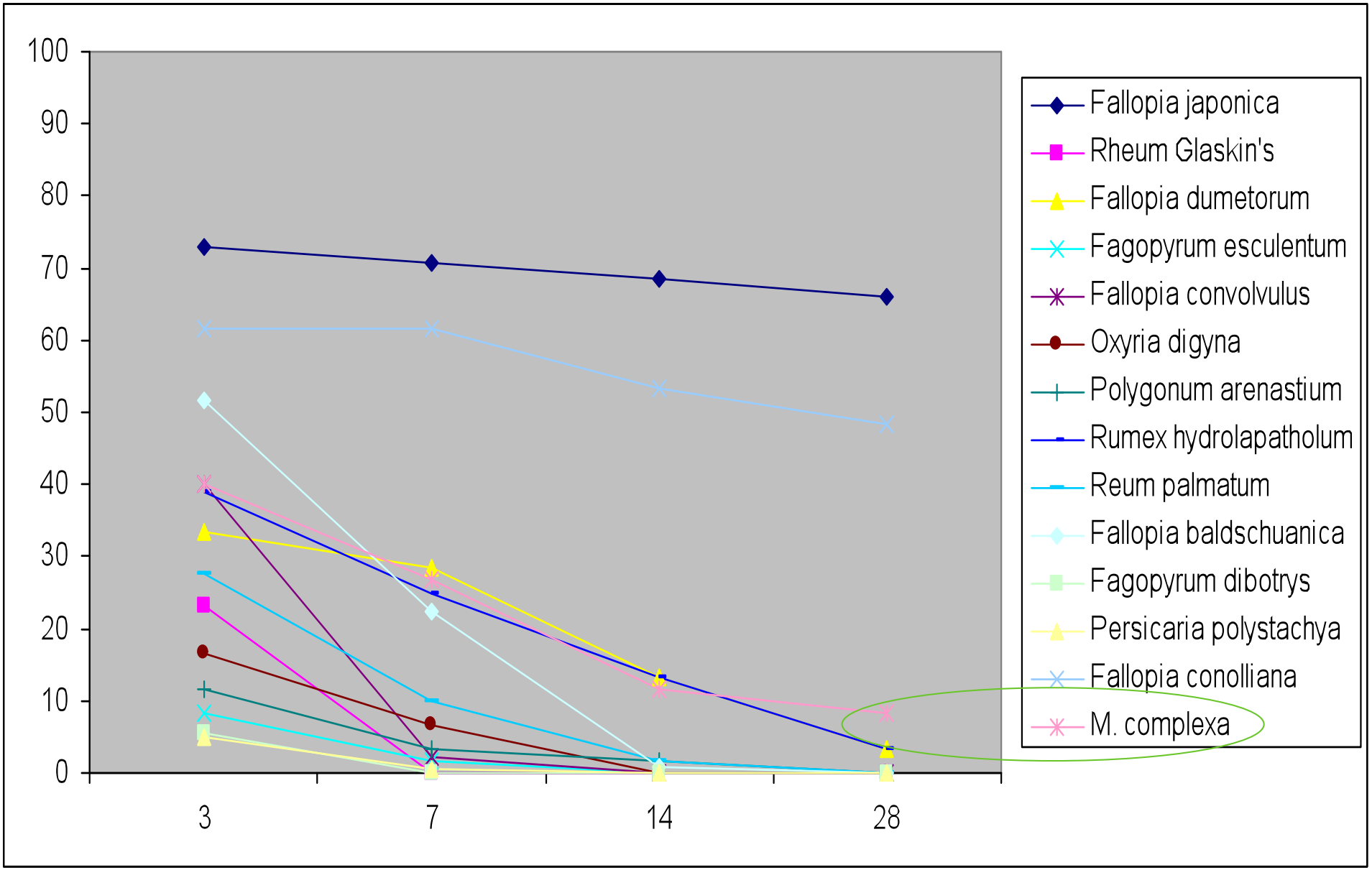
Test Plant List

- 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).

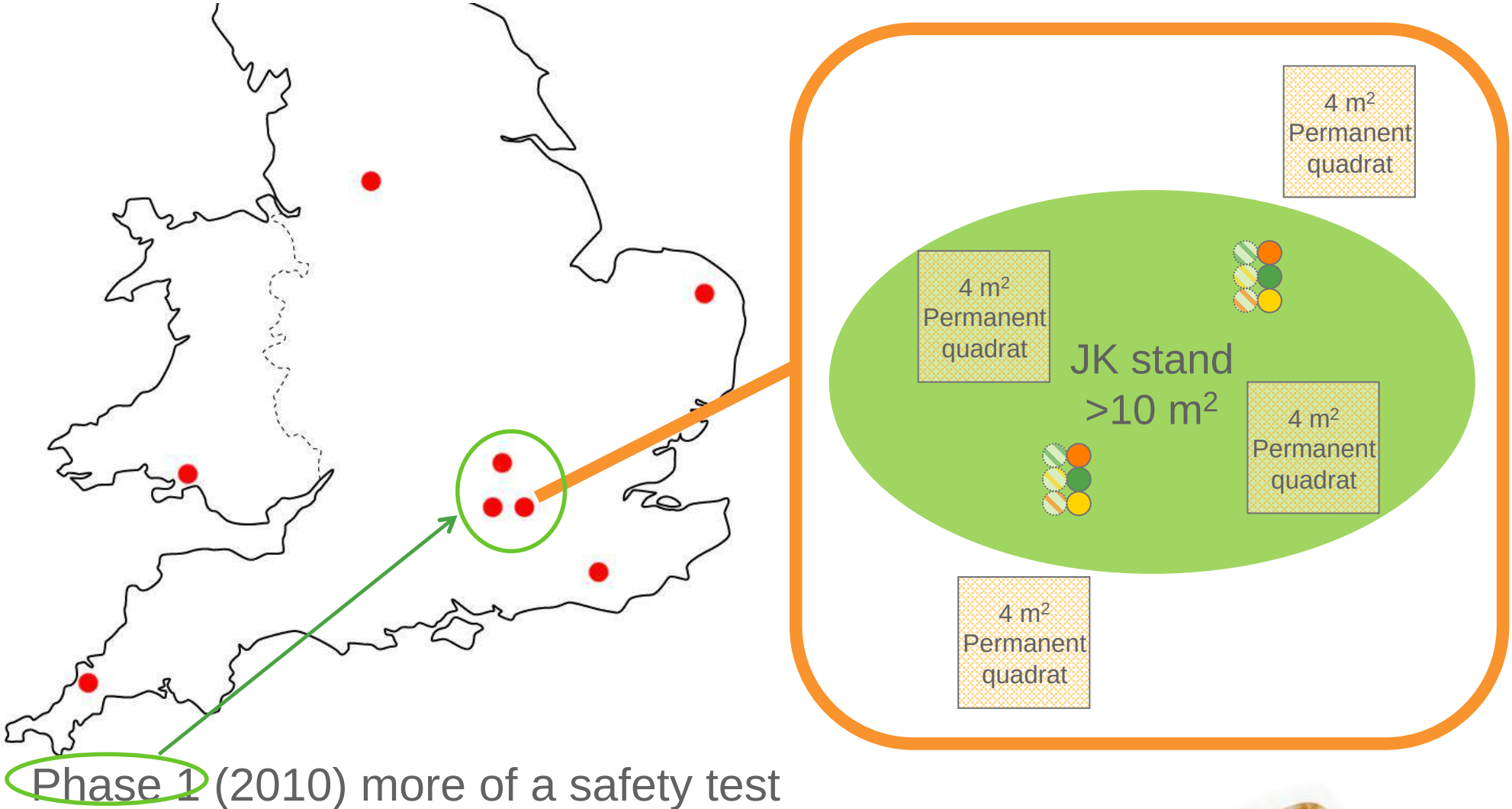
Nymph transferred
% survival over time



Pest Risk Analysis Necessary to free it from PHQL	W&C Act application for release Necessary to release an animal
Based on Eppo template	Brand new version for Wales & England
Internal Govt iterative review	Internal Govt iterative review
	ACRE Committee review
External Peer review	External Peer review
Public consultation (3 months)	Public consultation (3 months)
Chief Scientist advice	Chief Scientist advice
Ministerial decision for Sec. of State	Ministerial decision for Sec. of State
Release from PH quarantine licence	W&C license to release

EU Standing Committee on Plant Health Informed along the way

5 Year monitoring programme + contingency plan!

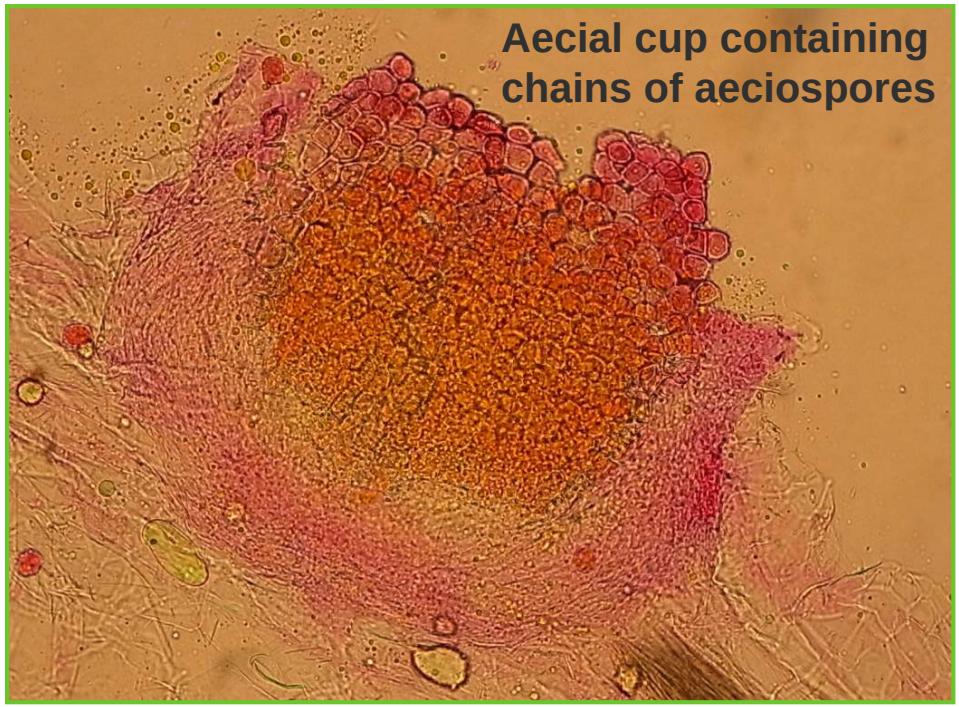


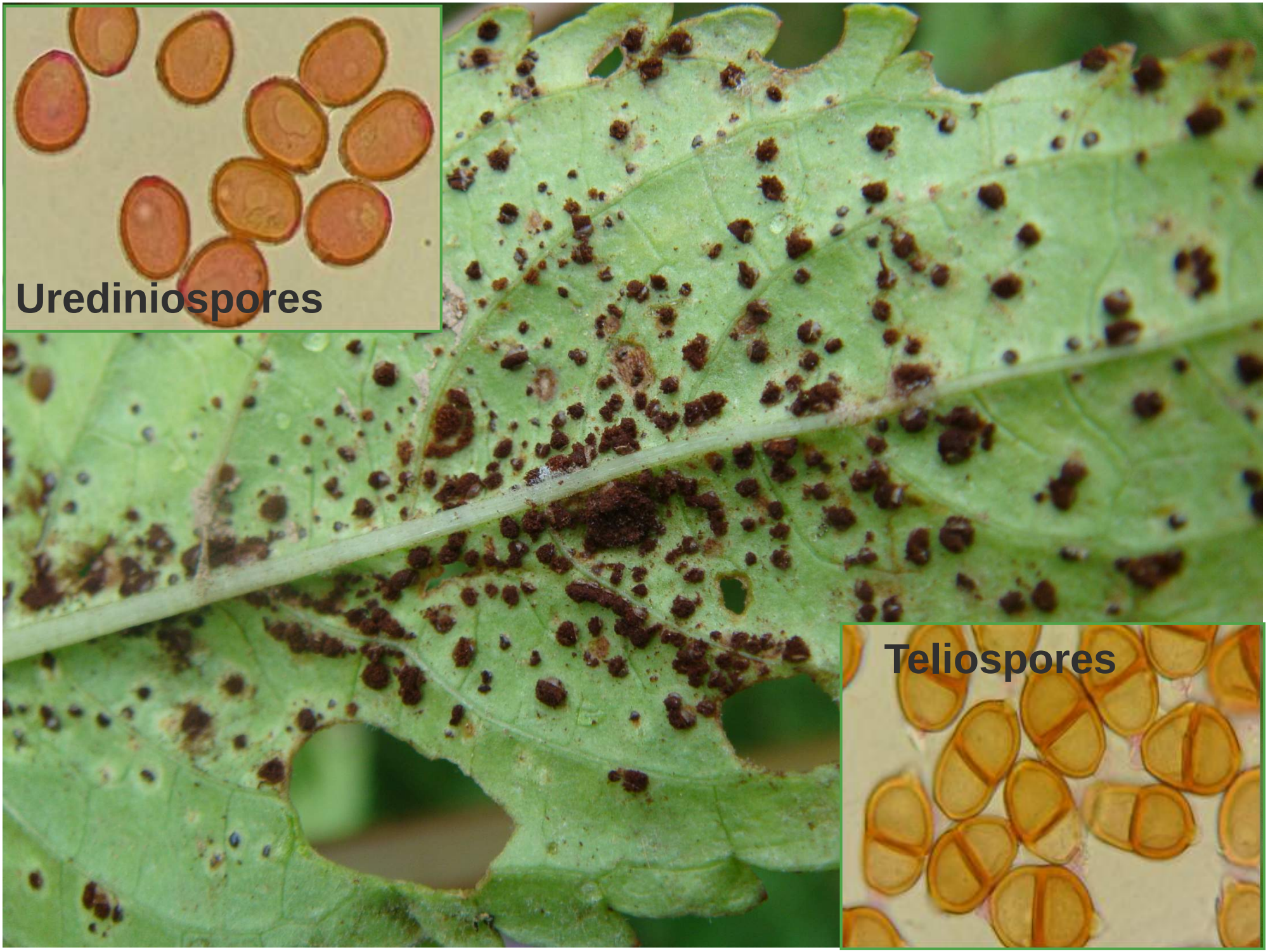
Phase 1 (2010) more of a safety test
8 pairs of release and control sites
3 recordings /season + 1 winter sample

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




Urediniospores
Teliospores

Approval of the PRA

A Pest Risk Analysis of *Puccinia komarovii* ex *Impatiens glandulifera* for the European Union (EU) Complied Using the CAPRA Software Developed by the European and Mediterranean Plant Protection Organization (EPPO)

(EPPO Standard PM 5/3(5))

The research detailed within this document was funded DEFRA, with contributions from the Environment Agency (UK) and the Scottish Government

Funded through the European Union Water Framework Directive

defra
Department for Environment Food and Rural Affairs

The Scottish Government
Riaghaltas na h-Alba

Environment Agency

The PRA was written by Rob Tanner and Marion Seier

Supporting documentation was written and compiled by Rob Tanner, Carol Ellison, Sonal Varia, Kate Pollard and Richard Shaw

Draft manuscripts included as appendices detail additional authors

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Bakeham Lane

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- 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

Site	County	Habitat
Sunningdale	Berkshire	Woodland
Silwood park	Berkshire	Woodland
Coldvreath Mill	Cornwall	Riparian

Release 2014

Baby Steps – Azolla weevil

Biological control of Azolla

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Azolla filiculoides

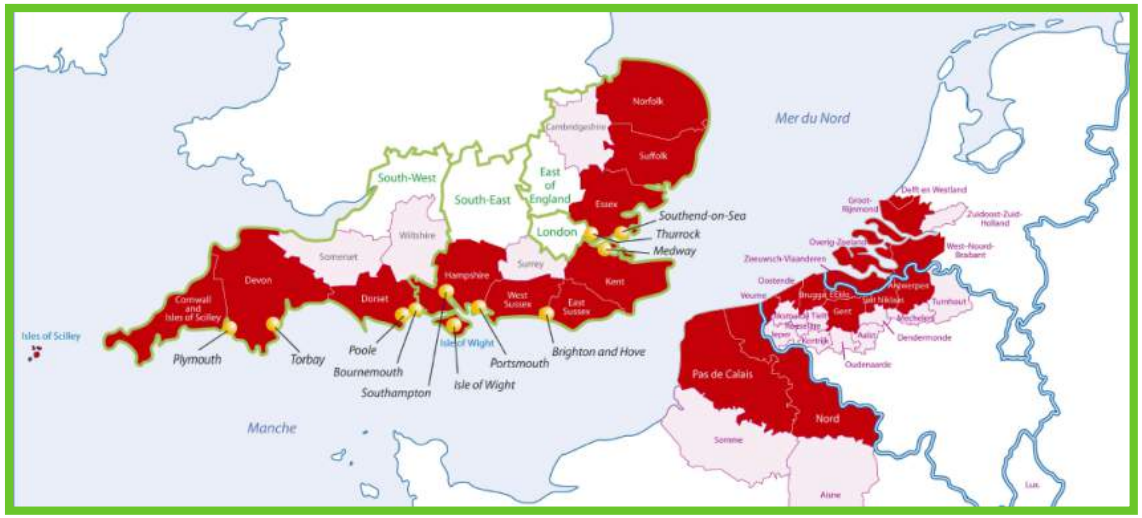
- Hugely successful biocontrol in S. Africa, no EU congenerics
- Weevil *Stenopelmus rufinasus* already present in mainland Europe-potential to augment existing weevil populations for Azolla biocontrol
- CABI partner in the European RINSE project (Reducing the Impacts of Non-native Species in Europe) - 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

RINSE

RINSE - Reducing the Impact of Non-native Species in Europe

www.cabi.org

- 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

RINSE

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Azolla weevil workshop at CABI, Egham UK

Differing requirements by country

UK	Netherlands	Belgium	France
“Ordinarily resident” Department for Environment, Food and Rural Affairs (Defra)	**Formal Risk Assessment required** Nederlandse Voedsel- en Warenautoriteit (NVWA) (Netherlands Plant Protection Organisation)	**“Naturally occurring”** Departement Leefmilieu, Natuur en Energie (LNE) (Department of Environment, Nature and Energy)	**Proof of residency required** Ministère de l'agriculture, de l'agroalimentaire et de la forêt (Ministry of Agriculture, Food and Forestry)
No restrictions to rearing and redistribution (England & Wales)	Pest Risk Assessment followed by water authority authorised trials with ‘native’ weevils	Rearing and redistribution of native stock to sites with permission of land managers/ local authorities	Collection and formal ID of weevils in France followed by rearing and regulated releases at limited sites


After


After

EU opportunities

Sheppard, Shaw & Sforza (2006) *Weed Research*

Gassmann *et al.* (2006) *Hydrobiologia*

Species	Form	Origin	EU distribution	Genus native?	Conflict	BC history
Buddleja davidii	Ph	China	Temperate	No[b]	O	Yes
Fallopia japonica	Ge	Japan	Temperate	Yes	No	Yes
Acacia dealbata	Ph	Australia	Mediterranean	No[b]	O	Yes[d]
Azolla filiculoides	Hy	N America	Temp/Med	No[b]	No	Yes[d]
Ailanthus altissima	Ph	China	Temp/Med	No[b]	No	Yes
Impatiens glandulifera	He	India	Temperate	Yes	O	No
Rhododendron ponticum	Ph	S Europe	Temp/Med	Yes	O	Yes
Robinia pseudoacacia	Ph	N America	Temperate	No	F	No
Senecio inaequidens	He	S Africa	Temp/Med	Yes	No	Yes
Ambrosia artemisiifolia	Th	C America	Temp/Med	Yes	No	Yes[d]
Carpobrotus edulis	Ch	S Africa	Temp/Med	No[b]	No	No
Heracleum mantegazzianum	He	W Asia	Temperate	Yes	No	Yes
Solanum elaeagnifolium	He	S America	Tem/Med	Yes	No	Yes[d]
Baccharis halimifolia	Ph	N America	Mediterranean	No	No	Yes[d]
Hydrocotyle ranunculoides	Hy	N America	Temp/Med	Yes	No	Yes
Ludwigia peploides	He	S America	Temp/Med	Yes	No	Yes
Crassula helmsii	Hy	Australasia	Temperate	Yes	No	No
Elodea canadensis	Hy	N America	Temperate	No	No	No
Myriophyllum aquaticum	Hy	S America	Temp/Med	Yes	No	Yes
Solidago canadensis	Ge	N America	Temperate	Yes	No	No

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

Crassula helmsii

Crassula helmsii in flower

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

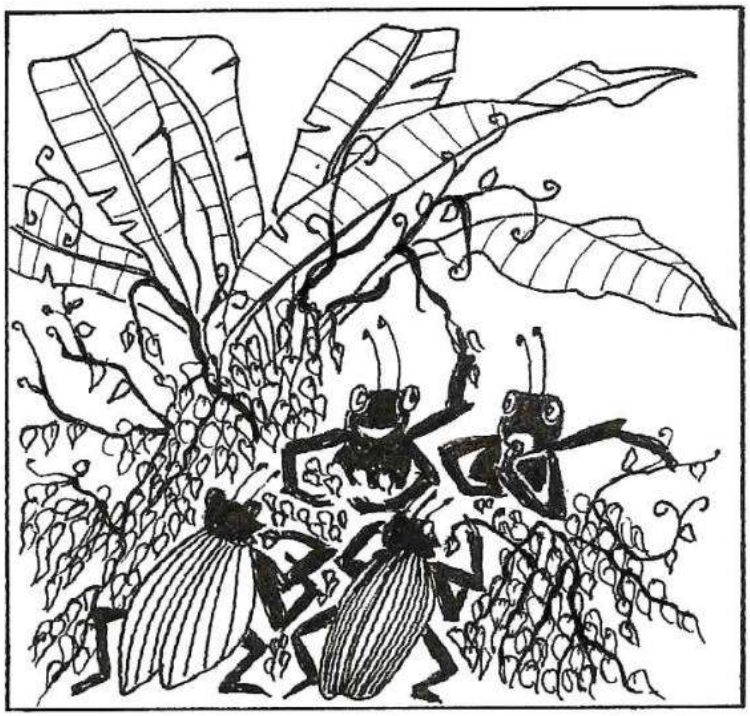
Disadvantages of CBC

- 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

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FOUNDED 1833


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PORTUGAL ESPAÇO ATLÂNTICO
U.K. ATLANTIC AREA


MAGYAR TUDOMÁNYOS AKADÉMIA
1825
HUNGARIAN
ACADEMY
OF SCIENCES


Royal Holloway
University of London

Many thanks

RINSE

RINSE partners:

Norfolk County Council

Netherlands Food and Consumer Product Safety Authority
Ministry of Economic Affairs, Agriculture and Innovation

inbo
Instituut voor natuur- en bosonderzoek
Research Institute for Nature and Forest

RATO vzw
RATTENBESTRIJDING OOST-VLAANDEREN

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