Problem formulation for the environmental risk assessment of weed biological control agents: Insects and fungi versus weeds.

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Many insects feeding on most parts

186 species of phytophagous arthropod recorded from Japanese knotweed in Japan. Plus 40 fungi
Unfair Advantage

● They arrived without the natural enemies that keep them in check in their native range. “Enemy Release Hypothesis”
● Those native 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
A process of elimination

- literature review
- field observations
- susceptibility studies
- host range tests
- suitable
Aphalara itadori
Mycosphaerella polygoni cuspidati
2 Categories of weed control

**Inundative** - a.k.a the “Mycoherbicide Approach” using normally 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 **always formulated**.
Knotweed mycoherbicide

- Failed host range testing as a classical agent due to risk to an important non-target plant species
- However, a mycelial preparation of a single mating type of Mycosphaerella **cannot** infect NTs
- UK and International Patent applied for in the name of UK Secretary of State
- UK Patent Application No. 1503510.8; [https://www.ipo.gov.uk/p-ipsum/Case/ApplicationNumber/GB1503510.8](https://www.ipo.gov.uk/p-ipsum/Case/ApplicationNumber/GB1503510.8)
- Next Proof of Concept
- PRA complete and risk to environment close to zero but experimental license process proving hard to pin down
- Needs to be released from PH quarantine licence and then field trials need to be authorised
Inundative Weed biocontrol = Low Risk Substance?

*Products authorised as a low-risk plant protection product provided no specific risk mitigation measures are needed following a risk assessment.*

**Substance not classified as:**
- explosive
- corrosive
- sensitising chemical
- very toxic or toxic
- CMR substance
- endocrine disrupter
- neurotoxic or immunotoxic
- persistent (half-life in soil >60 days)
- bioconcentration factor >10

**Safety requirements:**
- Physical – chemical properties
- Analytical methods
- Toxicology
- Residues
- Environment: Fate and Behaviour
- Ecotoxicology
- Efficacy

If not...
Aphalara itadori
GENERALIZED MODEL OF BIOCONTROL OF INVASIVE PLANTS
(adapted from Luck et al. 1995)

![Diagram showing population density over time for invasive plants and biocontrol agents.](image-url)

Diagram created by weedcenter.org

KNOWLEDGE FOR LIFE
Eichornia crassipes – Water Hyacinth
The real sequence of events

Louisiana Waterhyacinth Data

Graph courtesy of APHIS
Is It Safe?

Over more than a century there have been >1,500 introductions of >450 different BCA species vs. 175 weeds around the globe.

- Any non-target effects are predictable by the vigorous safety testing
- Guided by an International code of conduct ISPM 3
- 8 examples of “non-target” effects
- Most of these predicted by the science then, or would have been predicted by the science now

cf Europe pest control: >300 releases of 176 BCA species against crop pests outside the glasshouse
Centrifugal phylogenetic method:
Species more closely related to the target weed are more likely of being attacked than more distantly related ones.
Starvation Tests
Choice Tests
Oviposition Tests
Development Tests
Testing Biotrophic Fungi

Dew Chamber

- Constant dew period at perfect temperature for 48 hours
- Optimum conditions for infection
- Very high inoculum load
- Precautionary principle
Himalayan balsam
Himalayan balsam seedling infected with rustaecia

Aecial cup containing chains of aeciospores
Mostly done in quarantine
Problem formulation:
CBC – Direct effects

Introduction of exotic BCA

BCA outbreaks to attack non-target

BCA maintains attack of NT

NT plant population negatively affected

\( H_1 \)
Agent is a specialist
Test:
Native range observations
Quarantine
Lab Host range testing

\( H_2 \)
BCA can thrive on non-target
Test:
Sequential generation rearing on NT in lab

\( H_3 \)
NT pop dynamics not impacted upon
Testing:
Native range field experiments and modelling
**CBC – Indirect effects (Apparent Competition)**

**Introduction of exotic BCA**

**BCA becomes prey for generalist**

**Generalist population grows**

**Generalists suppress normal host**

**native host plant becomes weed**

**Food web irreparably damaged**

- **$H_1$** Generalist doesn’t feed on BCA
  - Testing: Lit review of shared prey genera
  - Lab feeding tests

- **$H_2$** Generalist performs worse on BCA
  - Testing: Lab feeding and development studies

- **$H_3$** Generalist does not feed on normal prey pop in field
  - Testing: Impossible to realistically test pre-release

- **$H_4$** Normal host pop does not change significantly in field
  - Testing: Impossible to realistically test pre-release

- **$H_5$** Changes in 3rd party species are temporary or insignificant
  - Testing: Impossible to realistically test pre-release
The problem of false positives from the Lab

- Native range field observations give a good indication of agent host range BUT the key non-targets are not normally present, can occasionally get permission to plant them.
- Insect host range studies start with no-choice/starvation tests and reveal the **FUNDAMENTAL** host range not the **REALISED** host range post release. This is normally much larger.
- Quarantine lab studies are precautionary and give a worst case scenario.
- E.g. rubbervine in Australia where 40,000km² of ecosystem have been saved by a rust fungus that attacked a rare native plant in the lab but didn’t in the field in outbreak conditions.
Doing nothing

No Introduction of exotic BCA → No natural control achieved → Continued expansion of invasive weed → NT plant population negatively affected → Control costs continue to rise → Environment & Economy irreversibly damaged

- Guaranteed
- Extremely likely
- Highly Likely
- Likely but depends on policy
- Very likely in the medium to long term
EFSA now has experience with CBC

- Experts should **review** the risk assessment
- This is an intention to release not a product for sale
- Needs to be quick
- Needs to include benefits
Conclusions

- Biocontrol is an option for even the worst invasive weeds
- Classical biocontrol is finally growing in Europe
- EU Invasive Species Regulation should drive CBC
- Current safety testing means that we are more likely to reject a good agent than release a dangerous one
- The regulation for biologicals is not ideal and if we are to have alternatives to chemicals then low-risk products need an easier passage
- There is a need for balance i.e risk:benefit because with invasive species…

DOING NOTHING IS NOT A LOW RISK OPTION
Risk of doing the wrong thing:
Water Hyacinth in the Guadiana river in Spain

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?
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