Factors that potentially mediate the ecological host range of *Trissolcus japonicus*

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Brown Marmorated Stink Bug (BMSB)
BMSB Integrated Pest Management (IPM) Working Group Meeting
November 30, 2016
Trissolcus japonicus (Ashmead) (Hymenoptera: Platygastridae)

High parasitism rates in the native range (60 to 80%)
Physiological Host-Specificity Tests (PHST)

Risk = Hazard x Exposure

PHST poses the risk hazard question,

“Can T. japonicus attack non-target species?”

To determine this,

• 23 Pentatomoidea spp. were tested; and
• Development and emergence occurred on 15 species in 11 genera.

• Therefore, the hazard prediction is that T. japonicus can complete development on some native Pentatomoidea.

• But, what about the exposure analysis?
“Will *T. japonicus* attack non-target species?”

Risk to non-target species decreases with increases in total mediation of hazard via ecological sieves.

**Ecological Sieves**

- Habitat Partitioning
- Habitat Complexity
- Semiochemicals
- Host Egg Characteristics

**Physiological (Potential) Host Range**

**Realized (Field) Host Range**

- Host Habitat Finding & Host Finding
- Host Acceptance, Suitability, & Regulation
June – Sept, 2014 - 2016
• Quantitative sampling (100 m transects sweeping/beating) in 4 Natural Areas:
  ❖ 5 Woodlots
  ❖ 8 Grasslands
• Qualitative sampling for BMSB.
Current Distribution in Michigan
Reported in 46 Counties
BMSB Sampling

Host Plants:

June – Sept:
- Tree of Heaven
- Honeysuckle
- Ash
- Boxelder
- Eastern White Cedar
- Black Locust
- Pokeweed

Sept:
- Soybean
15 species.
- *Banasa dimidiata* - 24%
- *Euschistus tristigmus luridus* - 24%
Pentatomomoidea in Grassland Communities

- 16 species.
- *Cormelaena* spp. - 59%
- *Euschistus variolarious* - 16%
Adventive *T. japonicus* in the Field

**Locations Where *T. japonicus* Have Been Found**

**As of 2015**

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*Trissolcus japonicus* (Ashmead) (Hymenoptera, Scelionidae) emerges in North America

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**Discovery of an Exotic Egg Parasitoid of the Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål) in the Pacific Northwest**

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URL: [http://www.bioone.org/doi/full/10.4289/0013-8797.118.3.466](http://www.bioone.org/doi/full/10.4289/0013-8797.118.3.466)
### Parasitoids by Host Species. 2015

<table>
<thead>
<tr>
<th>Host Common Name</th>
<th>Family</th>
<th>Parasitoids Species</th>
<th>Family</th>
<th>BMSB Eggs</th>
<th>No. Put</th>
<th>Attacked No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>American hornbeam or Ironwood, <em>Carpinus caroliniana</em></td>
<td>Betulaceae</td>
<td><em>Trissolcus cosmopeplae</em></td>
<td>Platygastridae</td>
<td>84</td>
<td>8</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Milkweed, <em>Asclepias albicans</em></td>
<td>Apocynaceae</td>
<td><em>Ooencyrtus sp.</em></td>
<td>Encyrtidae</td>
<td>84</td>
<td>8</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Milkweed, <em>Asclepias albicans</em></td>
<td>Apocynaceae</td>
<td><em>Trissolcus euschisti</em></td>
<td>Platygastridae</td>
<td>28</td>
<td>3</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Wild Grape, <em>Vitis vinifera</em></td>
<td>Vitaceae</td>
<td><em>Trissolcus cosmopeplae</em></td>
<td>Platygastridae</td>
<td>28</td>
<td>6</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>Wild Grape, <em>Vitis vinifera</em></td>
<td>Vitaceae</td>
<td><em>Ooencyrtus sp.</em></td>
<td>Encyrtidae</td>
<td>27</td>
<td>4</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Hawthorn, <em>Crategus rhipidophylla</em></td>
<td>Rosaceae</td>
<td><em>Ooencyrtus sp.</em></td>
<td>Encyrtidae</td>
<td>56</td>
<td>6</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>American basswood, <em>Tilia americana</em></td>
<td>Tiliaceae</td>
<td><em>Trissolcus cosmopeplae</em></td>
<td>Platygastridae</td>
<td>28</td>
<td>1</td>
<td>0.04</td>
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<tr>
<td>American basswood, <em>Tilia americana</em></td>
<td>Tiliaceae</td>
<td><em>Trissolcus euschisti</em></td>
<td>Platygastridae</td>
<td>28</td>
<td>2</td>
<td>0.07</td>
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<tr>
<td>American basswood, <em>Tilia americana</em></td>
<td>Tiliaceae</td>
<td><em>Trissolcus brochymenae</em></td>
<td>Platygastridae</td>
<td>20</td>
<td>1</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td>383</td>
<td>39</td>
<td>0.10</td>
<td></td>
</tr>
</tbody>
</table>

**MI Sentinel Egg Surveys**
Risk to non-target species decreases with increases in total mediation of hazard via ecological sieves.

Ecological Sieves

Physiological (Potential) Host Range

- Habitat Partitioning
- Habitat Complexity
- Semiochemicals
- Host Egg Characteristics

Realized (Field) Host Range

Host Habitat Finding & Host Finding

Host Acceptance, Suitability, & Regulation
Habitat Complexity Experiments

46 x 46 x 46 cm

1.5 x 1.5 x 2 m H
# Habitat Complexity Experiments

<table>
<thead>
<tr>
<th>Test</th>
<th>No. reps</th>
<th>BMSB</th>
<th>T. c. accerra</th>
<th>P. maculiventris</th>
<th>$X^2$ statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paired-choice</td>
<td>21</td>
<td>20</td>
<td>15</td>
<td>----</td>
<td>4.29</td>
<td>0.0384</td>
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<tr>
<td>21</td>
<td>18</td>
<td>----</td>
<td>12</td>
<td></td>
<td>4.2</td>
<td>0.0404</td>
</tr>
</tbody>
</table>
Risk to non-target species decreases with increases in total mediation of hazard via ecological sieves.

**Ecological Sieves**

**Physiological (Potential) Host Range**

- Habitat Partitioning
- Habitat Complexity
- Semiochemicals
- Host Egg Characteristics

**Host Habitat Finding & Host Finding**

**Host Acceptance, Suitability, & Regulation**

**Realized (Field) Host Range**
Semiochemicals

Host location by *Trissolcus basalis*:

- Egg kairomones (Bin *et al.* 1993).
- Adult cuticular hydrocarbons (Colazza *et al.* 2007).
- Defensive secretions (Laumann *et al.* 2009).
- Chemical footprints on leaves (Colazza *et al.* 2009).
- Feeding and oviposition damage (Colazza *et al.* 2004).
Semiochemicals

- Y-tube Olfactometer.

- Odor Sources.
  - Eggs.
  - Adult BMSB.
  - Chemical footprints.
  - Feeding damage.

- Under Continued Evaluation.
Risk to non-target species decreases with increases in total mediation of hazard via ecological sieves.
One, 24-h-old mated, naïve female *T. japonicus* placed in middle of arena.

Scored behaviors:
-遇 egg(s);
- Inspection of egg(s) by circling and antennal drumming;
- Egg rejection (abandoning); and
- Egg acceptance (oviposition).

 After 24-h, Petri dishes moved to an environmental chamber at 25°C; 60-80% RH; 16:8 L:D.

Wasp removed from the arena after 24-h.

Egg masses held separately until wasp or nymph emergence.
Multiple-Species Choice Tests

No. replicates in which eggs were accepted (blue) or rejected (orange) ($n = 30$)

* $p < 0.001$; $X^2$
Multiple-Species Choice Tests

Total Emergence ($n = 38$)

Overall Percent

- **H. halys**
  - Emerged Wasps: 30%
  - Unhatched Wasps: 20%
  - Unhatched Nymphs: 50%

- **T. c. accerra**
  - Emerged Wasps: 40%
  - Unhatched Wasps: 10%
  - Unhatched Nymphs: 50%

- **P. maculiventris**
  - Emerged Wasps: 50%
  - Unhatched Wasps: 20%
  - Unhatched Nymphs: 30%

- **E. variolarius**
  - Emerged Wasps: 60%
  - Unhatched Wasps: 10%
  - Unhatched Nymphs: 30%
Multiple-Species Choice Tests

Total Emergence ($n = 38$)

- **H. halys**
  - Emerged: 80%
  - Unhatched Wasps: 10%
  - Unhatched Nymphs: 10%

- **T. c. accerra**
  - Emerged: 70%
  - Unhatched Wasps: 5%
  - Unhatched Nymphs: 25%

- **P. maculiventris**
  - Emerged: 60%
  - Unhatched Wasps: 10%
  - Unhatched Nymphs: 30%

- **E. variolarius**
  - Emerged: 50%
  - Unhatched Wasps: 15%
  - Unhatched Nymphs: 35%
Development on Non-Target Hosts

• Does specificity differ?
  • Do compounds on eggs train wasps for preference?
  • Genetic inclination?

• Does fecundity differ?
  • Effects of phenotypic variation.
Multiple-Species Choice Tests

- **BMSB Reared**
  - $p < 0.001, \chi^2$
  - Comparison showing a significant difference in ovipositions and rejections.

- **T. caccerra Reared**
  - $p = 0.267, \chi^2$
  - Comparison showing a marginally significant difference in ovipositions and rejections.

- **P. maculiventris Reared**
  - $p = 0.069, \chi^2$
  - Comparison showing a significant difference in ovipositions and rejections.

Graphs showing the number of replicates for each species, with blue bars representing ovipositions and orange bars representing rejections.
Multiple-Species Choice Tests

BMSB Reared

Overall Percent

T.c. accera Reared

Overall Percent

P. maculiventris Reared

Overall Percent

P. variolarius Reared

Overall Percent

Legend:
- Emerged Wasps
- Unhatched Wasps
- Unhatched Nymphs
- Emerged Nymphs
Conclusions and Future Work

1. Risk = Hazard x Exposure, = “Can-Do” x “Will Do.”
   - Hazard is the innate capacity of a biological control agent to attack a non-target species and is determined in PHST; and
   - Exposure is determined by ecological sieves that may mediate the hazard.
   - A high hazard and a low exposure can mean that a potential biological control agent is “safe” to release.

2. The hazard analysis following PHST shows that *T. japonicus* can attack at least 11 genera of native Pentatomoidea.

3. The exposure analysis shows that there are some ecological sieves (habitat partitioning and host egg characteristics) that can mediate the potential hazard.

4. In the absence of mediating ecological sieves, we feel that the potential host range of *T. japonicus* is too broad, and it should not be approved for release.

5. However, since adventive populations of *T. japonicus* have been found in eastern and western U.S., this is a moot point, and efforts to identify ecological sieves and evaluate damage to native Pentatomoidea should be the focus of future research.
Acknowledgements

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