Predictability of pathogen host range in biological control of weeds

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Why aren't pathogens used more widely for weed control?

- **Worldwide, pathogens have only been introduced to 11 countries (Arg, Aus, Chile, China, Fiji, India, NZ, PNG, SAf, Tahiti, USA)**
- **No evidence of pathogen damage in the field that was not predicted by HR testing. Barton, J. (2004) Biological Control 31: 99-122.**

Methods

- List all pathogens ever used for biocontrol of weeds
- Find info. on pre-release host range testing
- Find info. on their behaviour in the field after release (‘pers. comm.’)
- Compare the two to determine how accurate pre-release predictions have been to-date

Results (2010)

- 37 projects worldwide (each project = intro. of 1 pathogen to 1 country for 1 weed complex)
- 28 spp. of pathogens (all fungi) released
- > 28 spp. of weeds targeted
- Pathogens from 16 countries
- Most pathogens have established, spread, and had at least some impact on their target

Results (2010): Non-target damage in the field

- **Out of those 37 projects:**
  - **2 projects with non-target damage in out-door field plots**
  - **2 projects with predicted non-target damage in the field**
  - **33 projects with no non-target damage in the field at all!**

Target weed: Musk thistle

- ***Carduus nutans*** **ssp. leiophyllus**

  (= *C. thoermeri*)
- **Major weed of pastures & rangelands in the USA (competes with pasture)**
- **From Europe & Asia**
- **Control with herbicide not economically feasible**

Image from http://www.issg.org/database/species/

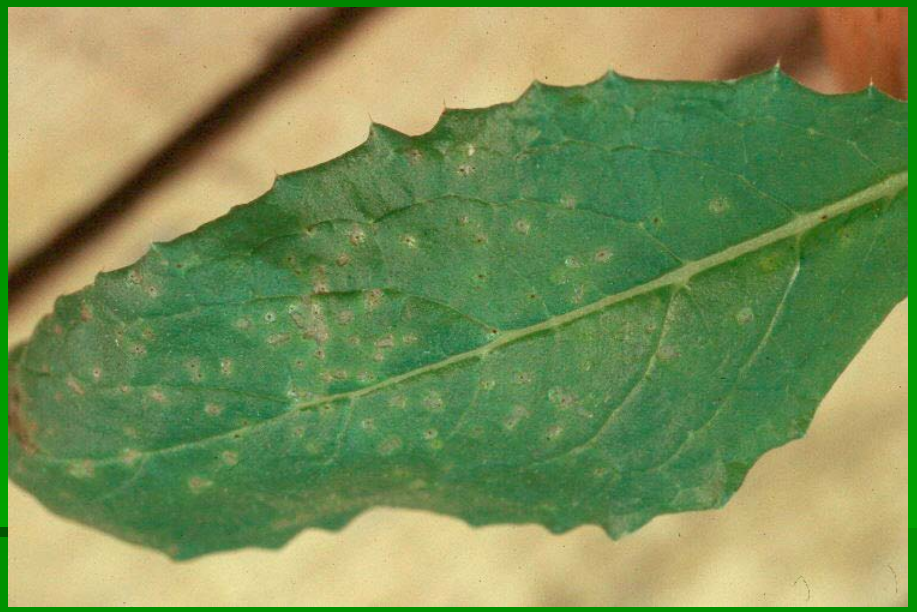
Puccinia carduorum

- **Rust fungus (Uredinales: Pucciniaceae)**
- **Attacks *C. thoermeri* (and many other *Carduus* spp.)**
- **Causes lesions on leaves and reduces plant growth and seed production**

Rust lesions on target weed in glasshouse. Image from Dr William L. Bruckart III, USDA-ARS-FDWSRU, Maryland, USA

Host range results: containment

- **Rust applied to 63 spp. (all Asteraceae)**
- **Target weed only plant with severe symptoms,**
- **BUT, in greenhouse limited infection also on non-targets, including globe artichoke and native American thistles (same tribe as target)**



Rust lesions on artichoke in glasshouse. Image from Dr William L. Bruckart III, USDA-ARS-FDWSRU, Maryland, USA

Host range: observations in the field

- In Eurasia the rust, the target weed, and globe artichoke all overlap in range
- Globe artichoke has not been recorded as a host there
- Field test needed due to contradiction between indoor and field observations

Image from http://www.hear.org/starr/hiplants/images/

Host Range Results: Field

- **Trial conducted over 2 years in area where eradication possible (Virginia)**
- **Tested globe artichoke (*Cynara scolymus*) + 10 spp. native American thistles (*Cirsium*)**
- **Only non-target damage = 1 pustule on 1/32 globe artichoke plants**

Decision

- **Concluded that "*P. carduorum* poses no threat to the non-target species tested"**
- **Rust in Virginia allowed to spread (1987)**

Behaviour after release

- ***P. carduorum* established in USA**
- **Has not been found on any non-target spp. in the field since release**

Parthenium hysterophorus (Parthenium weed or false ragweed)

- Annual, herbaceous plant (Asteraceae)
- Origin = Neotropics
- Major weed in Australia (Qld.) and India
- Aggressively invasive
- Causes allergic responses, respiratory problems, and dermatitis in susceptible people

Image from http://www.noble.org/imagegallery/Forbhtml/FalseRagweed.html

Puccinia melampodii (rust) Host range results: containment

- **Rust applied to 63 non-target species**
- **Caused symptoms on several non-target (but weedy) Asteraceous spp., and sunflower, in the glasshouse**
- **Decision made to release the rust in Australia (benefits > costs)**

Host range: observations in the field

- However, prior to decision re. India, further tests (outdoors, in Australia) were done on close relatives grown commercially there
- Indian variety of marigold (*Calendula officinalis*) found to be quite susceptible
- *Puccinia melampodii* was not released in India (as discussed by M. Seier of CABI)

Image from http://www.treknature.com Photo taken by Nirmal Roberts

Behaviour after release

- ***P. melampodii*** **released in Australia in 1999**

- **It has not been reported from any other non-target plants since release**

Image = Target weed with *P. melampodii* pustules. Supplied by M. Seier (CABI).

Acacia saligna (Port Jackson willow)

- Small tree (Fabaceae)
- From Western Australia
- Major weed in SAf
- Difficult to clear due to coppicing after fire or cutting
- Forms dense stands at the expense of native vegetation
- Can totally replace natural fynboss

Image from http://www.australianplants.com/images/acacia.saligna.jpg

Acacia saligna with galls caused by *Uromycladium tepperianum*

- **Gall rust (Uredinales: Pileolariaceae)**
- **Attacks A. *saligna* in Australia**
- **Causes galling on stems, branches, phyllodes and flowers and the formation of witches brooms on branches**
- **Severely affected plants more susceptible to drought**

Image from http://www.arc.agric.za/institutes/ppri/

Host range results: containment

- **Hosts included several *Acacia* spp. but evidence of species-specific strains**
- **Spores from galls on *A. saligna* applied to 24 species (23. spp. *Acacia* + 1 sp. *Paraserianthes*)**
- **Seedlings of both *A. pulchella* and *A. cyclops* (non-targets) developed abnormal galls after inoculation**

Host range: observations in the field

- **However, in Australia *A. pulchella* has not been recorded as a host of *U. tepperianum***
- ***A. cyclops* has previously been recorded as a host, but this appears to happen only occasionally**
- **Rust released in South Africa in 1987**

Behaviour after release

- Since release the rust has occasionally caused abnormal galls on *A. cyclops*
- As observed in Aus., this only occurs where heavily infected *A. saligna* and *A. cyclops* are growing in close proximity
- The galls do not spread and multiply on *A. cyclops*
- Behaving as predicted

Blackberry (*Rubus fruticosus* agg.)

Image from http://wildeherb.com

- **Common weed in many countries including Australia and New Zealand**
- **From Europe**
- **Grows and spreads vigorously**
- **Prickles problematic for grazing animals and humans**

Phragmidium violaceum (rust) Host range results: containment

- Agent chosen for Australian biocontrol project was a rust from Europe (*P. violaceum*)
- Rust applied to 51 non-target spp. (> 1 var)
- Caused symptoms on 15 *Rubus* spp. (> 1 var)
- 3 of 5 *Rubus* spp. native to NZ susceptible
- Decision made to release the rust in Australia 1991 (benefits > costs)
- Illegal release/s prior to legitimate (1984)

Behaviour after release

- ***P. violaceum*** **found on native *Rubus* in NZ during surveys (2000-09) looking for non-target damage from pathogens that attack weeds there**

see New Zealand Plant Protection (2009) 62: 41-49

Non-target damage in field (predicted)

- ***P. violaceum*** **found on 2/135 *Rubus cissoides* plants examined (2005)**
- **Rust not found on another native that was equally susceptible in tests (*R. schmidelioides*)**
- **Damage minor and occurred where non-target species was growing beside heavily infected target weed**

Overall results (2010): 37 Projects

- **18 cases where no damage predicted in HR testing and no damage observed in the field**
- **1 case where there was no HR testing done specifically for that project (used overseas results)**
- **18 cases (including the 4 case studies) where more species were damaged in HR testing than in the field**

Overall results (2010): 37 Projects

- **No cases of unpredicted damage to a non-target species in the field**

Expanded host range found in glasshouse tests

- Phenomenon not unusual
- Disease results from combination of pathogen, host and environment
- Optimum environmental conditions for disease development used to create ‘worst case scenario’
- Also, artificial conditions can ‘predispose’ non-target plants to attack

Use other info. to interpret glasshouse data

- **Host use by pathogen in native range**
- **Severity of disease symptoms on non-target plants compared with targets**
- **Results of host range tests conducted outdoors (where feasible), either**
  - **In native range of pathogen**
  - **In other country where pathogen has already been released**
  - **In country proposed for release (if eradication possible)**

Is it safe to use pathogens as classical biocontrol agents for weeds?

- **Yes!**
- **Introduction of exotic pathogens is (and should continue to be) a very safe and environmentally benign method of weed control**

Image: http://greensungardens.wordpress.com

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