Mighty Mites of

Pacific Northwest Tree Fruits

PB-ESA
2 April 2019
Hyatt Regency Mission Bay Spa & Marina
San Diego, CA

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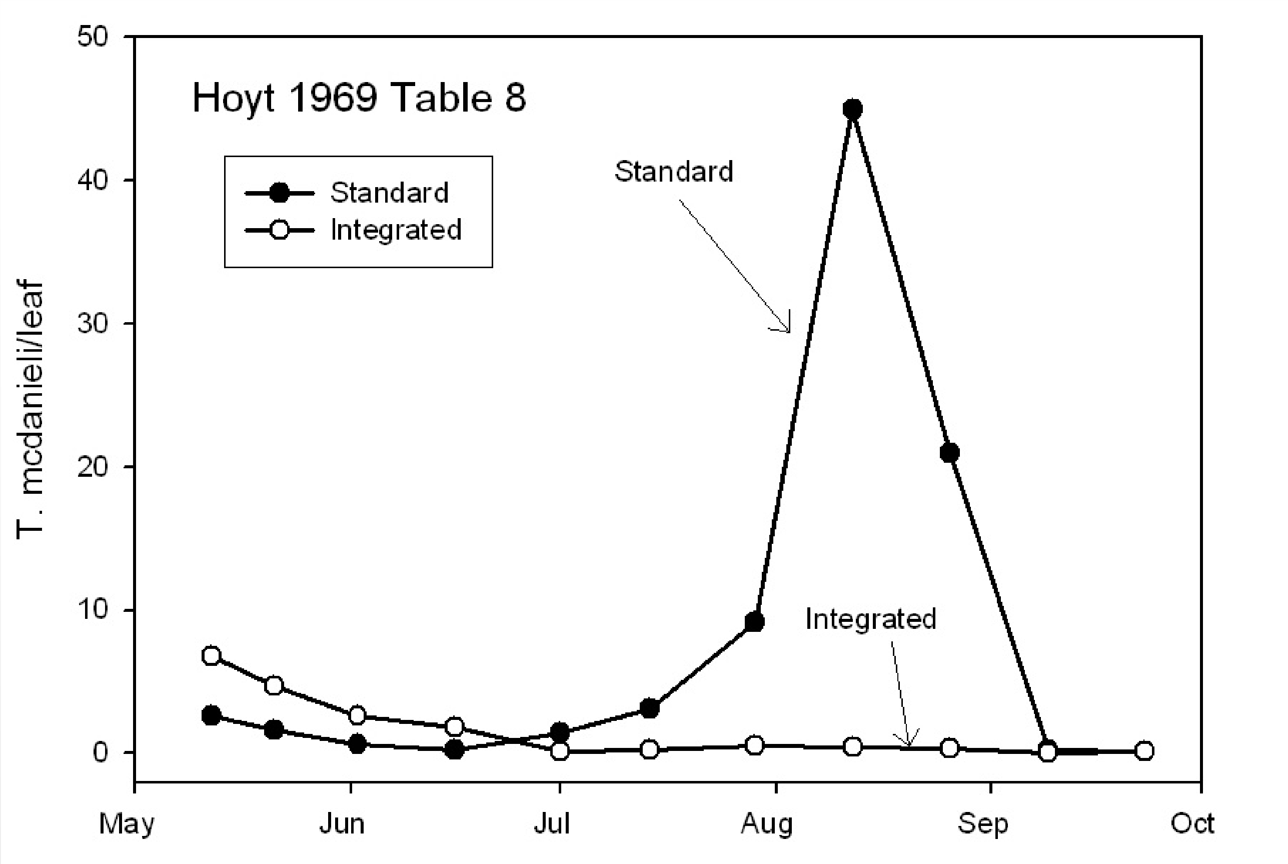
Tree Fruit Research & Extension Center
1100 N. Western Ave.
Wenatchee, Washington

Why do we have mite outbreaks?

Hoyt 1969

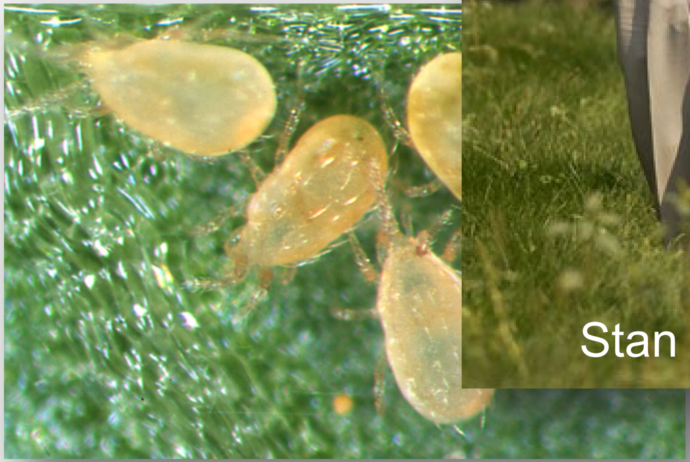


Stan Hoyt

Mites? I haven't sprayed for those in 25 years!

Hoyt, S. C. 1969. Integrated chemical control of insects and biological control of mites on apple in Washington. J. Econ. Entomol. 62: 74-86.

Primary vs. Secondary



Mite Pest Species on Apple & Pear

1960 1980 2000-present

Match.com – find your perfect phytoseiid

Galendromus occidentalis

- Arid climate adapted
- Resistant to OPs
- Prefers *Tetranychus* spp.
  - But will eat P. ulmi if necessary

A more diverse phytoseiid fauna?

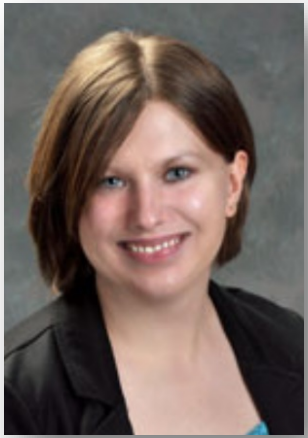
Galendromus occidentalis

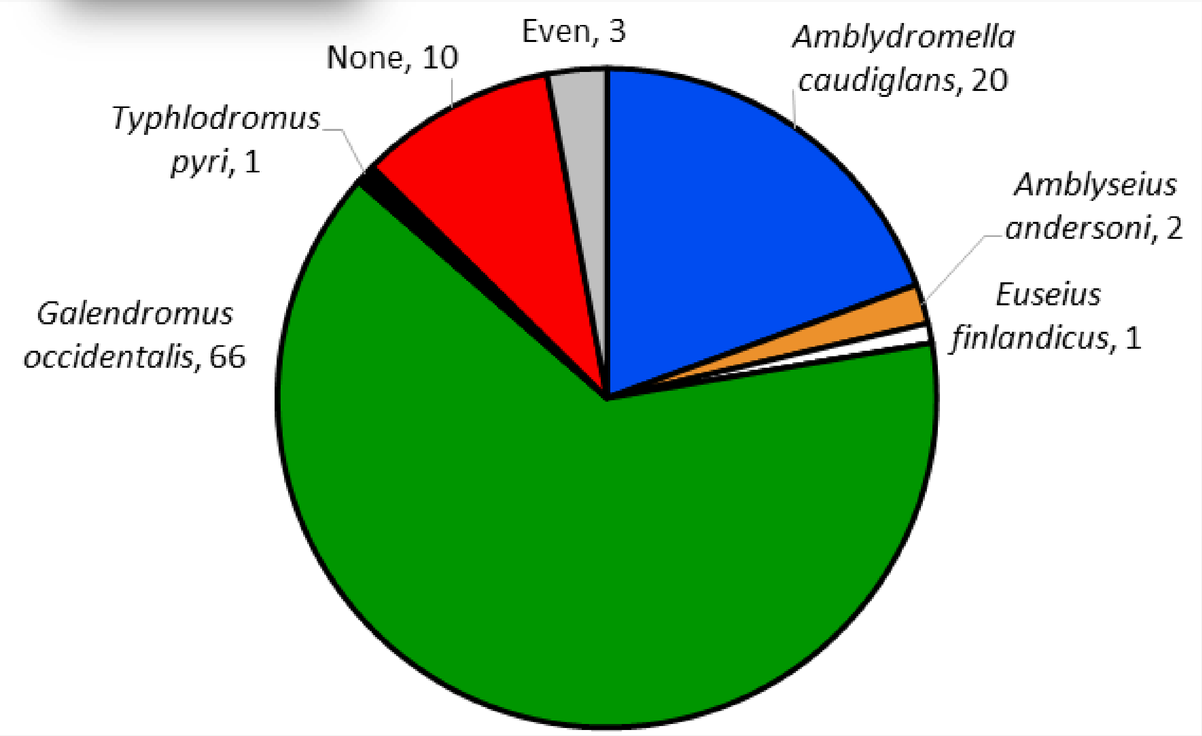
Amblydromella caudiglans

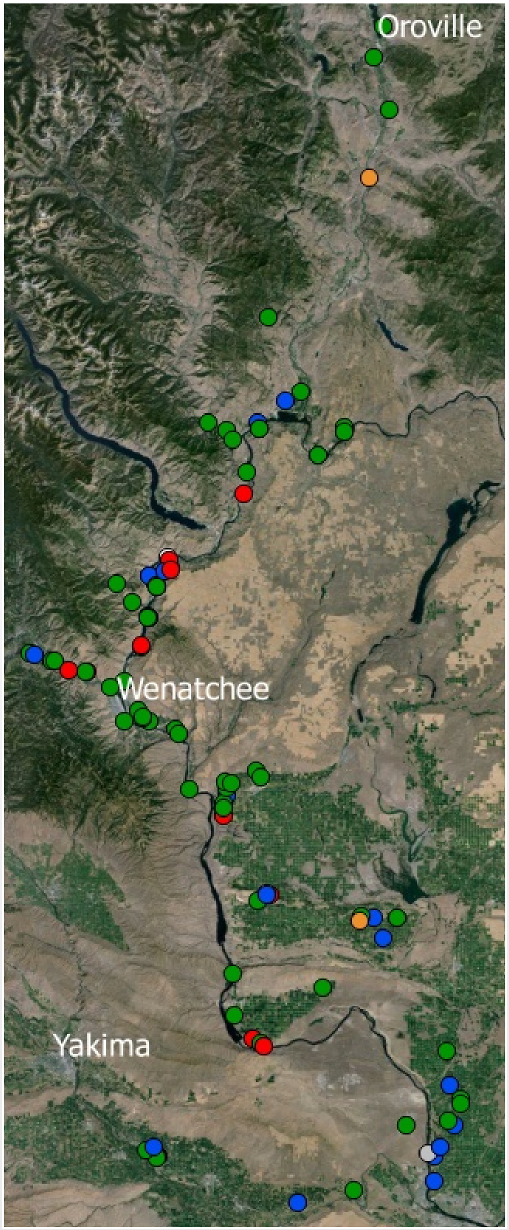
Galendromus flumenis

Kampimodromus corylosus

Why do we have mite outbreaks?







Schmidt-Jeffris et al. 2015

Integrated Mite Management

Twospotted spider mite

Nontarget Effects of Pesticides

...are the unintended (negative) consequences of a pesticide spray for a pest on beneficial insects

	Typhs
Warrior	
Assail	
Imidacloprid	
Actara	
Agri-Mek	
Delegate	
Rimon	
Ultor	
Sulfur	
Altacor	
Esteem	

Ecologically Relevant Measures

FORUM

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

JOHN D. STARK,[1] ROGER VARGAS,[2] AND JOHN E. BANKS[3]

J. Econ. Entomol. 100(4): 1027–1032 (2007)

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: sevenspotted lady beetle, *Coccinella septempunctata* L.; the aphid parasitoid *Diaeretiella rapae* (M'Intosh), and *Fopius arisanus* (Sonan), 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-mo period caused significant population delays.
the species used in these simulations reacted differently to the same levels of effect. T
D. rapae was the most susceptible species, followed by *F. arisanus* and *C. septempunctat*
indicate that it is not possible to generalize about potential long-term impacts of
biocontrol agents because susceptibility is influenced by differences in life hist
Additionally, populations of biocontrol agents may undergo significant damage wh
approaches 50% or when there is mortality of ≈30% and a 30% reduction in offspri
a sublethal effect. Our results suggest that more ecologically relevant measures of e
delays in population growth may advance our knowledge of pesticide impacts on p
beneficial species.

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

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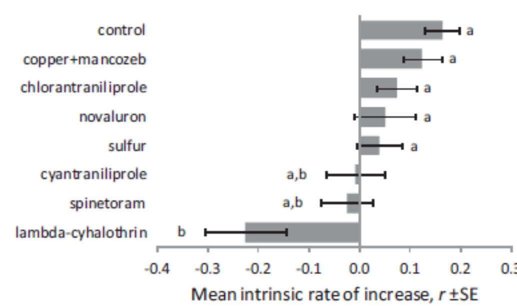
HIGHLIGHTS

- 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.

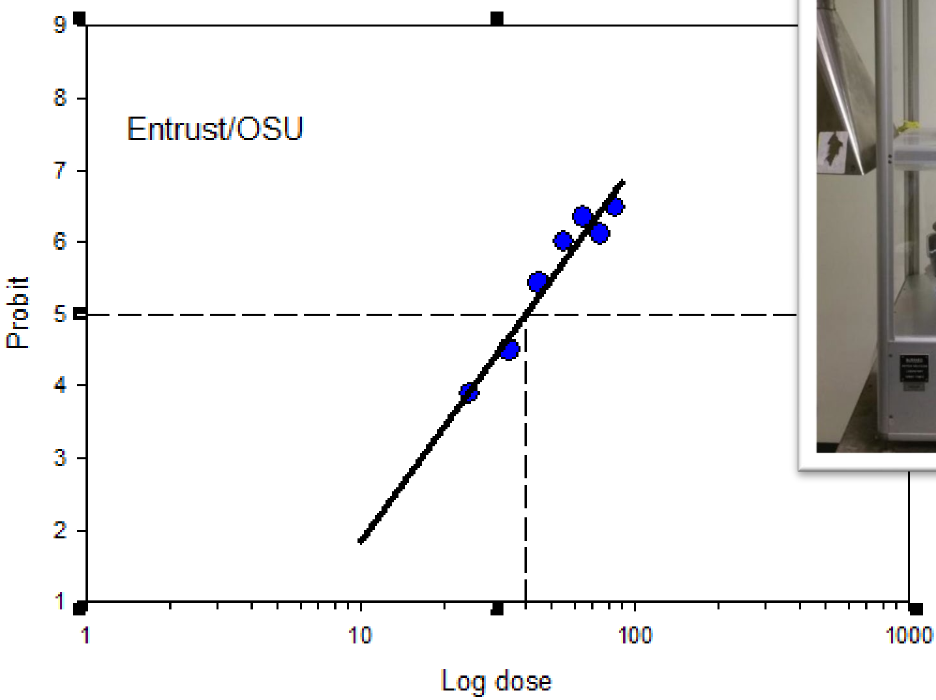
GRAPHICAL ABSTRACT



Probit Bioassays: Love 'em and Leave 'em

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

- ✓ Mortality
- ✓ Fecundity
- ✓ Fertility
- ✓ Developmental time
- ✓ Sex ratio
- ✓ Repellency
- ✓ …



Ecologically Relevant Measures: % Reduction of F_1

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Impacts of orchard pesticides on *Galendromus occidentalis*: Lethal and sublethal effects

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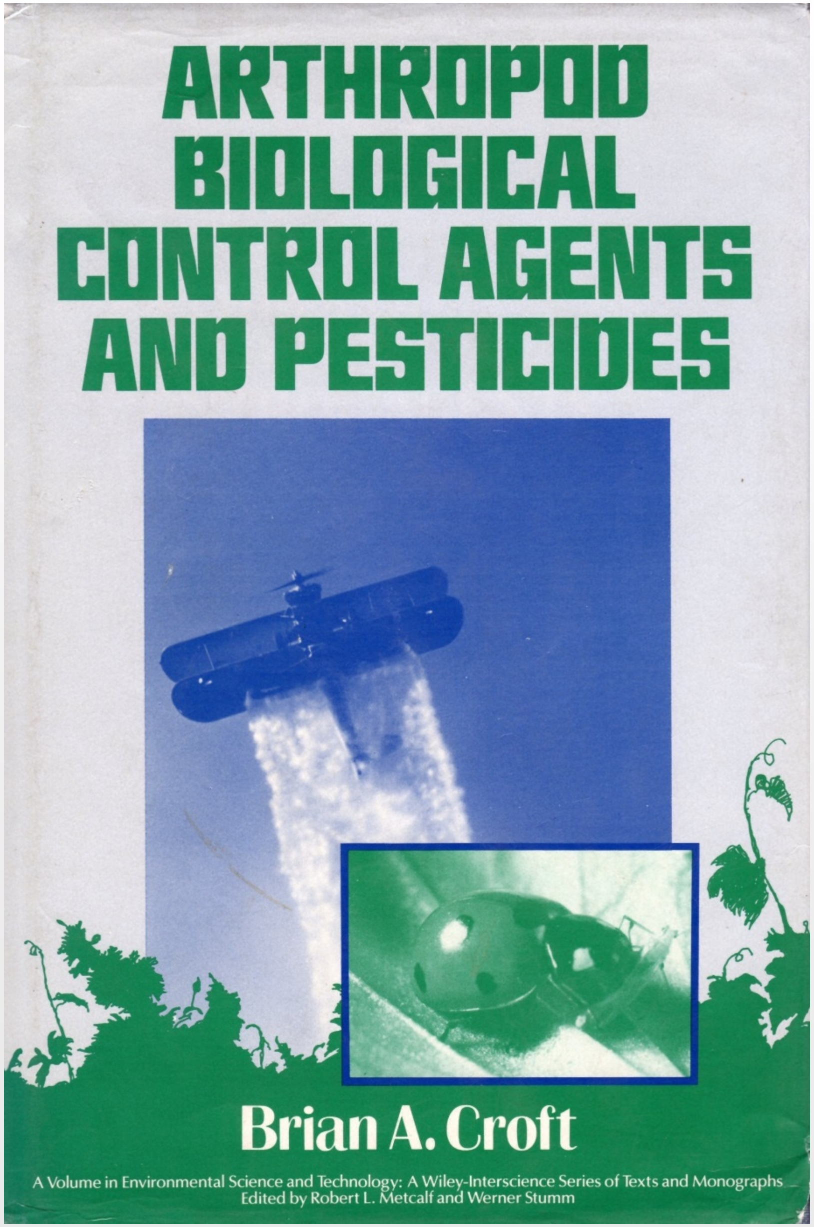
Washington State University, Western Ave., Wenatchee, WA 1100 N, USA

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

Selectivity Ratio: Croft 1990



$$\frac{LC_{50}\ \text{Pest}}{LC_{50}\ \text{Predator}}$$

$$\frac{10\ \text{ppm pest}}{0.1\ \text{ppm predator}} = 100$$

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

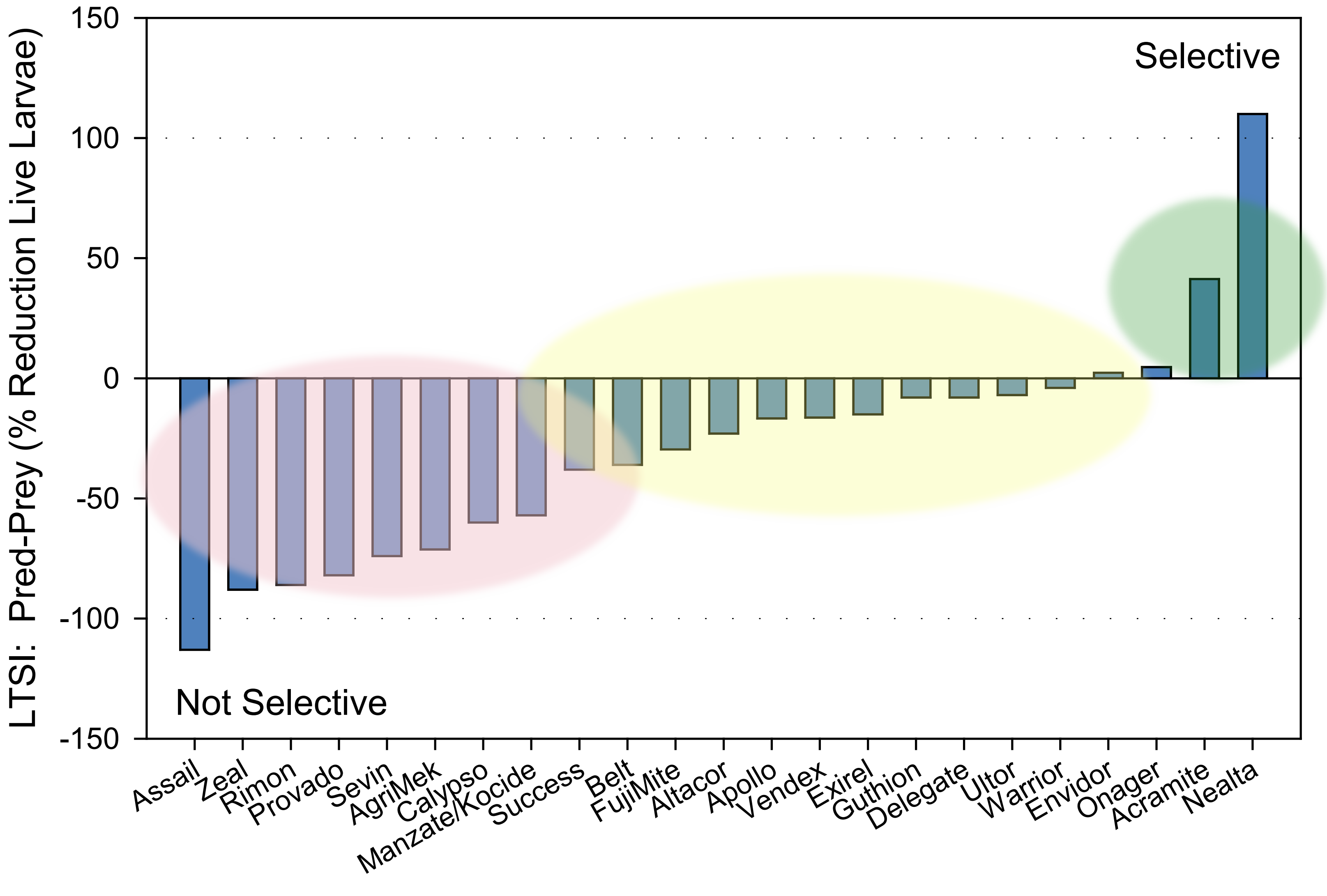
Life Table Selectivity Index: LTSI

% Reduction F_1 Predator - % Reduction F_1 Prey

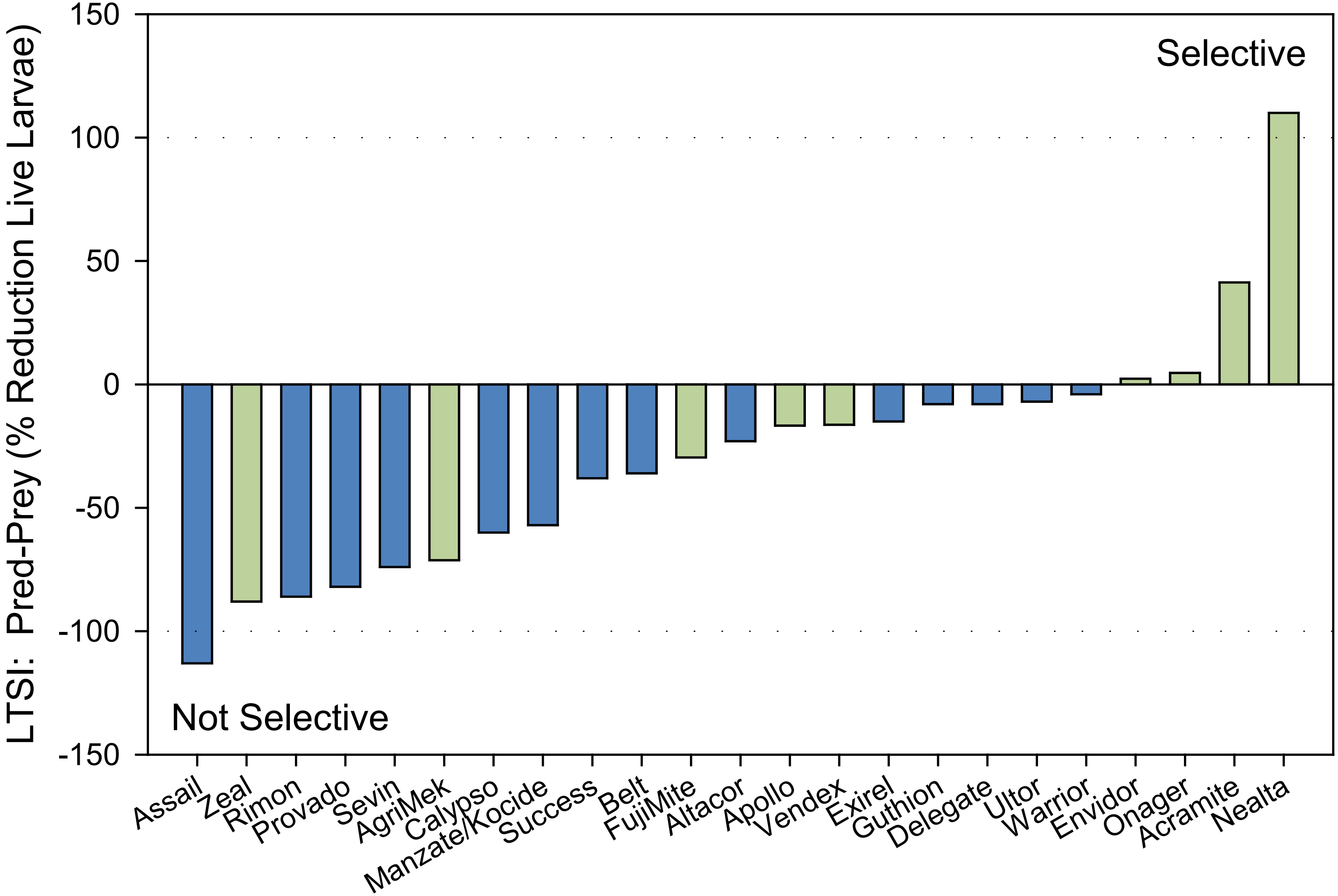
Range: -200 to +200

Schmidt-Jeffris, R. A., and E. H. Beers. 2018. Potential impacts of orchard pesticides on *Tetranychus urticae: a predator-prey perspective. Crop Prot. 103: 56-64.*

Ecologically Relevant Measures: LTSI



Ecologically Relevant Measures: LTSI



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

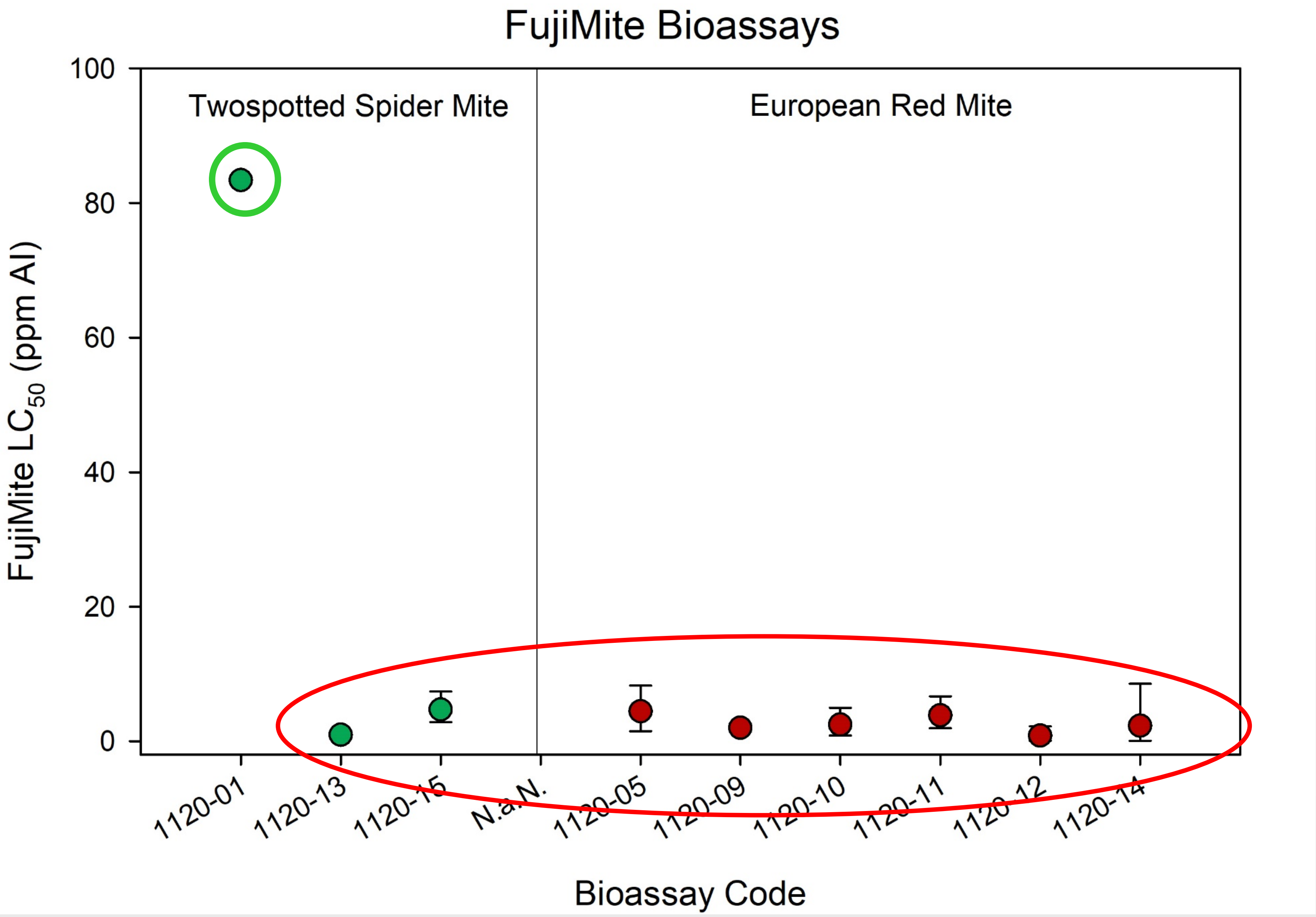
Historical Miticides

Acaricide	Year		Acaricide	Year
Neotran	1945		Chlorbenside	1953
DMC	1946		Fenson	1953
Shradan	1946		Dioxathion	1954
Parathion	1947		Tetradifon	1954
Ovex	1949		Carbophenothion	1955
EPN	1950		**Ethion**	1955
Aramite	1950		Binapacryl	1960
Dinocap	1950		**Morestan**	1960
Sulphenone	1952		**Omite**	1960
Demeton	1952		Pentac	1960
Chlorobenzilate	1952		**Plictran**	1969
Dicofol	1952		Galecron	1969

Source: Table 1 in:

Jeppson, L. R., H. H. Keifer, and E. W. Baker. 1975. History of chemical control and mite resistance to acaricides, pp. 47-61, Mites injurious to economic plants. University of California Press, Berkeley, CA.

A tale of two mites?

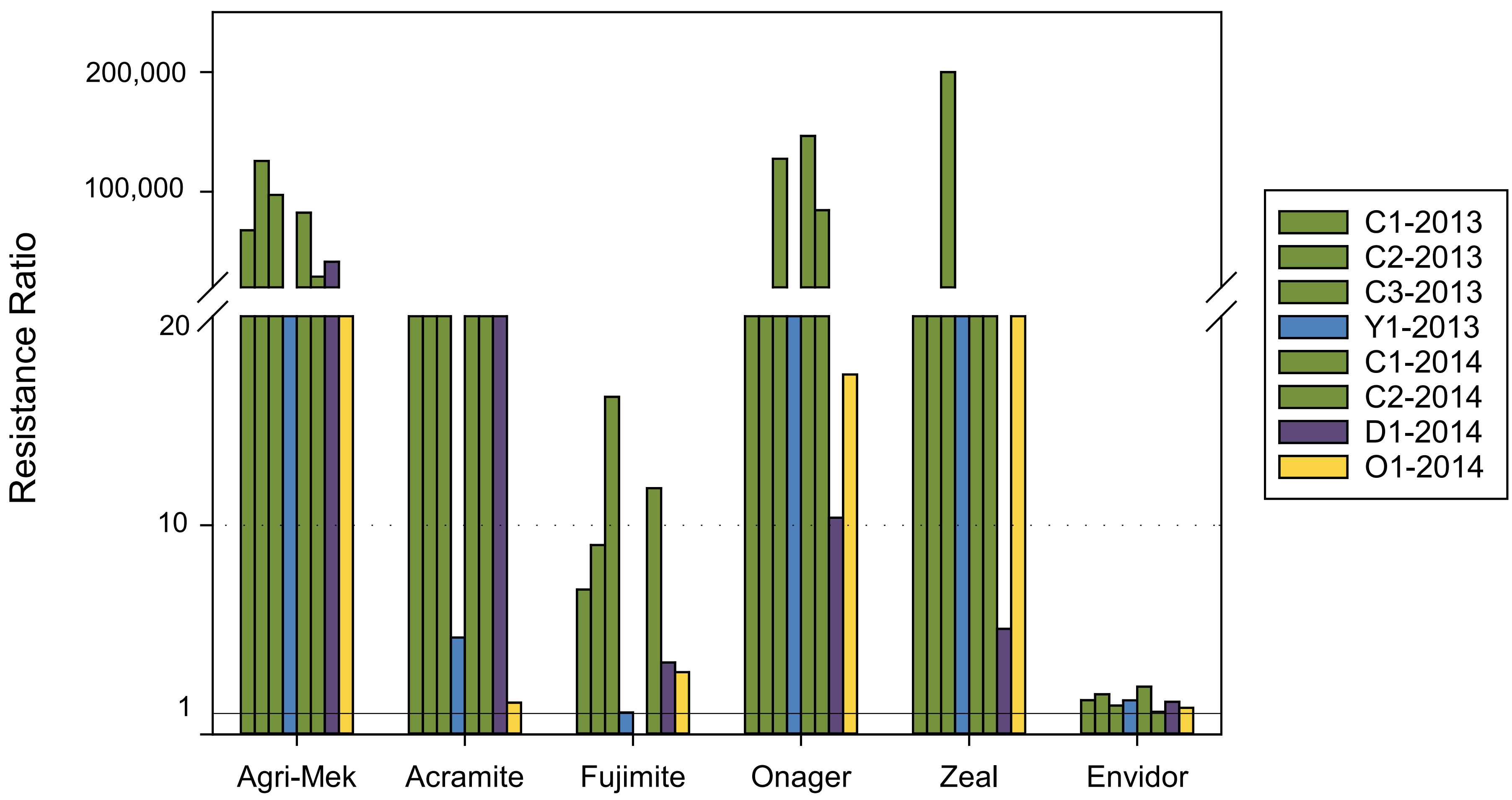


A tale of two crops!

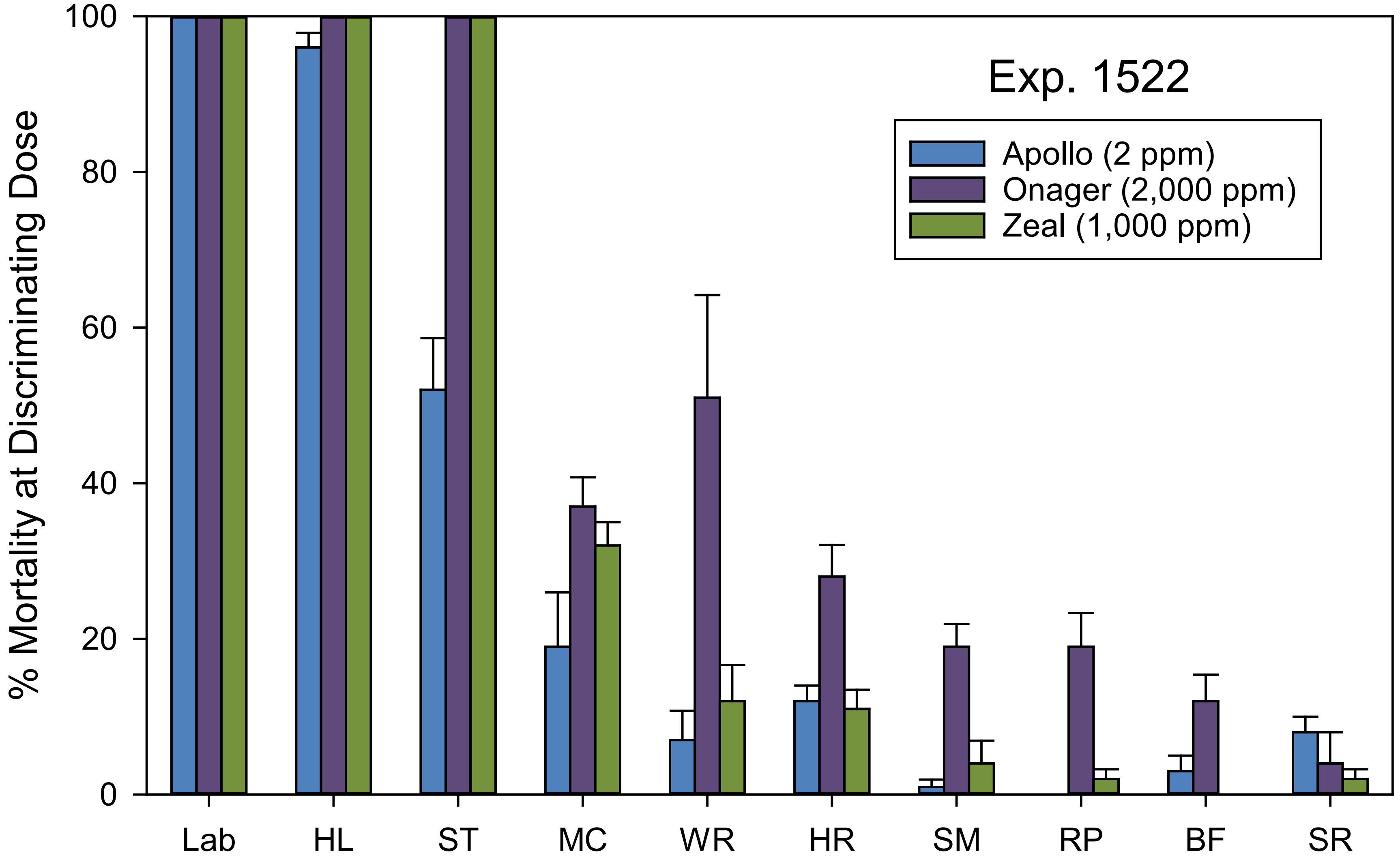
Apple

Pear

Miticide Resistance



Cross-Resistance in Group 10 Miticides



Acknowledgments

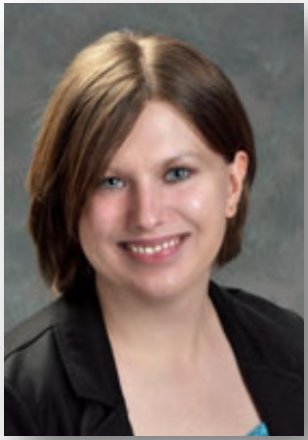
Deepest thanks to the organizations who sponsored this research, and the people who helped make it happen

WASHINGTON TREE FRUIT RESEARCH COMMISSION

USDA NIFA

Crew of 2017

L to R, back: Chris Sater, Peter Smytheman, Bruce Greenfield, Jim Hepler, Josh Milnes, Adrian Marshall, Louie Nottingham, Molly Darr
Front: Thomas Smytheman, Brooklyn xxxxx, Allie xxxx, CJ Squires, Kayla xxxx, Betsy



Rebecca Schmidt-Jeffris

Luis Martinez-Rocha

Dario Fernandez

Lessando Gontijo

Peter Smytheman

Bruce Greenfield

Chris Sater

Key Influencers

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Stan Hoyt
Jay Brunner
Everett Burts
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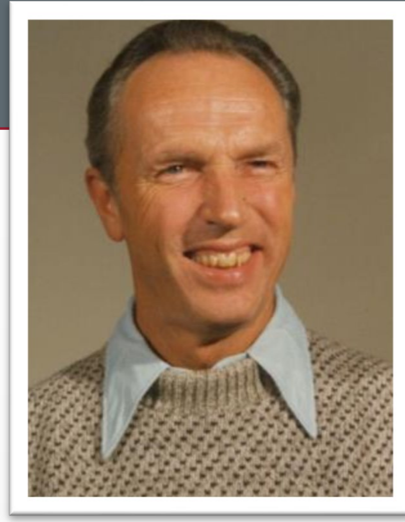

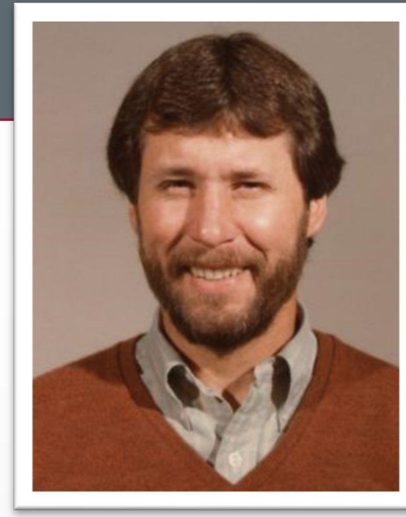

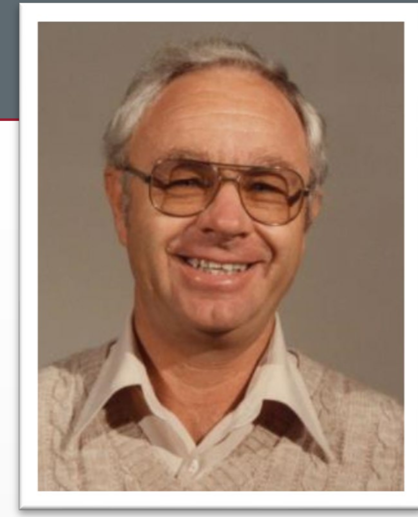

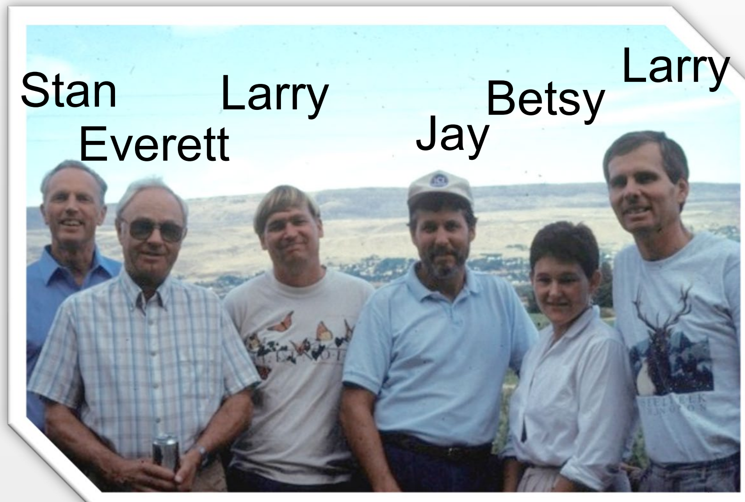

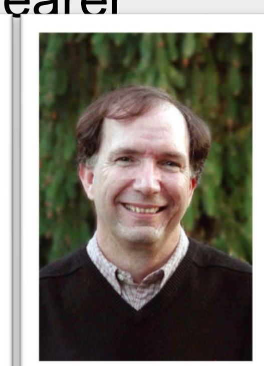

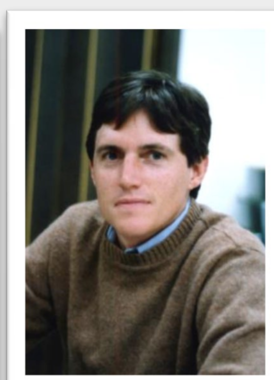

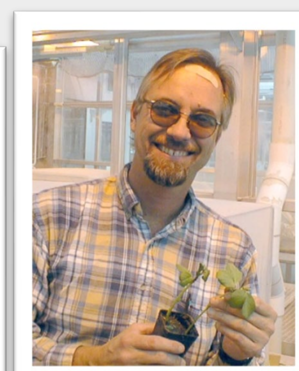

Take Home Messages

"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