Biological control as a habitat restoration tool?

The recovery of the native and endemic flora after the introduction of a fungal pathogen to control the invasive tree *Miconia calvescens* in Tahiti (French Polynesia)

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Assessment of biological control success

- Direct negative impacts of biocontrol agents on the target invasive species
  - distribution: geographic and habitat range
  - demography: abundance, rate of spread, growth rate, cover…
  - reproduction: fruit set, seed production, seed germination
    (Smith & DeBach 1942, Briese 2000, Myers & Bazely 2003)

- Indirect positive effects on the recovery of economic plant species in agrosystems
  - density, biomass
  - plant growth
    Economic productivity
    (Huffaker & Kennett 1959, J. Range Management 12)

- Few studies on the recovery of native species in natural ecosystems = the conservation benefits of biocontrol
Miconia invasion in Tahiti, French Polynesia

- Small tree (6-12 m tall) native to Tropical America
- Occurs between 0 and 1400 m asl in native rain- and cloud forests
- Forms dense monospecific stands (light in the understorey)

>50% of the plant species endemic to Tahiti are directly threatened by Miconia

(Meyer & Florence 1996, J. of Biogeography 23)
Miconia biocontrol agent

- *Colletotrichum gloeosporioides* forma specialis *miconiae* (*Cgm*)
- Discovered in Brazil in 1996-97
- Highly specific to Miconia
- Cultivated in Hawaii
- First released in Tahiti in 2000

*Cgm* causes leaf anthracnose and necrosis

↓

kills seedlings + Miconia partial defoliation & canopy opening

↓

↑ Light in the understorey

Objectives / Hypothesis

- Indirect effects on the recovery of endemic plant species?
- Effects on native and alien plant recruitment in the forest understorey?
- Vegetation dynamics with time?

Taravao permanent plot
Year 2000

Myrsine longifolia (CR)

Year 2006

(Cgm)

(Meyer, Dupony & Taputuarai 2007, Rev. Ecol.)
Study sites

- 4 sites, permanent plots
- Dense Miconia forests
- Elevation (rainfall & temperature) gradient
- Relatively easy to access!

<table>
<thead>
<tr>
<th>Sites</th>
<th>Plots elevation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aorai</td>
<td>400 630 940 950 1200</td>
</tr>
<tr>
<td>Pic Vert</td>
<td>600 970 970</td>
</tr>
<tr>
<td>Marau</td>
<td>800 800</td>
</tr>
<tr>
<td>Taravao</td>
<td>500 600 700 1000 1020</td>
</tr>
</tbody>
</table>

4 yrs monitoring (2005-2009)
3 yrs monitoring (2006-2009)
2 yr monitoring (2008-2009)
%Cgm leaf damage

- 10 Miconia trees cut down around each permanent plot
- 25 canopy leaves collected on each tree
- Grid mesh (2 x 2 cm)

\[
\text{% Cgm leaf damage} = \frac{\text{Number of squares with C.g.m. leaf spots}}{\text{Leaf area (estimated number of squares)}} \times 100
\]


**Cgm** impact with elevation (yr 2008, N=15 plots)

\[ y = 0.0352x - 8.4389 \]

\[ R^2 = 0.759*** \]

\[ \Rightarrow \] Partial defoliation of Miconia canopy trees: 5-35% with elevation

\[ \Rightarrow \text{Cgm} \text{ more efficient at high elevation (higher rainfall and/or lower temperature?)} \]
Study on *Ophiorrhiza subumbellata* (Rubiaceae)

- Rare and threatened endemic sub-shrub (0.5-1.8 m tall)
- Small isolated populations (1-67 individuals)
- Occurs in rainforest and cloudforest between 700-1,200 m asl

⇒ *Ophiorrhiza* habitat range is included in Miconia’s distribution
Method

• Study sites selected at same elevation, same Miconia density, but different % Cgm leaf damage
• Circular plot (25m²) centered on the tallest reproductive plant

➢ Density
  - Number of seedlings (<5 cm tall)
  - Number of juveniles and adult plants (>5 cm)

➢ Fertility
  - Number of cymes (inflorescences and/or infrutescences)
  - Number of flowers and/or fruits
Positive effect of *Cgm* on *Ophiorthiza* density

(Mann-Witney U Test
n.s. = not significant;
** : p<0.01)

⇒ Positive effect on the density of reproductive plants

*(Meyer & Fourdrigniez 2010, Biological Conservation)*
Ophiorrhiza fertility

(Mann-Whitney U Test:
** : p<0.01
*** : p<0.001)

⇒ Positive effect on fertility for all height classes
**Ophiorrhiza** recruitment and survival

(Pearson Chi-square test: \( \chi^2 = 35.8 \); \( ddf = 2 \); \( p < 0.001 \))

⇒ Positive effects on seedling recruitment and plant survival
The Miconia biological control agent has contributed to the recovery of threatened endemic plants in Tahiti (e.g. *Ophiorrhiza* spp., *Myrsine longifolia*, *Psychotria* spp.…)

- Positive effects on the whole plant community (flowering plants & ferns)?
- Effect on more shade-tolerant species?
- Reinvasion by other alien species?

⇒ Long-term monitoring of all forest understorey species
Study plots

100 m² permanent quadrats, 20 subplots/year
Measurements on plots

- **Miconia’s invasion**
  - Stem density (> 1.30m)
  - Basal area (DBH)

- **Understorey stratum** (≤ 1.30m)
  - % cover of all species in each subplot
  - Species status (native or alien)
  - Light preference (light demanding vs semi-shade vs shade-tolerant species)
Evolution of the understorey vegetation

Species number

(Friedman Test - Wilcoxon Signed Rank Test with Bonferroni correction)

⇒ Significant increase of species number + an increase of plant cover with time

% cover
Light preference

Species number

% cover

⇒ Significant increase of light demanding/pioneer species (number & cover) with time

LD = Light demanding
SST = Semi-shade tolerant
ST = Shade tolerant
Species classification and status

Species number

⇒ Significant increase of native flowering plants (number & cover) with time

 NF = Native ferns  NA = Native angiosperms  AP = Alien plants
Conclusions

• **Direct negative impacts of* Cgm *on Miconia**
  ➔ with elevation (effect of rainfall and temperature)

• **Indirect positive effects: recovery of some rare endemic plant species**
  ➔ Fertility
  ➔ Seedling recruitment

• **Plant dynamics in the understorey with time**
  ➔ Species number (light demanding & semi-shade natives)
  ➔ Cover (light demanding)
  ➔ Alien species number, but not too much cover ⇒ No reinvasion?

- **Biocontrol as a habitat restoration tool in Miconia invaded forests?**
- **Long-term monitoring is still -and always- needed...**
Acknowledgements


• the Délégation à la Recherche (2005-2009)