New Prospects for Biological Control of Brazilian Peppertree, *Schinus terebinthifolia* (Anacardiaceae)

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Schinus distribution in the US

Classic tree invader damaging native habitats (Richardson & Rejmanek 2011)

- Introduced for horticulture
- Bird dispersed
- Invasive in several regions of the world, North America, Australia, South Africa
- In Fla & HI one of our most invasive spp
Schinus biological control research

Began in HI 1950s–60s

Introduced 3 spp in HI

1. leaf roller *Episimus unguiculus* (Tortricidae) established
2. seed feeder *Lithraeus atronotatus* (Bruchidae) established
3. stem borer *Crasimorpha infuscata* (Gelechiidae)
Schinus biological control research

- USDA/ARS begin in 2005
- Previous research criticized for lack of extensive overseas surveys, no candidate list
- Emphasis on mapping weed and compiling an inclusive list of candidates
- Finding and testing potential candidates for safe release
Where have we searched for biological control agents?

Surveys of Brazil up to Aug 2014

Defining the range
• Herbaria from 1) Rio de Janeiro Botanical Garden, 2) NYBG, 3) Tropicos distribution data

• Other biological control work HI, UF

• Our surveys, 20 trips to Brazil; > 900 sites

• Clusters of plants – gaps in distribution
Surveys of Brazil up to Aug 2014

- Distribution of Schinus haplotypes:
  - 14 haplotypes discovered,
    - ‘A’ – ‘N’
  - A - primarily coastal from ES to RG do S; inland in MG
  - B – only from Salvador, Bahia
  - In Fla & HI we have A, B, and intraspecific hybrids
  - Origins of Fla plants are near southern Santa Catarina (A) and Salvador (B)
What have we found?

- Total number of spp 124 +
  - Caterpillars (Lepidoptera) 65 spp
  - Beetles (Coleoptera) 27 spp
  - Bugs (Hemiptera) 10 spp
  - Diseases 4 + spp (Barreto, Bruckart & de Macedo)

- Number potentially suitable, not already rejected or being worked on: 42 spp
Species accumulation curve

- Did we find everything?
- Changes in discovery rate due to sampling changes
Potential candidates of *Schinus* control

- Pseudophilothrips ichini
- Omolabus piceus
- Oospila pallidara
- Nystalea ebalea
- Leurocephala schinusae
- Tecmessa elegans
- Plectrophoroides lutra
Geometridae from Brazilian pepper native range surveys

*Iridopsis* sp.

*Prochoerodes* sp.
One of 4 boxes sent to Geometridae specialists
Diversity of potential agents: *Paectes* spp. (Euteliidae)

DNA reveals many species

**Florida spp.:**
*Paectes nana* & *P. asper*

**Brazilian spp.:**
*P. longiformis, P. similis, P. sinuosa,* and more
Diversity of potential agents: ‘Episimus’ spp.
Diversity of potential agents: 'Episimus' spp.
Diversity of potential agents:

- *Episimus unguiculus* (Tortricidae) target
- Gelechiidae sp.1
- Gelechiidae sp.2
- *Psilocorsis* sp. (Depressariidae)
- *Argyrotaenia sphaleropa* (Tortricidae)
- *Clarkeulia* sp. (Tortricidae)
Schinus biological control

P. ichini adults

Pseudophilothrips ichini Thrips

P. ichini damage

P. ichini adults
P. ichini thrips testing*

- Test plant list:
  - Anacardiaceae - small family in US with 11 reported genera ([www.plants](http://www.plants) list 22 genera)
  - 48 US species ([www.plants](http://www.plants) list 61 spp)
  - We included 22 subtropical spp Anacardiaceae in no-choice (starvation) tests

- Total no-choice tested:
  - 21 families
  - 58 genera
  - 117 spp

- Tested for F₁ adults

* With Manrique & Overholt
### Results of thrips **no-choice, starvation** trials

<table>
<thead>
<tr>
<th>Species</th>
<th>Avg $F_1$</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Schinus terebinthifolia</strong></td>
<td>124.9</td>
<td>12-388</td>
</tr>
<tr>
<td>Schinus molle</td>
<td>20.3</td>
<td>0-65</td>
</tr>
<tr>
<td>Metopium toxiferum</td>
<td>1.4</td>
<td>0-10</td>
</tr>
<tr>
<td><em>Rhus sandwicensis</em> (HI)</td>
<td>5.5</td>
<td>0-33</td>
</tr>
<tr>
<td><em>Rhus typhina</em></td>
<td>2.9</td>
<td>0-26</td>
</tr>
<tr>
<td>Dodonea viscosa</td>
<td>2.8</td>
<td>0-16</td>
</tr>
<tr>
<td><strong>All other spp</strong></td>
<td>&lt; 1</td>
<td></td>
</tr>
</tbody>
</table>
**P. ichini** thrips results, $F_1$ produced in *choice* trials

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<tr>
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<td>129</td>
<td>12-325</td>
</tr>
<tr>
<td>Schinus molle</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cotinus coggygria</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Metopium toxiferum</em></td>
<td>0.1</td>
<td>0-1</td>
</tr>
<tr>
<td>Pistacia vera</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rhus glabra</td>
<td>0.3</td>
<td>0-3</td>
</tr>
<tr>
<td>Rhus sandwicensis</td>
<td>1.1</td>
<td>0-4</td>
</tr>
<tr>
<td>Rhus typhina</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
**P. ichini** thrips results
- multiple generation tests

Multiple generation test with *Pseudophilothrips ichini*

- **S. terebinthifolia**
- **S. molle**
- **R. glabra, C. coggygria, P. chinensis, R. typhina, D. viscosa**
## TAG petition submitted for biological control of Brazilian pepper

<table>
<thead>
<tr>
<th>TAG No.</th>
<th>Petitioner</th>
<th>Petition Type</th>
<th>Agent (Biological Control Organism)</th>
<th>Target Weed</th>
<th>TAG Recommendation (date)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-05</td>
<td>Alec McClay and Urs Schaffner</td>
<td>Field Release</td>
<td><em>Dictyophora aerata</em> Pierce &amp; Metcalfe (Lepidoptera: Tortricidae), <em>Cyphocleonus trisulcatus</em> Horbst (Coleoptera: Curculionidae), <em>Apion stellatum</em> German (Coleoptera: Curculionidae), and <em>Tephritus neesi</em> Moigen (Diptera: Tephritidae)</td>
<td>Oxeye daisy, <em>Leucanthemum vulgare</em> (Vaill.) Lam. (Asteraceae)</td>
<td>Under Review</td>
</tr>
</tbody>
</table>

Acknowledgements

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• Work:
  K. Dyer USDA/ARS
  V. Manrique, B. Overholt, UF