Mighty Mites of Pacific Northwest Tree Fruits

Elizabeth H. Beers & Rebecca Schmidt-Jeffris
Tree Fruit Research & Extension Center
1100 N. Western Ave.
Wenatchee, Washington
Why do we have mite outbreaks?
Mites? I haven’t sprayed for those in 25 years!

Mite Pest Species on Apple & Pear

- *Panonychus ulmi*
- *Tetranychus mcdanieli*
- *Tetranychus urticae*

Timeline:
- 1960
- 1980
- 2000-present
Galendromus occidentalis

- Arid climate adapted
- Resistant to OPs
- Prefers *Tetranychus* spp.
  - But will eat *P. ulmi* if necessary
A more diverse phytoseiid fauna?

Galendromus occidentalis

Amblydromella caudiglans

Galendromus flumenis

Kampimodromus corylosus
Why do we have mite outbreaks?

Schmidt-Jeffris et al. 2015
Integrated Mite Management

Twospotted spider mite

European red mite

Save our Mother Earth
...are the unintended (negative) consequences of a pesticide spray for a pest on beneficial insects
Ecologically Relevant Measures

Incorporating Ecologically Relevant Measures of Pesticide Effect for Estimating the Compatibility of Pesticides and Biocontrol Agents

JOHN D. STARK, ROGER VARGAS, AND JOHN E. BANKS

ABSTRACT The compatibility of biological control agents with pesticides is a central concern in integrated pest management programs. The most common assessments of compatibility consist of simple comparisons of acute toxicity among pest species and select biocontrol agents. A more sophisticated approach, developed by the International Organisation of Biological Control (IOBC), is based on a tiered hierarchy made up of threshold values for mortality and sublethal effects that is used to determine the compatibility of pesticides and biological control agents. However, this method is unable to capture longer term population dynamics, which is often critical to the success of biological control and pest suppression. In this article, we used the delay in population growth index, a measure of population recovery, to investigate the potential impacts that the threshold values for levels of lethal and sublethal effects developed by the IOBC had on three biocontrol agents: seven-spotted lady beetle, Coccinella septempunctata L.; the aphid parasitoid Diaeretiella rapae (M’Intosh), and Eoisaris arisanus (Soman), a parasitoid of tephritid flies. Based on life histories of these economically important natural enemies, we established a delay of 1-generation time interval as sufficient to disrupt biological control success. We found that delays equivalent to 1-generation time interval were caused by mortality as low as 50% or reductions of offspring as low as 58%, both values in line with thresholds developed by the IOBC. However, combinations of mortality and reduction of offspring lower than these values (from 32 to 43% each) over a simulated 4- to 6-year period caused significant population delays, the species used in these simulations reacted differently to the same levels of effect. D. rapae was the most susceptible species, followed by E. arisanus and C. septempunctata. This indicates that it is not possible to generalize about potential long-term impacts of pesticides on biocontrol agents because susceptibility is influenced by differences in life history. Additionally, populations of biocontrol agents may undergo significant damage with approaches 50% or when there is mortality of ~30% and a 30% reduction in offspring, which delays in population growth may advance our knowledge of pesticide impacts on beneficial species.

Comparative analysis of pesticide effects on natural enemies in western orchards: A synthesis of laboratory bioassay data

Nicholas J. Mills, Elizabeth H. Beers, Peter W. Shearer, Thomas R. Unruh, Kaushalya G. Amarasekare

*Department of Environmental Science and Policy Management, University of California, Berkeley, CA 94720-3114, USA

†Department of Entomology, Tree Fruit Research and Extension Center, Washington State University, 1100 N. Western Ave., Wenatchee, WA 98801, USA

‡Mid-Columbia Agricultural Research and Extension Center, Oregon State University, 3005 Experiment Station Drive, Hood River, OR 97814-9512, USA

§USDA-ARS, Yakima Agricultural Research Laboratory, 5230 Konnecoo Pass Road, Wapato, WA 98951, USA

HIGHLIGHTS

- We report acute and sublethal effects of pesticides on natural enemies.
- Acute mortalities were greater for adult than juvenile life stages for spinetoram.
- Sublethal effects on daily fecundity, fertility, and sex ratio are documented.
- Population models are used to estimate the effects of pesticide exposure.

GRAPHICAL ABSTRACT

![Graphical abstract showing effects of pesticides on natural enemies.](image-url)
Probit Bioassays: Love ‘em and Leave ‘em

- Acute topical
- 24-48 h
- One stage only

- Mortality
- Fecundity
- Fertility
- Developmental time
- Sex ratio
- Repellency
- ...

Graph showing Probit versus Log dose with data points and a linear trend line.
### Ecologically Relevant Measures: % Reduction of F1

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>MOA</th>
<th>Larval mortality</th>
<th>Female mortality</th>
<th>Prey Consumption</th>
<th>Fecundity</th>
<th>Egg hatch</th>
<th>Live larvae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbaryl</td>
<td>1A</td>
<td>32</td>
<td>11</td>
<td>-36</td>
<td>-52</td>
<td>-18</td>
<td>-97</td>
</tr>
<tr>
<td>Azinphosmethyl</td>
<td>1B</td>
<td>40</td>
<td>0</td>
<td>-26</td>
<td>-49</td>
<td>0</td>
<td>-46</td>
</tr>
<tr>
<td>Lambda-cyhalothrin</td>
<td>3</td>
<td>87</td>
<td>94</td>
<td>-72</td>
<td>-72</td>
<td>0</td>
<td>-98</td>
</tr>
<tr>
<td>Acetamiprid</td>
<td>4A</td>
<td>36</td>
<td>32</td>
<td>-89</td>
<td>-81</td>
<td>0</td>
<td>-99</td>
</tr>
<tr>
<td>Thiacloprid</td>
<td>4A</td>
<td>4</td>
<td>64</td>
<td>-59</td>
<td>-36</td>
<td>0</td>
<td>-59</td>
</tr>
<tr>
<td>Imidacloprid</td>
<td>4A</td>
<td>51</td>
<td>65</td>
<td>-93</td>
<td>-68</td>
<td>0</td>
<td>-83</td>
</tr>
<tr>
<td>Spinosad</td>
<td>5</td>
<td>86</td>
<td>24</td>
<td>80</td>
<td>-48</td>
<td>-25</td>
<td>-79</td>
</tr>
<tr>
<td>Spinetoram</td>
<td>5</td>
<td>15</td>
<td>96</td>
<td>-35</td>
<td>-100</td>
<td>0</td>
<td>-100</td>
</tr>
<tr>
<td>Novaluron</td>
<td>15</td>
<td>1</td>
<td>33</td>
<td>-21</td>
<td>-39</td>
<td>-24</td>
<td>-94</td>
</tr>
<tr>
<td>Spirotetramat</td>
<td>23</td>
<td>(0)</td>
<td>10</td>
<td>-3</td>
<td>-87</td>
<td>-44</td>
<td>-100</td>
</tr>
<tr>
<td>Chlorantraniliprole</td>
<td>28</td>
<td>5</td>
<td>8</td>
<td>-14</td>
<td>-13</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Flubendiamide</td>
<td>28</td>
<td>8</td>
<td>30</td>
<td>-19</td>
<td>-10</td>
<td>0</td>
<td>-34</td>
</tr>
<tr>
<td>Cyantraniliprole</td>
<td>28</td>
<td>15</td>
<td>4</td>
<td>-27</td>
<td>-50</td>
<td>15</td>
<td>-27</td>
</tr>
<tr>
<td>Mancozeb+Copper</td>
<td>M1/M3</td>
<td>6</td>
<td>28</td>
<td>-38</td>
<td>-64</td>
<td>0</td>
<td>-68</td>
</tr>
<tr>
<td>Sulfur</td>
<td>M2</td>
<td>94</td>
<td>23</td>
<td>-42</td>
<td>-51</td>
<td>-24</td>
<td>-100</td>
</tr>
</tbody>
</table>
Selectivity Ratio: Croft 1990

\[ \frac{\text{LC}_{50} \text{ Pest}}{\text{LC}_{50} \text{ Predator}} = 100 \]

10 ppm pest

\[ \frac{0.1 \text{ ppm predator}}{} = 100 \]

Field rate of 1,500 ppm = everyone’s dead!
A new way to look at Selectivity

- Incorporates effects on both pest and NE
- Field relevant rates
- Lethal and sublethal effects, multiple life stages
- Scalable to different pest and NE combinations

Life Table Selectivity Index: LTSI

% Reduction $F_1_{\text{Predator}}$ - % Reduction $F_1_{\text{Prey}}$

Range: -200 to +200

Ecologically Relevant Measures: LTSI

LTSI: Pred-Prey (% Reduction Live Larvae)

Selective

-150 -100 -50 0 50 100 150

Not Selective

Assail, Zeal, Rimon, Provado, Sevin, AgriMek, Calypso, Manzate/Kocide, Success, Belt, FujiMite, Altacor, Apollo, Vendex, Exirel, Guthion, Delegate, Ultor, Warrior, Envidor, Onager, Acramite, Nealta
Ecologically Relevant Measures: LTSI

### LTSI: Pred-Prey (% Reduction Live Larvae)

-150  -100  -50   0    50    100   150

**Selective**

**Not Selective**

Assail, Zeal, Rimon, Provado, Sevin, Agrimex, Calypso, Manzate/Kocide, Success, Belt, FujiMite, Altacor, Apollo, Vendex, Exirel, Guthion, Delegate, Ultor, Warrior, Envidor, Onager, Acramite, Nealta
LTSI: shortcomings

- Short time horizon, length of residues not accounted for
- Can vary with resistance levels (both predator and prey)
- Materials that are very toxic to predators are likely to have negative consequences in the future
The Black Hole: Resistance
## Historical Miticides

<table>
<thead>
<tr>
<th>Acaricide</th>
<th>Year</th>
<th>Acaricide</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neotran</td>
<td>1945</td>
<td>Chlorbenside</td>
<td>1953</td>
</tr>
<tr>
<td>DMC</td>
<td>1946</td>
<td>Fenson</td>
<td>1953</td>
</tr>
<tr>
<td>Shradan</td>
<td>1946</td>
<td>Dioxathion</td>
<td>1954</td>
</tr>
<tr>
<td><strong>Parathion</strong></td>
<td>1947</td>
<td>Tetradifon</td>
<td>1954</td>
</tr>
<tr>
<td>Ovex</td>
<td>1949</td>
<td>Carbophenothion</td>
<td>1955</td>
</tr>
<tr>
<td>EPN</td>
<td>1950</td>
<td><strong>Ethion</strong></td>
<td>1955</td>
</tr>
<tr>
<td>Aramite</td>
<td>1950</td>
<td>Binapacryl</td>
<td>1960</td>
</tr>
<tr>
<td>Dinocap</td>
<td>1950</td>
<td><strong>Morestan</strong></td>
<td>1960</td>
</tr>
<tr>
<td>Sulphenone</td>
<td>1952</td>
<td><strong>Omite</strong></td>
<td>1960</td>
</tr>
<tr>
<td>Demeton</td>
<td>1952</td>
<td>Pentac</td>
<td>1960</td>
</tr>
<tr>
<td>Chlorobenzilate</td>
<td>1952</td>
<td><strong>Plictran</strong></td>
<td>1969</td>
</tr>
<tr>
<td>Dicofol</td>
<td>1952</td>
<td>Galecron</td>
<td>1969</td>
</tr>
</tbody>
</table>

A tale of two mites?

FujiMite Bioassays

Twospotted Spider Mite

European Red Mite

FujiMite LC_{50} (ppm Al)

Bioassay Code

A tale of two crops!

Apple

Pear
Acknowledgments

Deepest thanks to the organizations who sponsored this research, and the people who helped make it happen.

Rebecca Schmidt-Jeffris
Luis Martinez-Rocha
Dario Fernandez
Lessando Gontijo

Peter Smytheman
Bruce Greenfield
Chris Sater
Key Influencers

Larry Hull
Stan Hoyt
Jay Brunner
Everett Burts
John Dunley
Vince Jones
Tom Unruh
Dave Horton
Pete Landolt
Alan Knight
Bill Snyder
Dave Crowder
Steve Welter
Helmut Riedl
Peter Shearer

(etc.)
Take Home Messages

“The Whole is Greater than the Sum of its Parts”

--- Aristotle

“You don’t have to stand on the shoulders of giants to see farther – average height also works”

----- Betsy Beers