Classical Biological Control of Weeds in Europe – An underused tool

Dick Shaw – Country Director UK

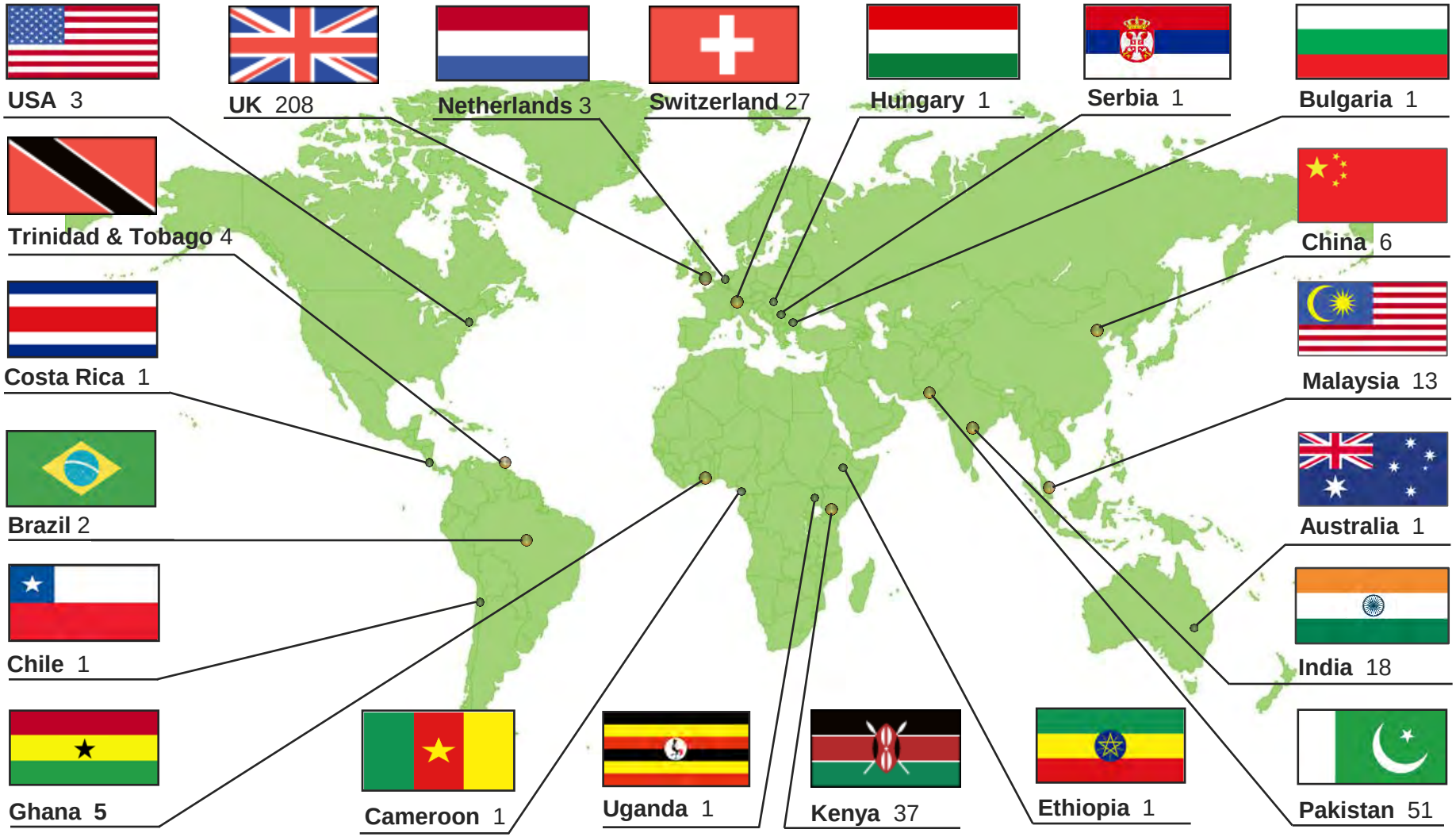
CABI

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**

Global reach

We have 499+ staff across 21 locations worldwide



2000 ISC Datasheets

Welcome to Invasive Species Compendium (Beta): Log-out

Invasive Species Compendium (Beta)

www.cabi.org

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- Viruses

Datasheets > Fallopia japonica (Japanese knotweed) back

Cover | Images | Identity | Distribution | Biology & Ecology | Impacts | Management | References | Report

Last modified: 21 October 2010

Datasheet Type(s): Pest, Invasive Species

Preferred Scientific Name
Fallopia japonica

Preferred Common Name
Japanese knotweed

Taxonomic Tree
Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae

More...

Summary of Invasiveness

F. japonica is an extremely invasive weed despite its lack of sexual reproduction in most of its introduced range. It is included on various lists of invasive weeds and is one of the 100 worst invasive species as identified by the IUCN. It is...

Picture

click on the picture for further information

Distribution map

click on the map for further information

Our IAS Research Capabilities in Europe

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

Recognised globally as leaders in biological control

Unfair Advantage

They arrived in EU without the natural enemies that keep them in check in their native range.

Those native (EU) species which do attack them do not cause enough damage

Some of the many insects and diseases in the area of origin may be safely released as classical agents

2 Categories of Weed Biological Control

Inundative - a.k.a the "Mycoherbicide Approach" using native pathogens for repeated application

Classical - Using Co-evolved (highly specific) NEs from the area of origin of the plant to provide self-sustaining control after a single release.

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.

Stenopelmus rufinasus

No stranger to biocontrol

Biological control of Azolla

www.cabi.org/isc.

Azolla filiculoides

- Hugely successful biocontrol in S. Africa,
- 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 http://www.rinse-europe.eu/
- Demonstration trials of *S. rufinasus* on Azolla could be an important first step for weed biocontrol in mainland Europe.
- Great potential in rest of Europe

•www.azollacontrol.com


30/07/2008

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 (against insects and weeds).

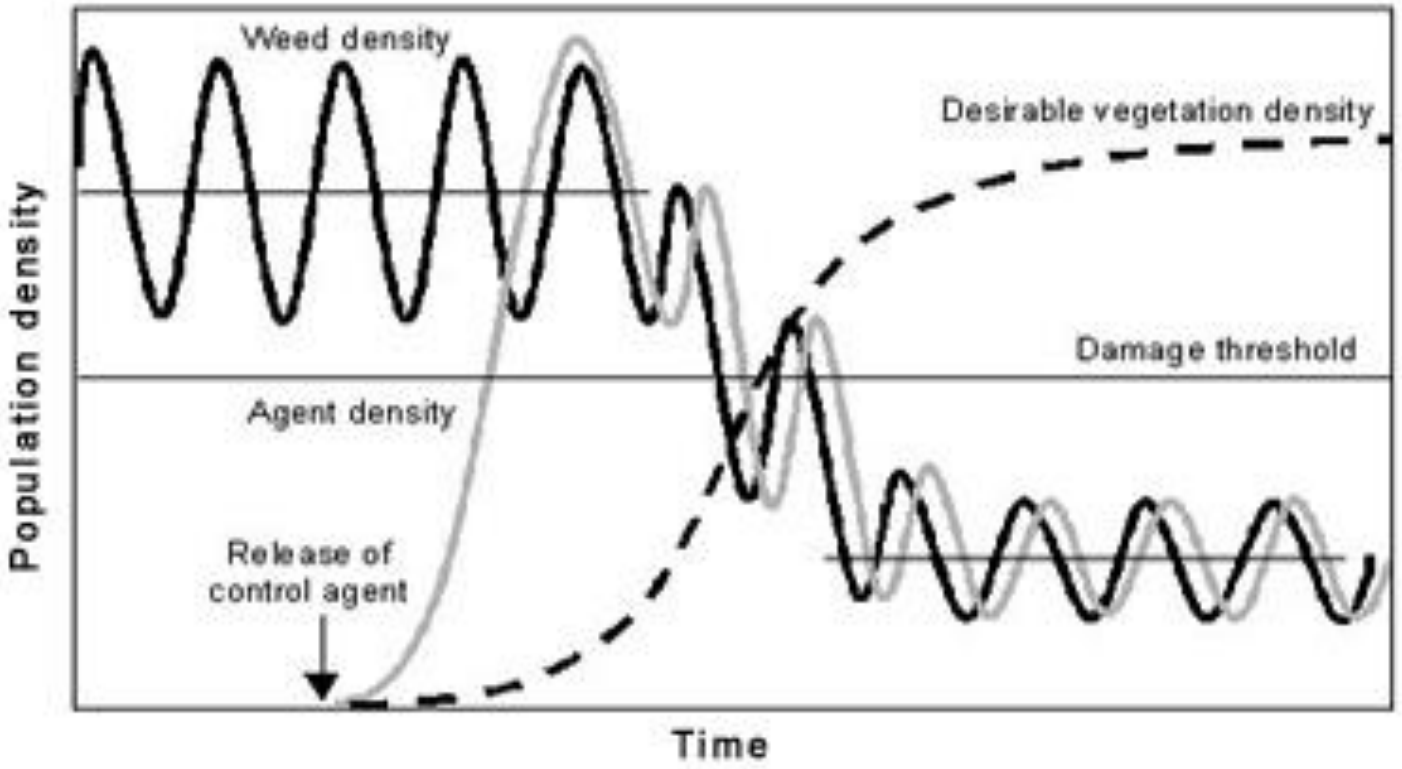
The enemy release hypothesis

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.

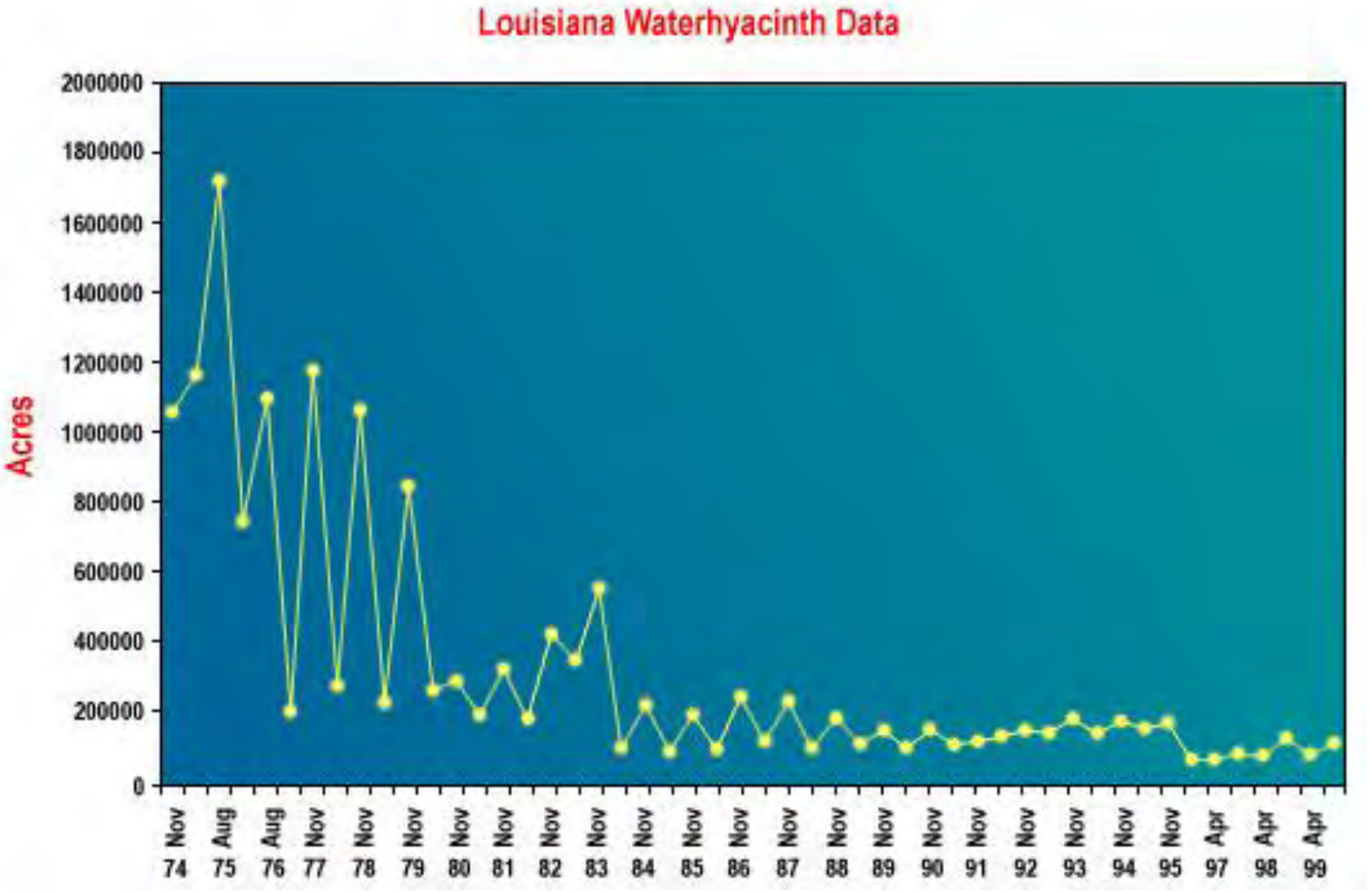
The normal sequence of events



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

Would it have been wiser to spend 5% of that budget on finding a cold tolerant strain of the legendary Neochetina biocontrol agent so there is a back up plan when it comes back?

Before - 50million acres invaded

After – 250,000km^2 cleared

Rubber vine weed

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 the past 100 years, more than 400 different biocontrol agents have been used against around 150 target plants, totalling over 1,300 introductions around the globe.

- A century of research
- Any non-target effects are predictable by the vigorous safety testing
- An International code of conduct (effectively written by CABI)
- 8 examples of “non-target” effects

BUT…..

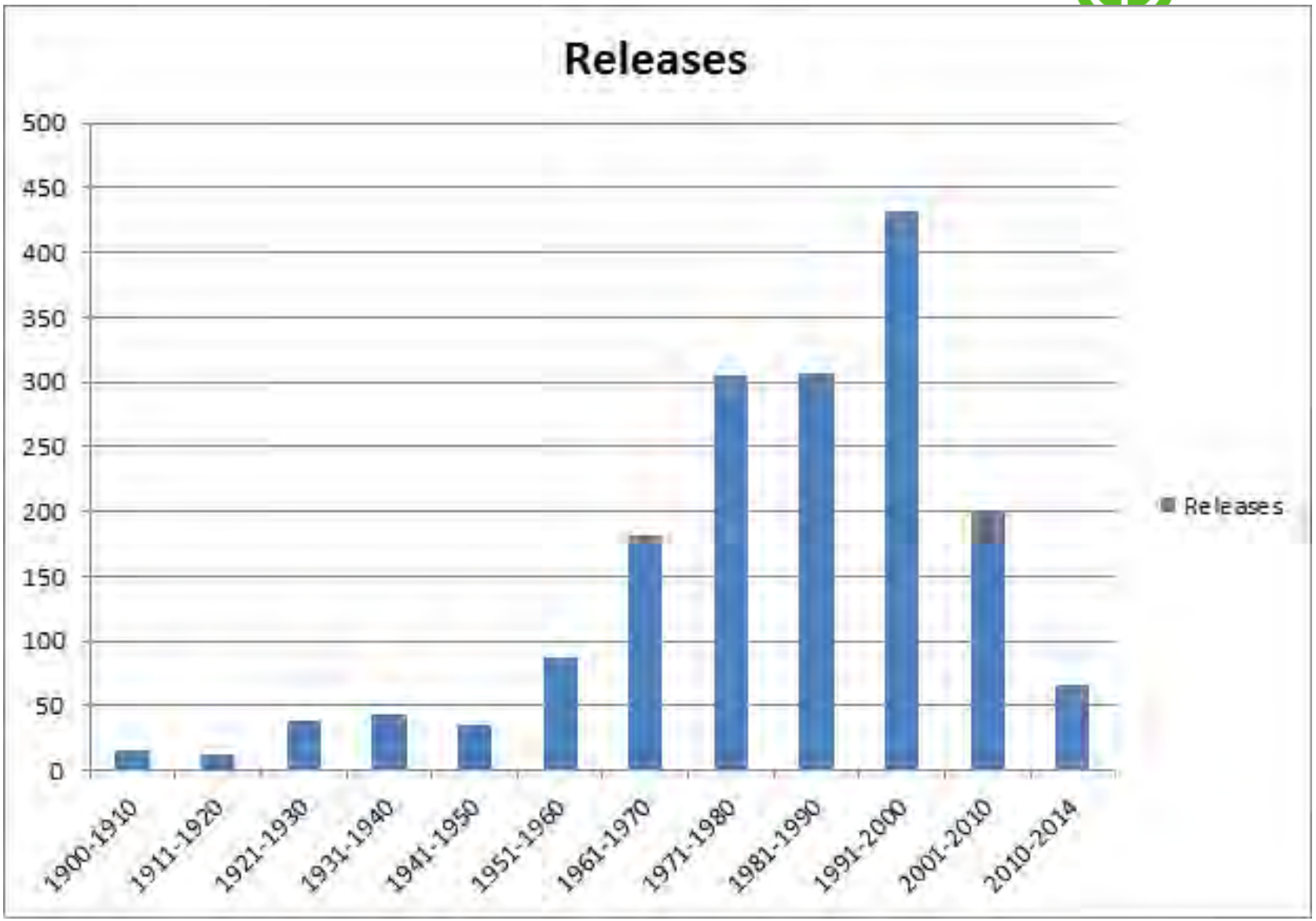
Relatively low success rate around 30-35% of releases

When projects have been well funded this rises to 60-70%

As we improve there will be less willy-nilly releases

Australians now quote 80% success

A Century of Biocontrol



http://www.ibiocontrol.org/catalog/.

Historically Europe has been a source of weeds……& agents

Weed BCA release history after Cock *et al* (2010)

Country	Recipient	Source
Austria	0	52
Finland	0	5
France	0 (1)	120
Germany	0	52
Greece	0	33
Hungary	0	5
Italy	0	72
Portugal	0	24
Serbia	0	1
Spain	0	16
Sweden	0	3
UK	2 (inc. rust)	41
Total	**1**	**425**

Doesn't include Switzerland,
Former Yugoslavia
Turkey, Romania

N.B Haltica carduorum
(Baker et al 1972)

Aphalara itadori Japanese knotweed psyllid, released in 2010

EU opportunities

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

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

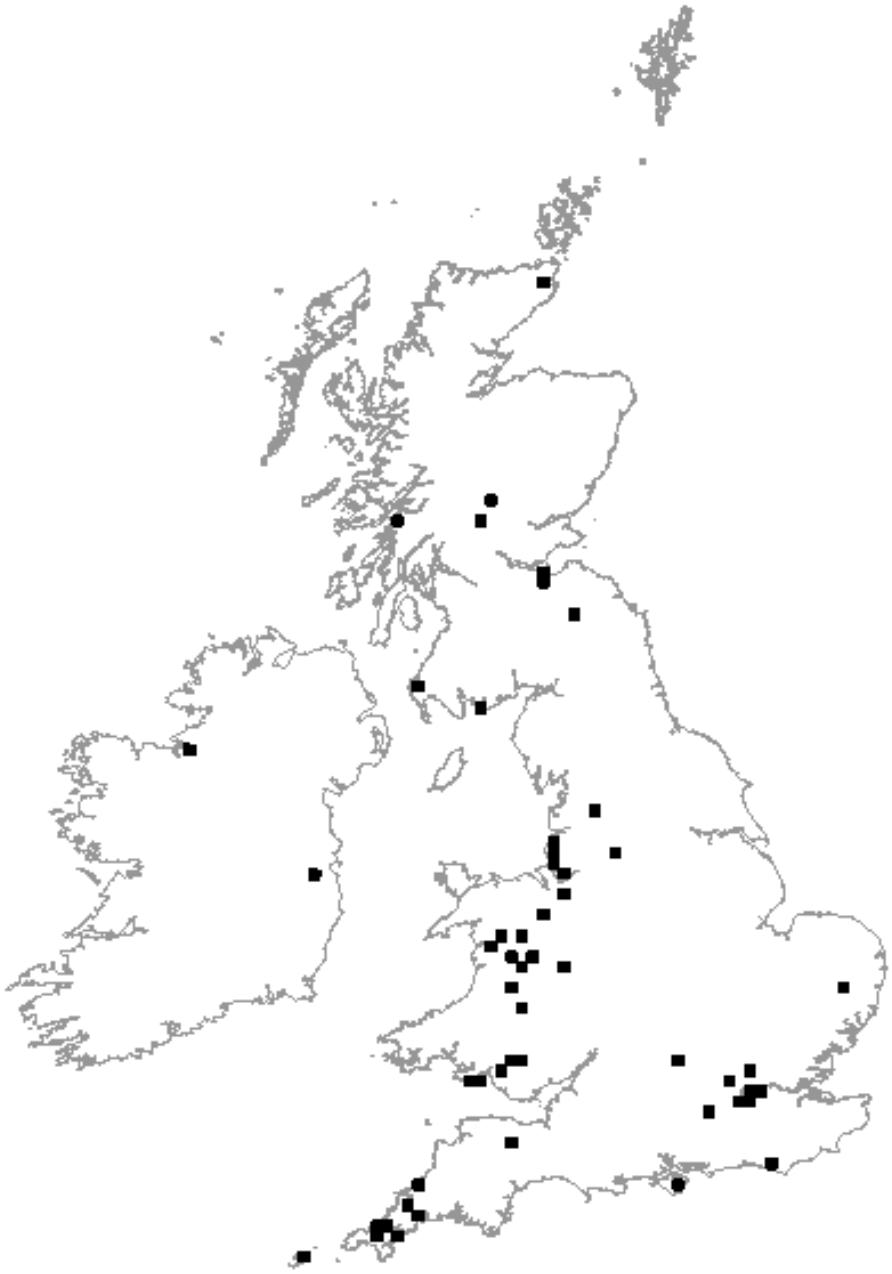
www.cabi.org

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

Japanese knotweed

1900

1940



1970

2006

WANTED:

CREEPY CRAWLY FOR KNOTTY PROBLEM

■ *Above, Dick demonstrates the strength of*

behind the government's decision to identify Japanese knotweed as one

"If the fungi or insect we are testing doesn't attack members of the same

ALIEN INVASION

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www.cabi.org

Britain's gardeners are living in fear of an evil stalker

The Weed from Hell

By Ann Treneman

Face it suckers, the knotweed is only the start

THESE days, it's hard to find anyone who has a good word to say

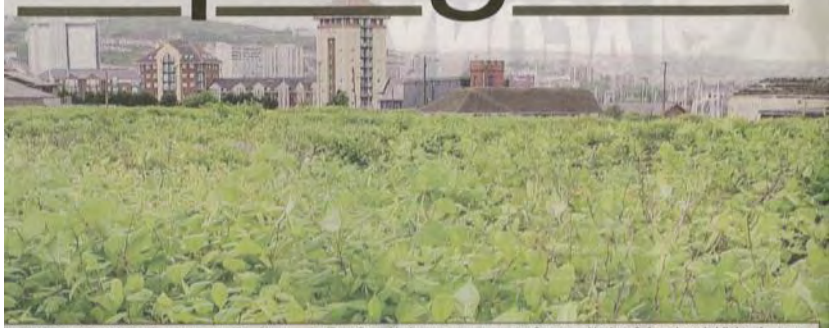
special instructions to destroy the Japanese knotweed.

The insect is known as The

PUBLIC ENEMY No 1

This is a warning — some stalwarts of the suburban British garden have escaped into the wild and they are wre

Super grass



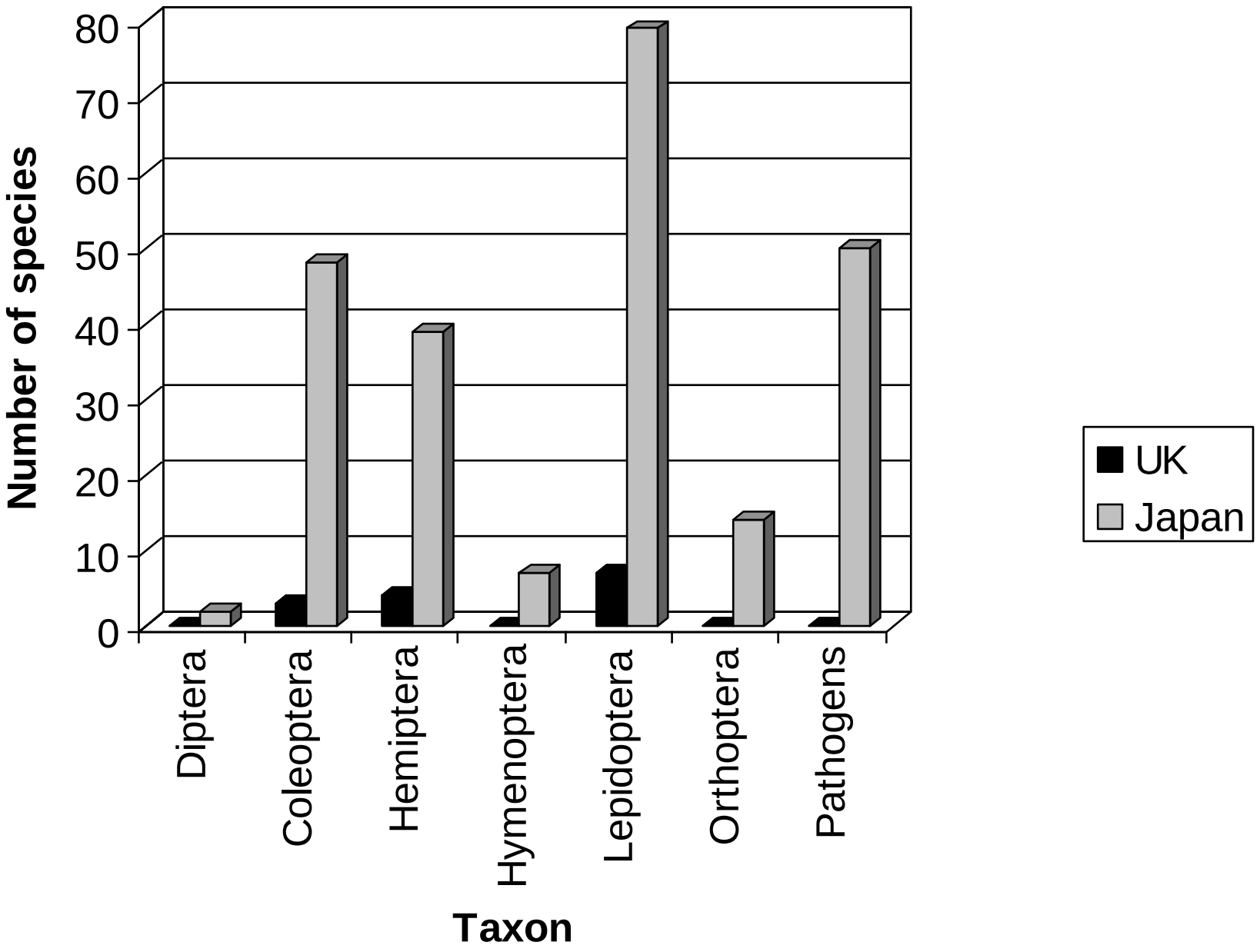
NOTWEED CITY LIMITS: The plant, engulfing knotweed officer Sean Hathaway, converges on Swansea Marina. Below, how it blights the town

THE WEED THAT IS EATING SWANSEA

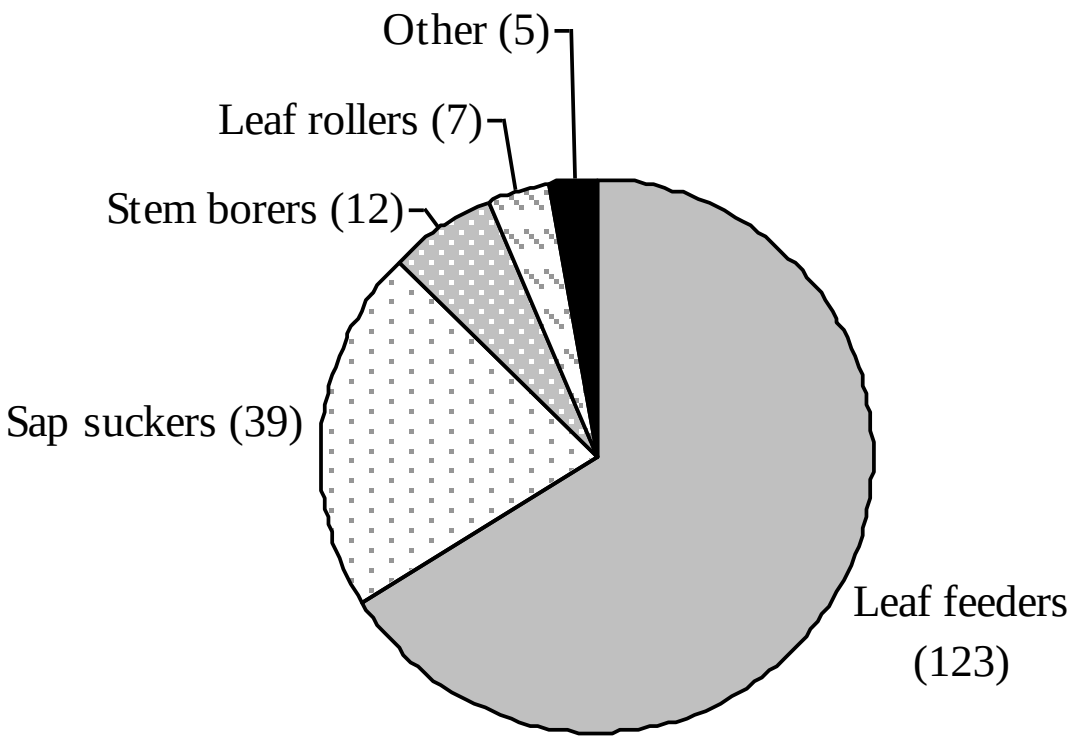
chnology

Killing the green monster

Once the super-plant Japanese knotweed takes hold, there's little to stop it. But,


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

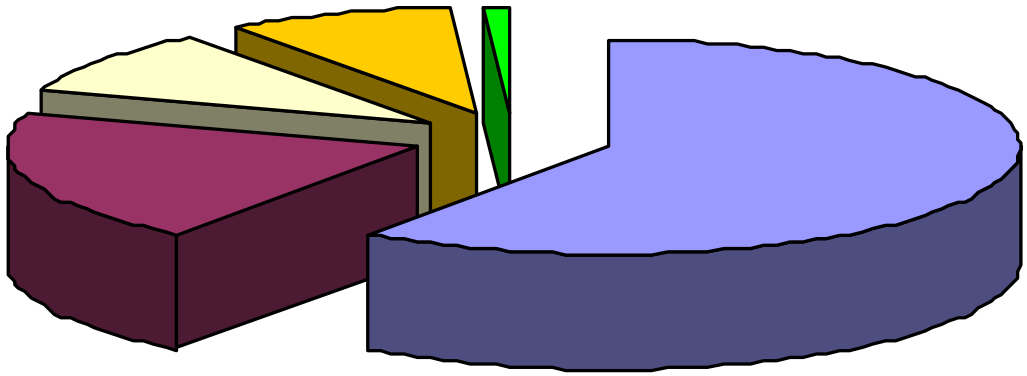
Many insects feeding on most parts



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

Remarkably only one generalist root feeder of note

A process of elimination



- literature review
- field observations
- susceptibility studies
- host range tests
- suitable

Allantus luctifer

Gallerucida bifasciata

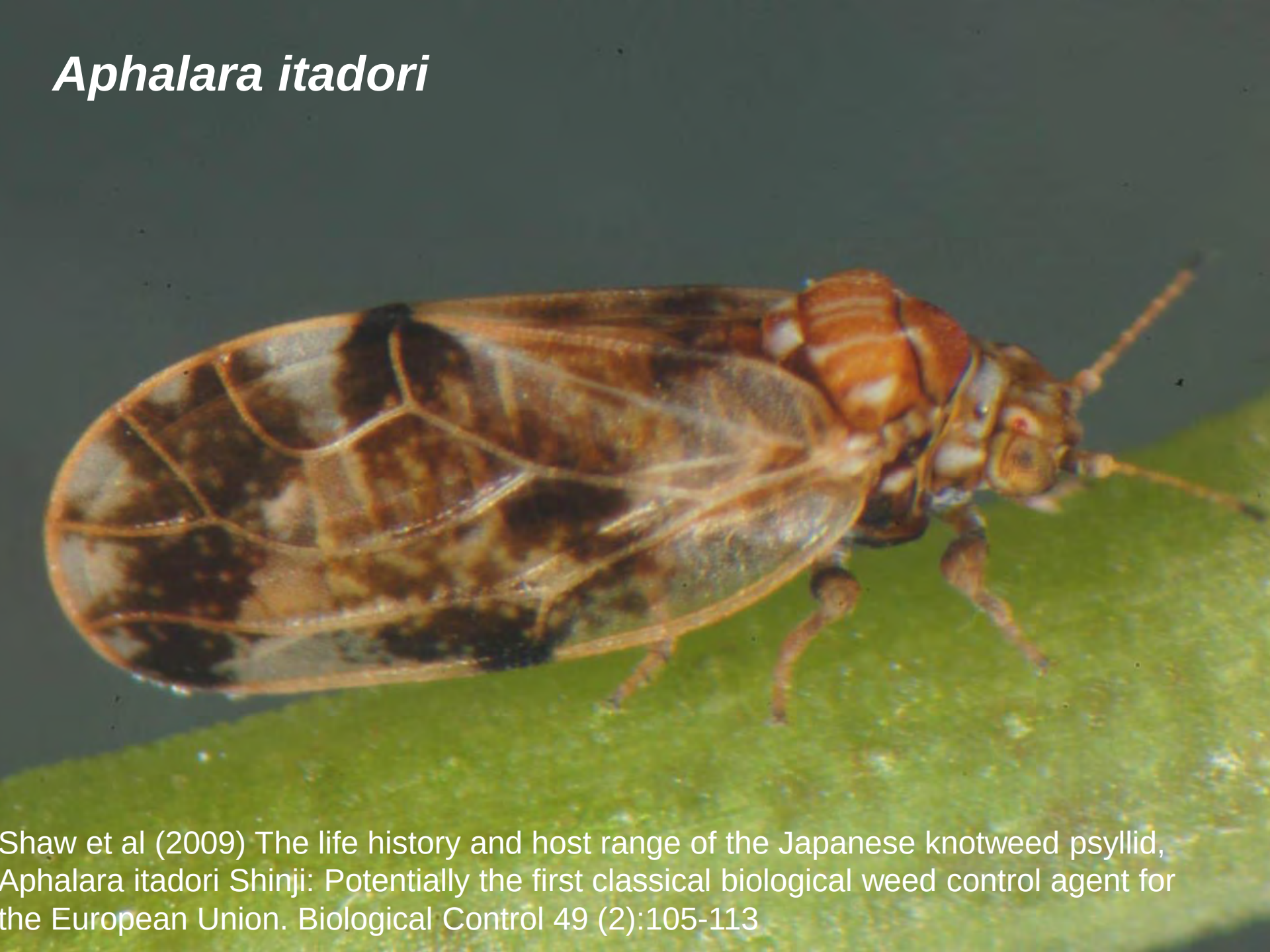
REJECTED

(for Europe)

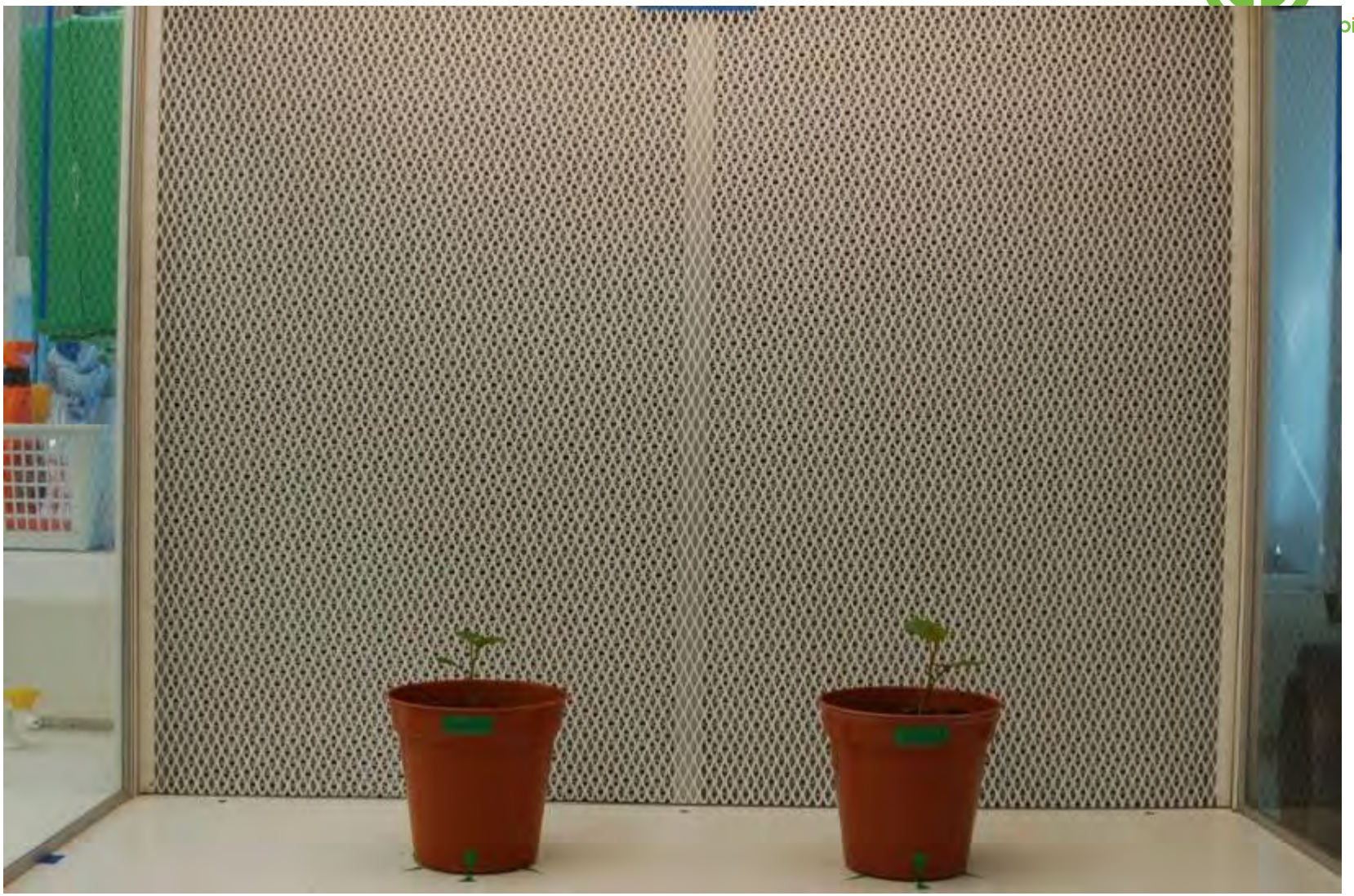
Lixus impressiventris

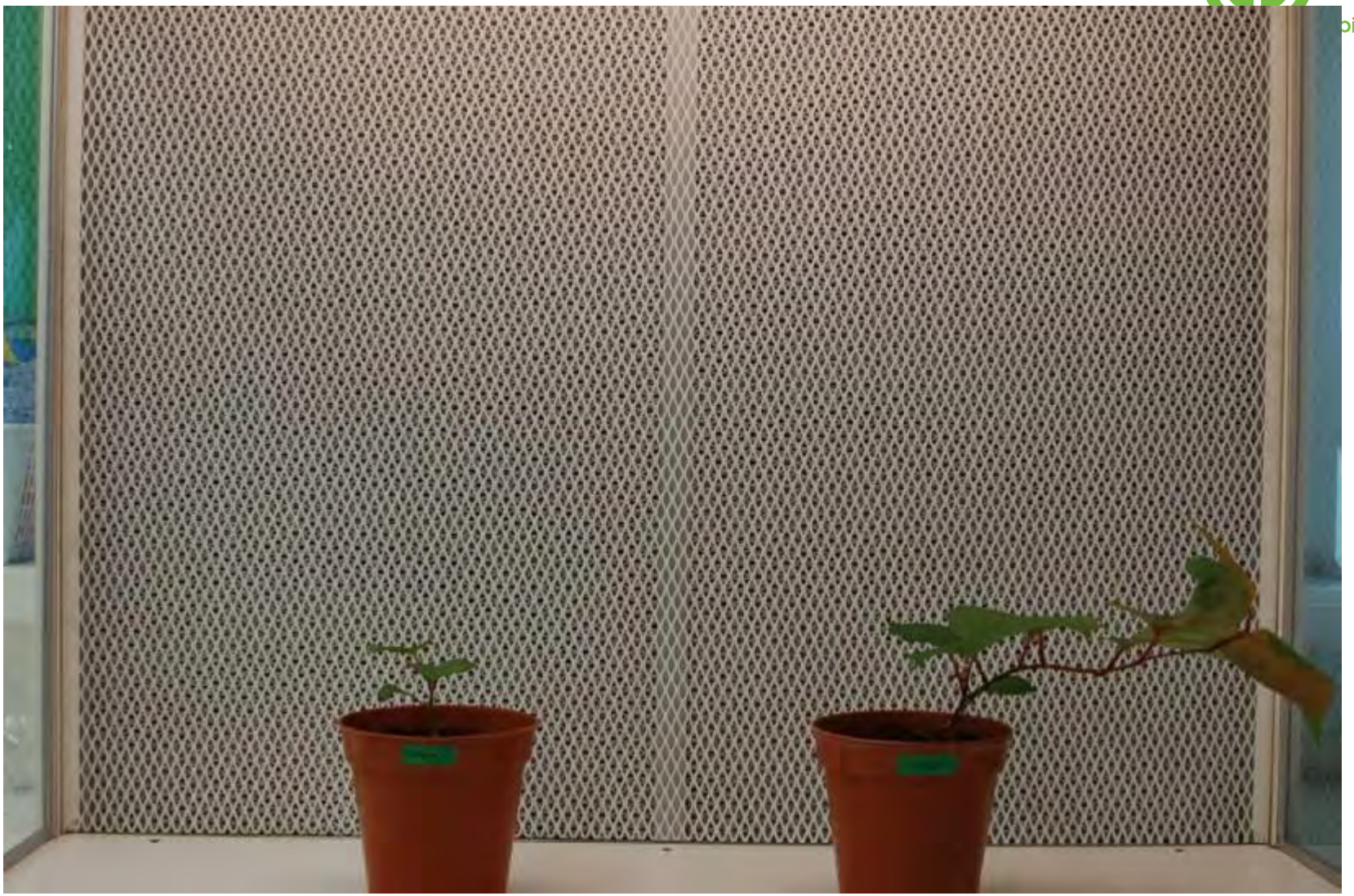
Machiatella itadori

Aphalara itadori



Shaw et al (2009) The life history and host range of the Japanese knotweed psyllid, Aphalara itadori Shinji: Potentially the first classical biological weed control agent for the European Union. Biological Control 49 (2):105-113





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

Latest news

- Psyllid not working YET
- but releases at more appropriate riparian release sites taking place this year thanks to UK regulator
- New stock from Japan undergoing comparative trials in field cages (old stock 120 generations in Japanese summer)
- Plan to release at many more sites, perhaps with new stock
- Netherlands PRA is public on the NVWA website http://www.nvwa.nl/actueel/nieuws/nieuwsbericht/2062681
- Canada now releasing
- USA application in the bottleneck with all the rest
- Proof of concept for mycoherbicide – subject to funding

Knotweed mycoherbicide

UK & International Patents applied for

Himalayan balsam

Biological control of Himalayan balsam

www.cabi.org/isc.

Impatiens glandulifera

www.cabi.org

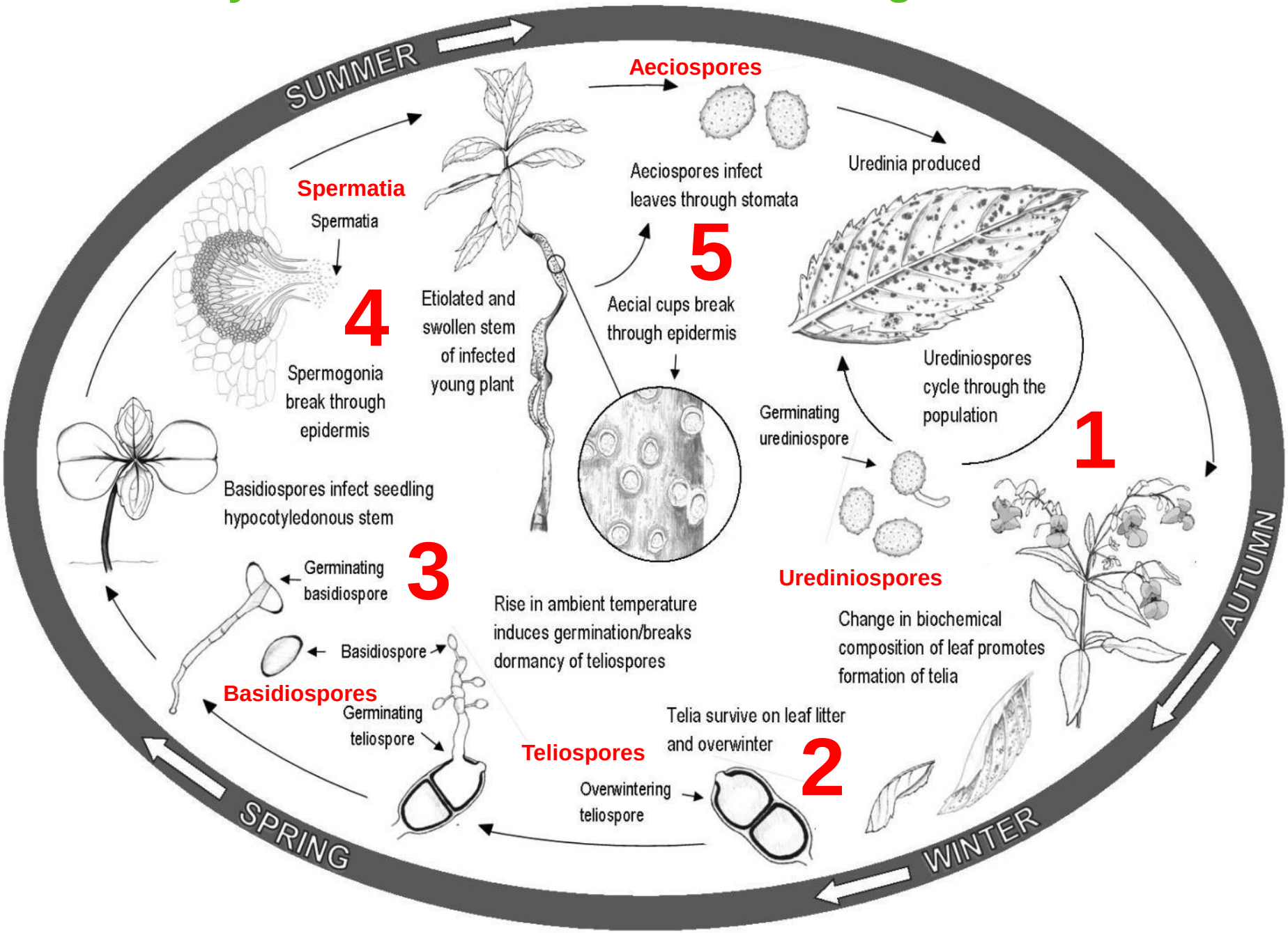
- Only one *Impatiens* spp. native to Europe
- Started in 2006
- Water Framework Directive project funded by Defra /UK Government (2010-2015)
- Autoecious rust, *Puccinia komarovii* *var. glanduliferae* (renamed as part of the project based on host range data)
- First pathogen release against a weed in Europe
- Opportunities for piggy-backing by other EU MS

defra

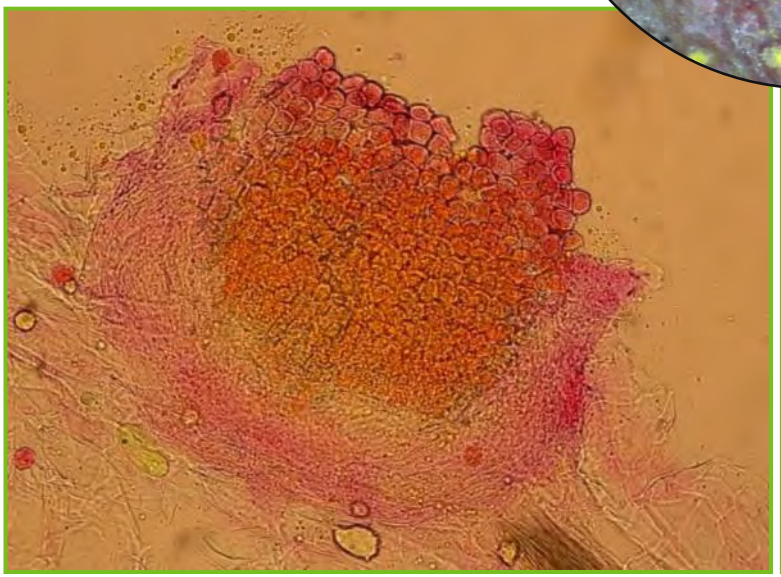
Environment Agency

The Scottish Government
Riaghaltas na h-Alba

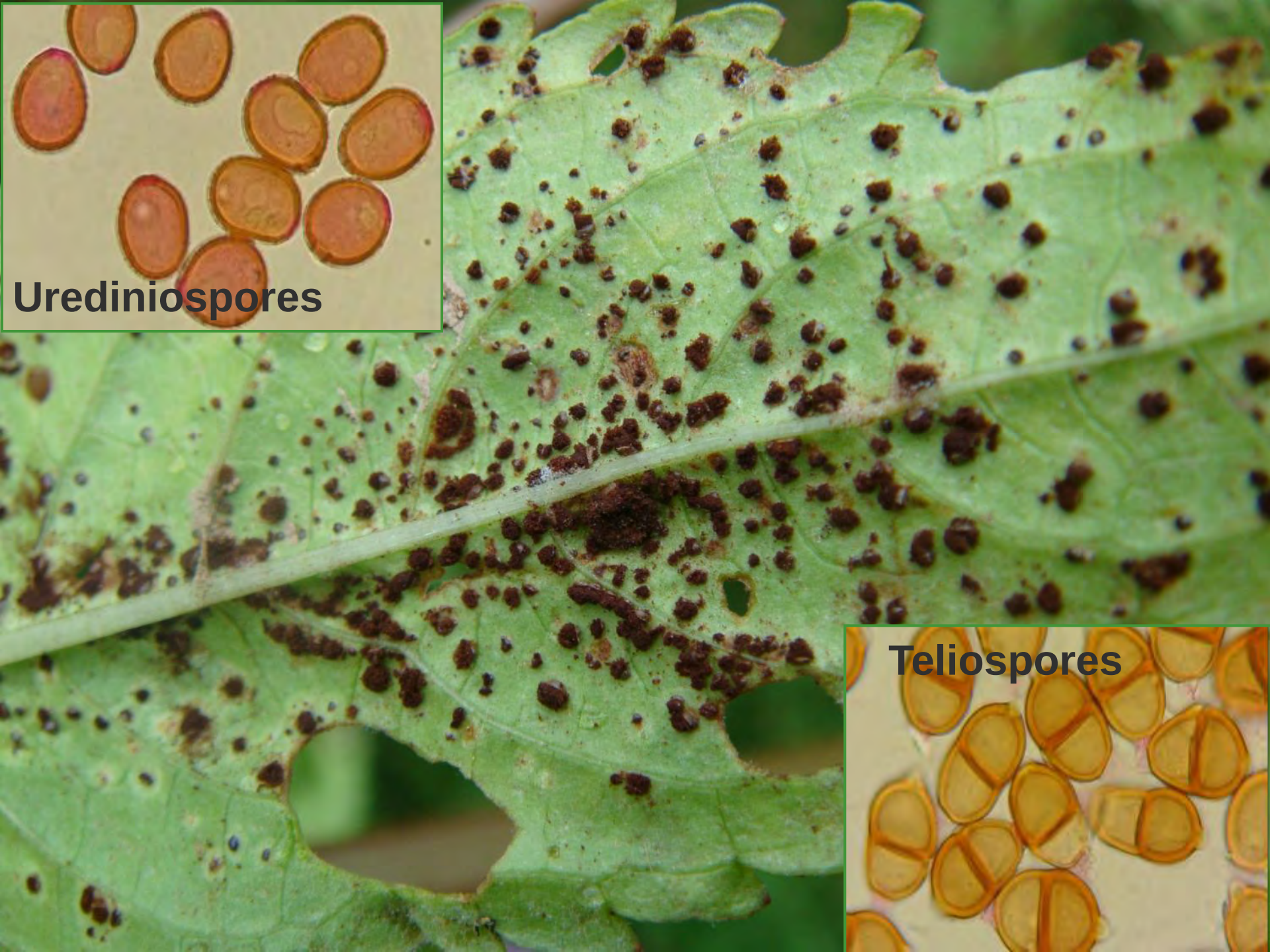
Life-cycle of *Puccinia komarovii var. glanduliferae*



Himalayan balsam seedling infected with rust aecia



Aecial cup containing chains of aeciospores


Urediniospores
Teliospores

Approval of the PRA

Rob Tanner releasing the rust

- PRA went to UK National authority in 2013
- Team invited to SCOPH 26th June 2014
- More information required
- PRA revised to cover the whole of Europe
- Accepted by SCOPH on 18th July, without any EFSA involvement
- Ministerial approval secured on July 2014
- Released from the PH quarantine license
- Release into the field via infected plants 26th August 2014

Rust overwinters in the field and infects seedling in the Spring!

A Himalayan balsam stems showing early signs of warping and reddening due to *Puccinia komarovii* var. *glanduliferae* infection

B Infected seedling elongating more than the non-infected seedlings, taking the spores above the canopy for release into air currents

C Arrows show spermogonia visible on stem surface, where cross fertilisation occurs to produce the next stage, aecia.

Biological control of Wattle spp.

www.cabi.org/isc.

Acacia longifolia

- The gall wasp, *Trichilogaster acaciaelongifoliae*, and the seed-feeding weevil, *Melanterius ventralis* have decreased *A. longifolia* reproductive potential by >90% in South Africa (Dennill *et al*., 1999)
- Biological control agents investigated in Portugal at Centre for Studies of Natural Resources, Env. and Society
- Lab and field safety testing and climate studies have proved safety (Marchante, 2011)
- Gall wasp released in 2015 after review by Plant Health Panel at EFSA
- Hopeful for establishment evidence this year

Future Releases

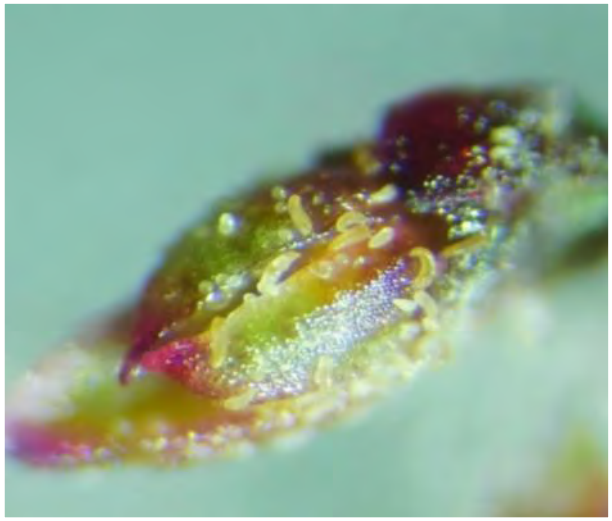
Hydrocotyle ranunculoides – floating pennywort

- Very fast growing floating aquatic weed - can grow up to 20cm per day
- Very difficult to control due to ability to grow from tiny fragments
- Forms dense impenetrable mats across water bodies, not only to the detriment of native species but also to flood defences, navigation and leisure activities
- Origins in South/Central America

Top contender - *Listronotus elongatus*

Only found on *H. ranunculoides* in the field and no equivalent feeding lesions found on any other Hydrocotyle spp.

Crassula helmsii



Mite (*Aculus* sp.) top candidate for *Crassula* biocontrol

- **Family:** Eriophyidae
- **Distribution:** southern Australia

- **Life cycle:** Mites feed and shelter in shoot tips
- Several generations in growing season
- Abnormal growth prevents spread from the nodes

- **Growth form/ organ targeted:** Shoot tips of terrestrial and emergent plants.

- **Host range:** Narrow, no non-target development in no choice tests to date including UK native *Crassula* species.

Future targets

Ludwigia spp

Creeping water primrose

- Native to South America
- Complex taxonomy
- On-going eradication in UK, impossible in other regions, particularly France
- Very high management costs and ecological damage
- Known natural enemies thanks to previous work by FuEDEI in Argentine
- Joint Concept note produce by UK, France and Argentina

Ludwigia in a canal in France

Ophraella communa vs *Ambrosia artemisiifolia*

Accidental introduction of ragweed flea beetle is having a dramtic effect on the plant and its allergenic pollen

http://ragweed.eu/

Conclusions

- Its is possible to do biocontrol of weeds in the EU
- GB has been an early (EU) adopter of this very old technology
- We have released
  - ordinarily resident exotic insect against plant
  - exotic Insect against plant
  - fungus against plant
- We hope to release
  - A mite against plant
  - mycoherbicide
- It is a plant health issue
- It’s not easy!


Canal & River Trust


North West Kent
Countryside Partnership


www.cabi.org


wakefield council
working for you


one and all
onen hag oll
CORNWALL
COUNCIL


defra
Department for Environment
Food and Rural Affairs


Environment
Agency


Network Rail


The Scottish Government
Riaghaltas na h-Alba


South West of England
Regional Development Agency


Llywodraeth Cymru
Welsh Government


NATURAL
ENGLAND


waterwaysnet


Westcountry
Rivers
Trust


Working for your
Countryside
MEDWAY
VALLEY
COUNTRYSIDE
PARTNERSHIP


ROYAL ENTOMOLOGICAL SOCIETY
FOUNDED 1833


YorkshireWater


INTERREG IIIB
ESPAÑA ESPACIO ATLÁNTICO
FRANCE ESPACE ATLANTIQUE
IRELAND ATLANTIC AREA
PORTUGAL ESPAÇO ATLÂNTICO
U.K. ATLANTIC AREA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1825
HUNGARIAN
ACADEMY
OF SCIENCES


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