

How to Conserve Biocontrol Agents w/ the Use of Selective Insecticides and Tactics

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Penn State University





Brown Marmorated Stink Bug
2010

U.S. Apple - \$37 M loss in apple alone

Stink bug injuries on apples occurred during late summer



Codling Moth/OFM Injury



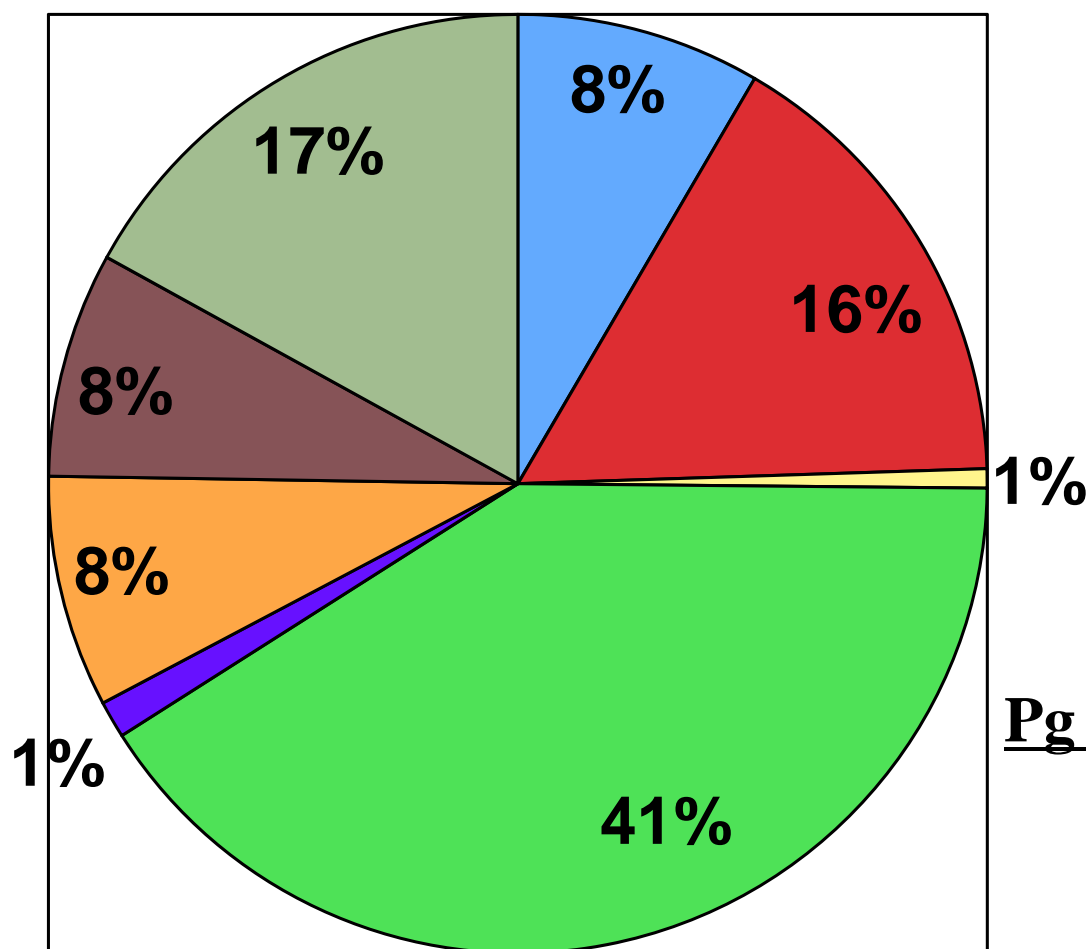
D. Biddinger








THE GOOD, THE BAD, & THE UGLY BUGS

- 50+ pests of apple
- Low tolerance for fruit injury
- Broadspectrum insecticides less risky to growers
- Less need to monitor pests



Fresh Market Apple Production Budgets for High Density (900 trees/A) Orchards



-  Insecticides
-  Fungicides
-  Herbicides
-  Labor
-  Fertilizer
-  Plant Growth Regulators
-  Fuel & Tractor

Pg 294

Another Major Threat to the Organophosphate Insecticides



Resistance*



CM



OFM



TABM



OBLR

*Documented resistance to OPs in Pennsylvania

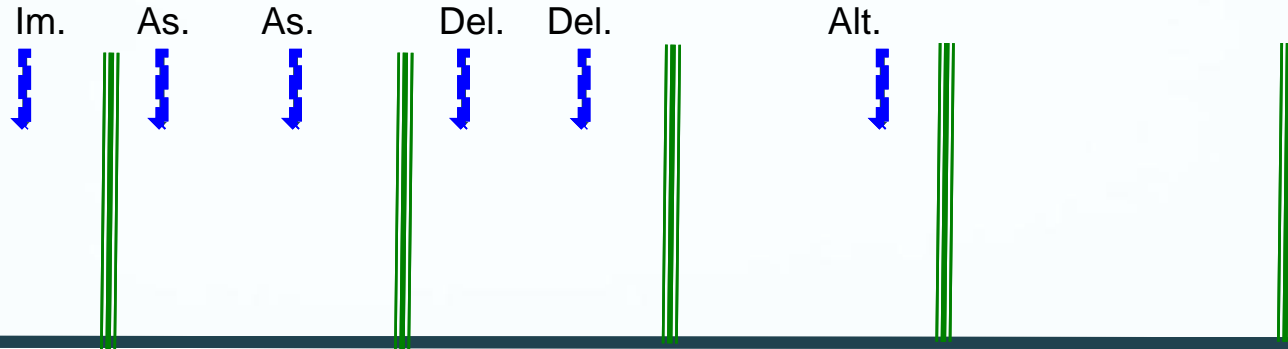


Seasonal insecticide applications; apple

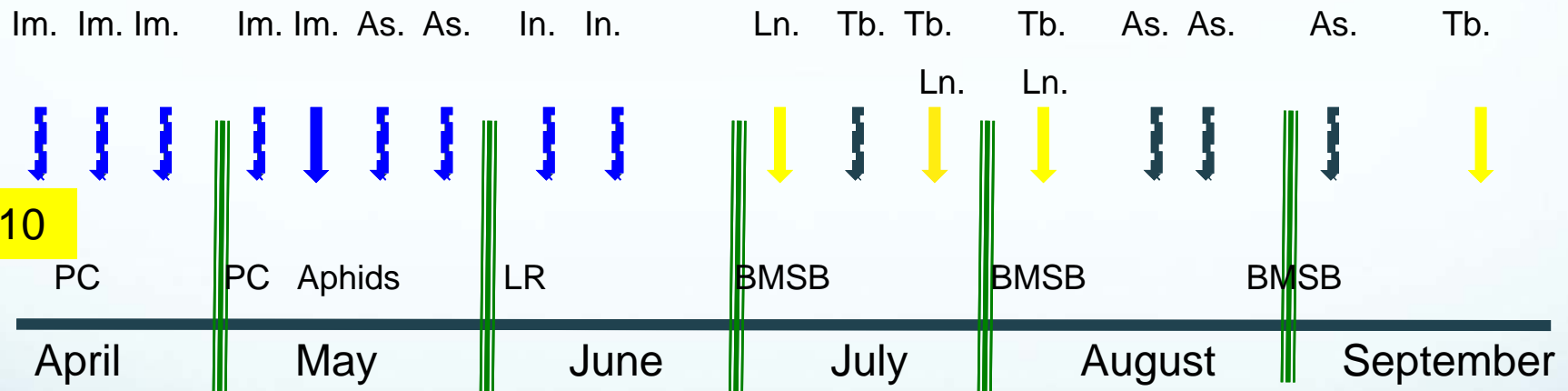
Grower 1. Lancaster County, PA



2009



2010



- ↓ BMSB - Complete spray
- ↓ BMSB - ARM spray
- ↓ Other pests - ARM spray

Insecticides:

Im. - phosmet; As. - acetamiprid; In. - methoxyfenozide;
Ln. - methomyl; Tb. - cyfluthrin; Del - spinetoram;
Alt. - rynaxypyr

F = Food
Q = Quality
P = Protection
A = Act



OR



F = Frequent
Q = Questions about
P = Pests without
A = Answers

Integrated Pest Management

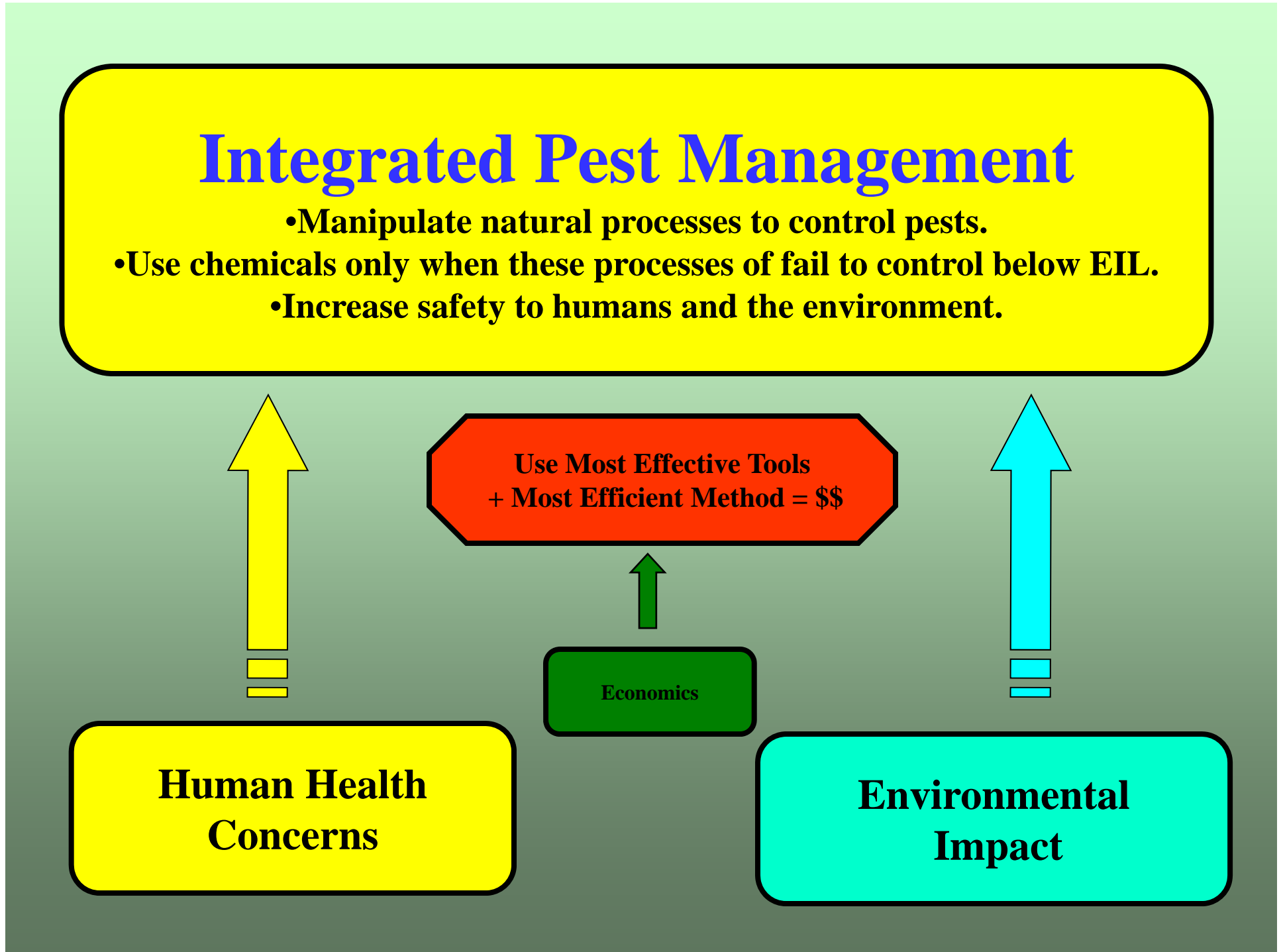
- Manipulate natural processes to control pests.
- Use chemicals only when these processes fail to control below EIL.
- Increase safety to humans and the environment.

Use Most Effective Tools
+ Most Efficient Method = \$\$

Economics

Human Health
Concerns

Environmental
Impact



The Impact of Neonicotinoid Insecticides On Pollinators in Tree Fruit IPM Programs

**D. Biddinger, C. Mullin, E. Rajotte, J. Frazier, N. Joshi,
M. Otieno, J. Chen & M. Frazier - Penn State University**

J. Robertson – USDA-Forest Service (ret.)

R. Donovall – Pennsylvania Dept. of Agric.

Mace Vaughn – Xerces Society



B. Hollabaugh

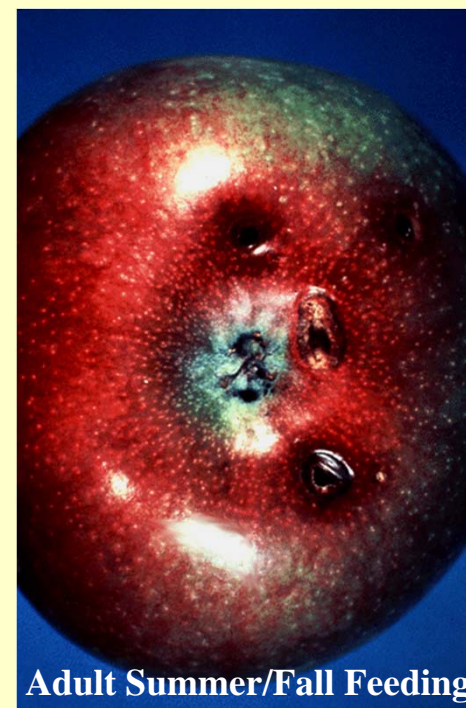
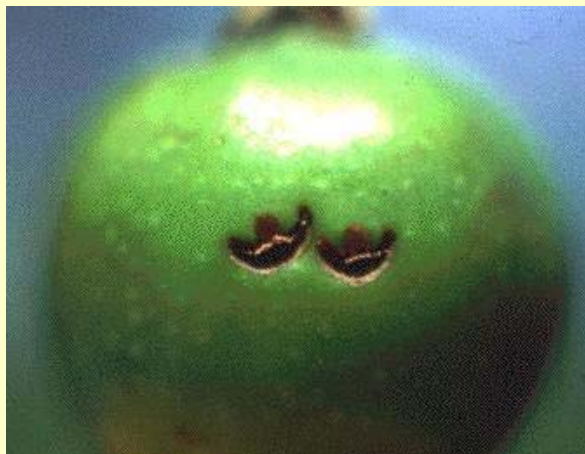


Rosy Apple Aphid

- Lorsban/pyrethroid resistance
- Control at pink w/ neonicotinoid.
- PF spray too late

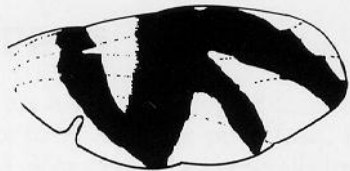


Plum Curculio

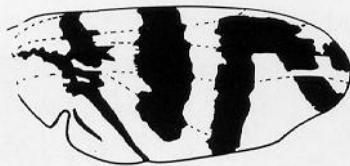


Adult Summer/Fall Feeding

Apple Maggot



APPLE MAGGOT AND BLUEBERRY MAGGOT FLY



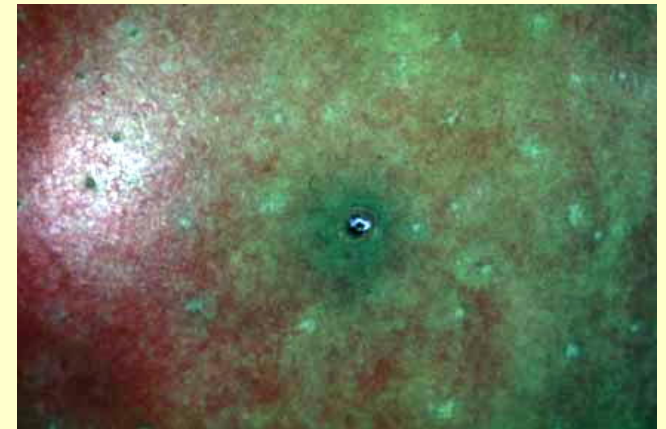
CHERRY FRUIT FLY



WALNUT HUSK FLY



UC Statewide IPM Project
© 2000 Regents, University of California



UC Statewide IPM Project
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**Reductions in
OP & Neonicotinoid Use?**

Drops left on ground.

2007-2013 Orchard Bee Survey

4,000 species in North America
~ 450 in Pennsylvania
~180 in Pennsylvania orchards
40-50 visiting apple bloom in NY & PA

Carpenter bee - male
Xylocopa virginica
Family: Apidae



Lifestyle: solitary
Food: pollen & nectar
Nest: tunnels in dead wood

by Alex Sanchez

Green metallic bee - male
Agapostemon sp.
Family: Halictidae



Lifestyle: solitary
Food: pollen & nectar
Nest: burrows in soil

by Alex Sanchez

Green metallic sweat bee - female
Augochlora pura
Family: Halictidae



Lifestyle: solitary
Food: pollen & nectar
Nest: burrows in soft, rotten wood

by Alex Sanchez

Sweat bee - female
Lasiglossum zephyrum
Family: Halictidae



Lifestyle: solitary
Food: pollen & nectar
Nest: burrows in soil

by Alex Sanchez

Sweat bee - female
Halictus ligatus
Family: Halictidae



Lifestyle: solitary
Food: pollen & nectar
Nest: burrows in soil

by Alex Sanchez

Small carpenter bee - male
Ceratina sp.
Family: Apidae

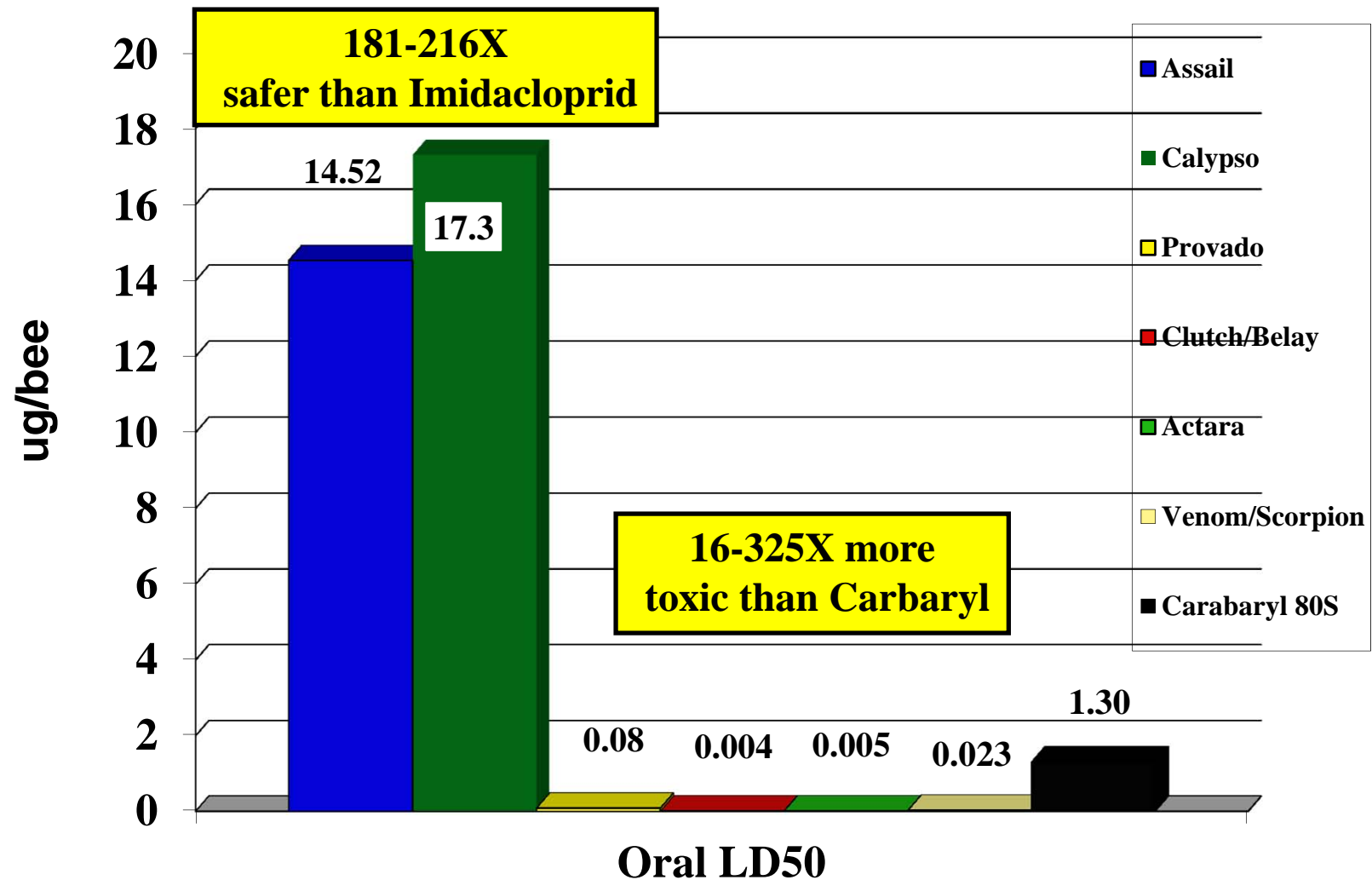


Lifestyle: solitary
Food: pollen & nectar
Nest: hollow stems

by Alex Sanchez



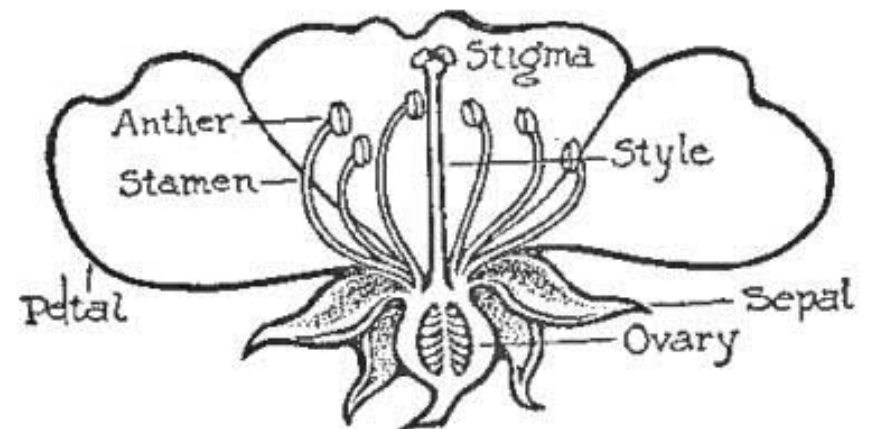
Neonicotinoid Toxicity To Honey Bees



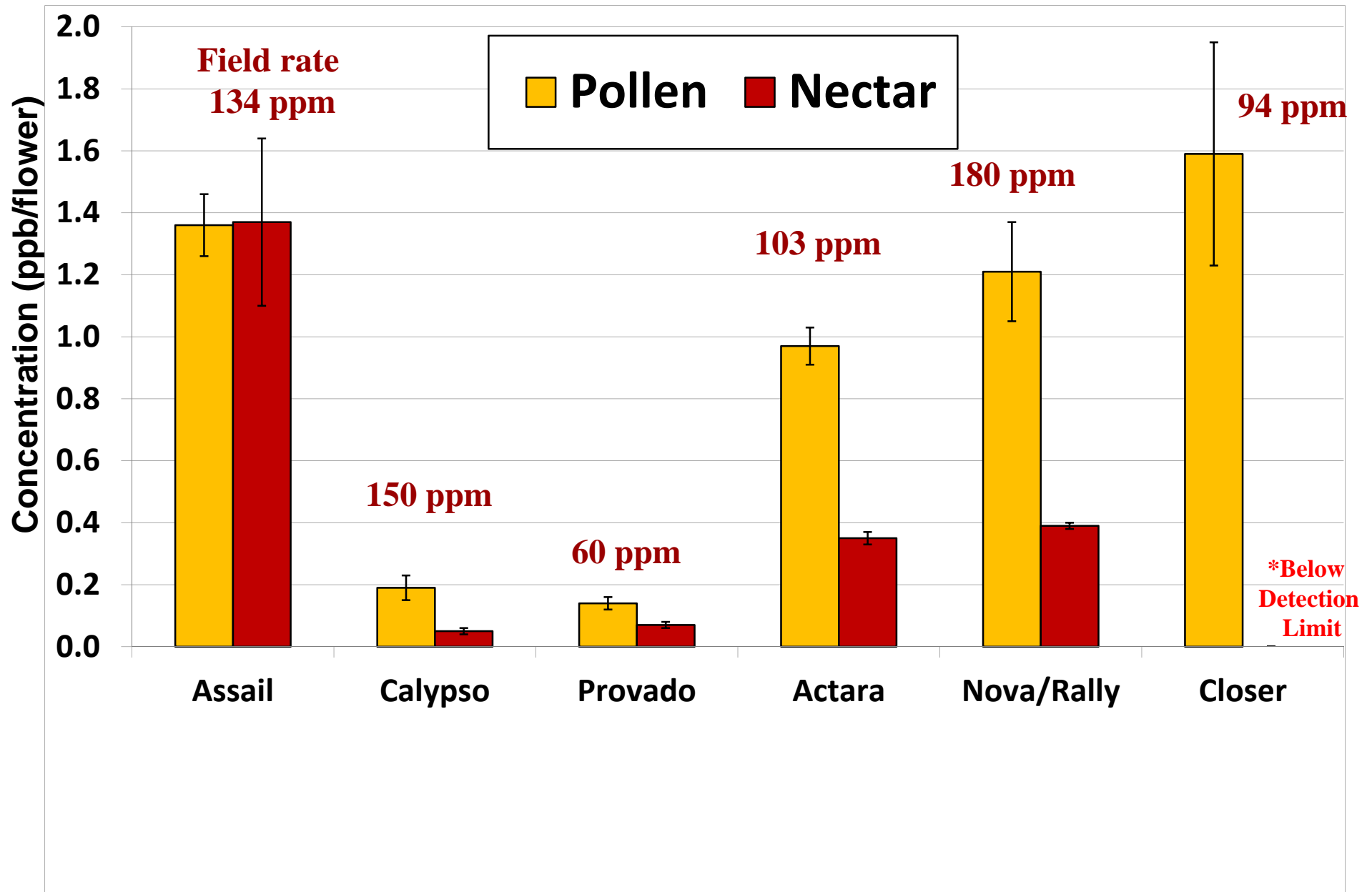
*Values from Hopwood et al. 2012



- 6 treatments, replicated 5 times
- applied at pink
- 50 flowers/tree
 - Collected whole flowers before & after application
 - nectar in 1 microliter pipettes
 - pollen with eyebrow combs



Pesticide Residue Level in Apple Pollen & Nectar



PREDATORS



PARASITOIDS



Ascogaster quadridentata

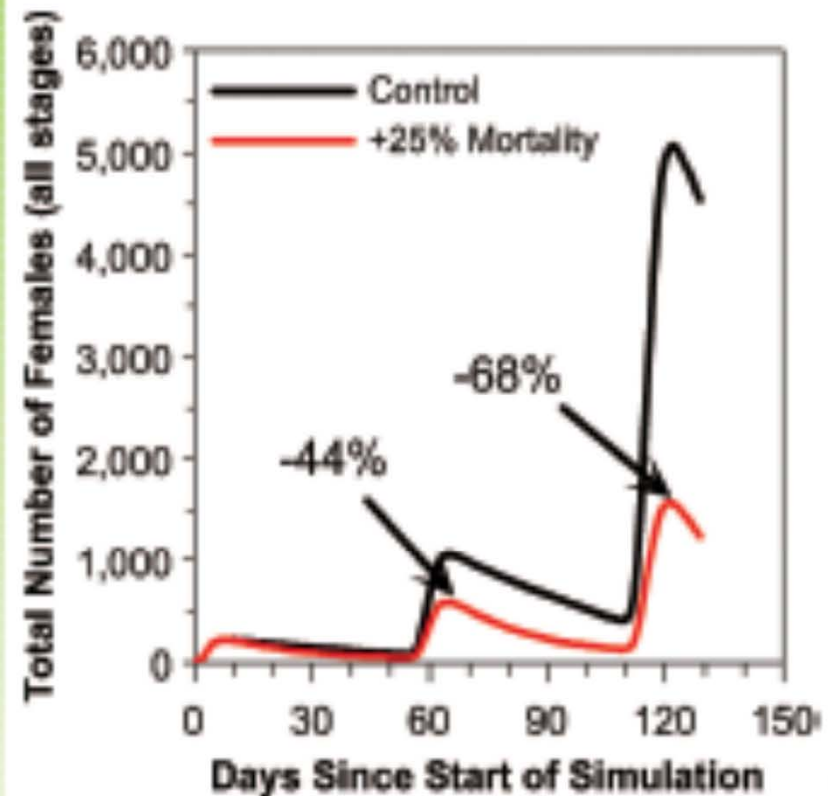


FIGURE 1 The effect of low levels of mortality on population growth

The population model is started using 16 fertile female codling moths. We ran the model twice, the first time using mortality rates observed in the laboratory (the control) and the second time using the same mortality rates but with an additional 25 percent mortality at the larval stage, to simulate natural-enemy induced mortality. We then plotted the size of the control population and the one with the additional larval mortality.

Both populations increase rapidly, but the one with 25% mortality added increases slower than the control population. After a single generation, there are 44% fewer individuals in the population and after two generations 68% fewer in the 25% mortality treatment compared with the control.

The effect in each generation is the result of not only killing the additional 25% of larvae, but also eliminating all the progeny of those individuals. Another way to think of this is that the additional mortality acts similarly to compound interest in a savings account. As the savings grow because of interest paid, the greater the interest earned the following period.



* V. Jones, T. Unruh, D. Horton, & J. Brunner. Improving Apple IPM. Good Fruit Grower. Dec. 2006.

Conservation of Biological Control Agents of Secondary Pest To Prevent Outbreaks

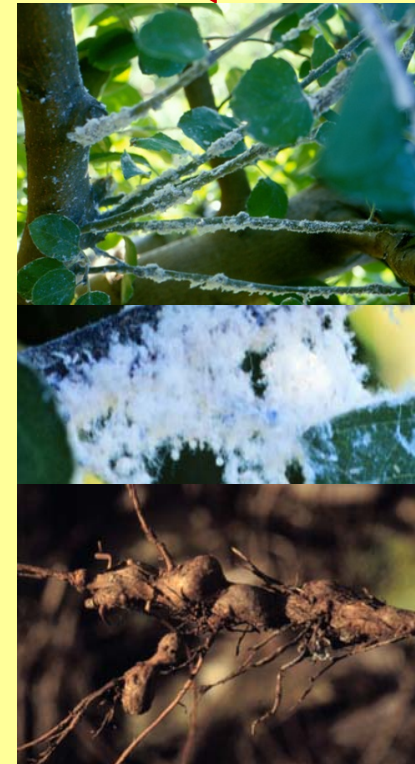
15+ pyrethroids, + Lannate use



European red mite



San Jose scale



Woolly apple aphid

PA Biological Control – **NO Pyrethroids**

Green Lacewing Larva



Stethorus punctum



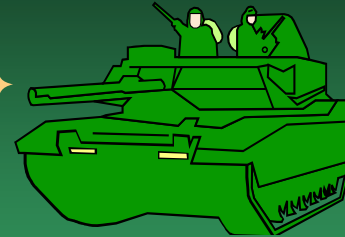
Typhlodromus pyri



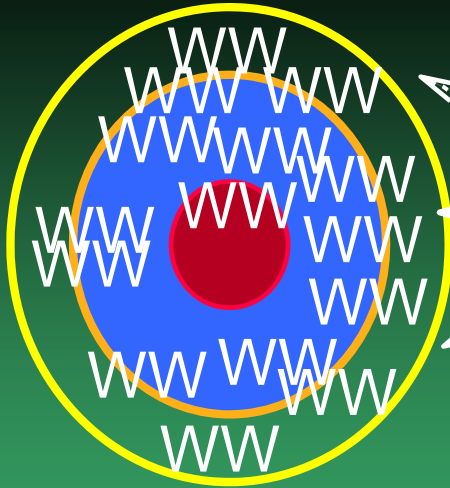
**Woolly Apple
Aphid Parasitoid
*Aphelinus mali***



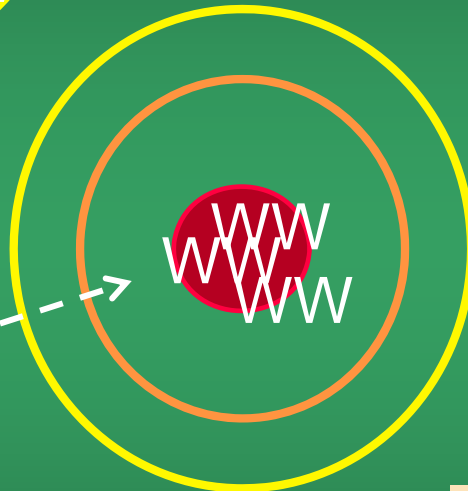
**Broad-spectrum
Insecticides**



**OPs,
Carbamates
Pyrethroids
Neonicotinoids?**



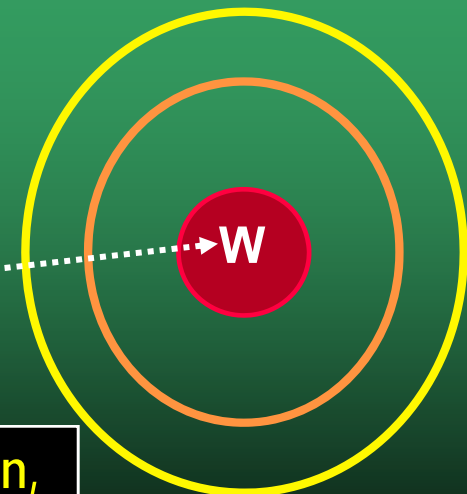
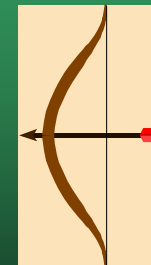
Higher Cost



**Reduced
Risk**

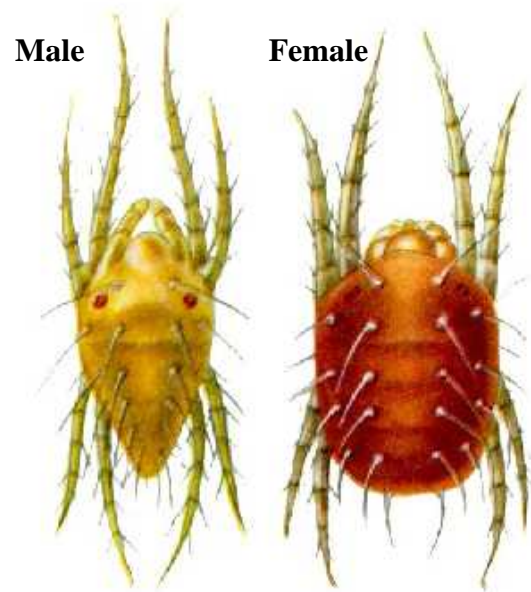


**Avaunt, IGR's
Assail, Bts etc.**

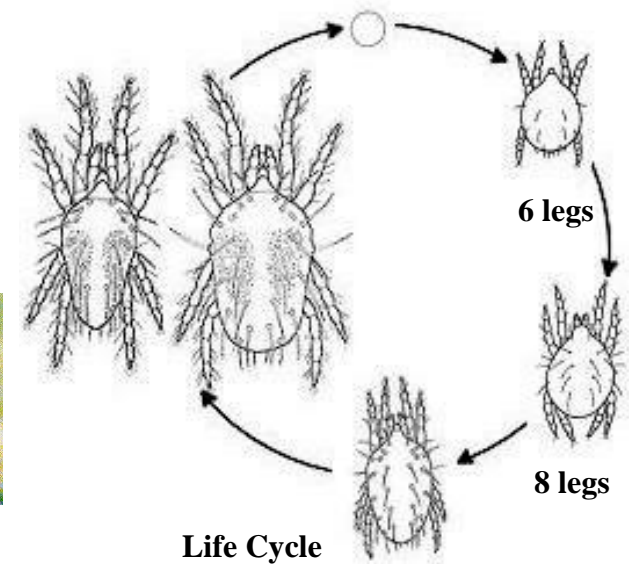
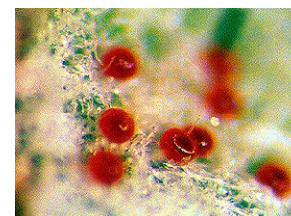
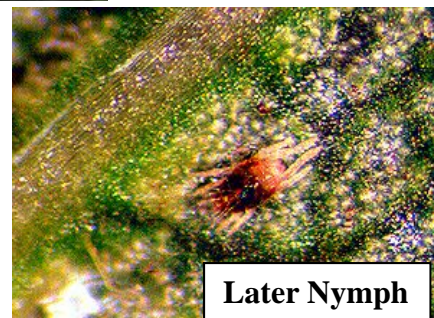
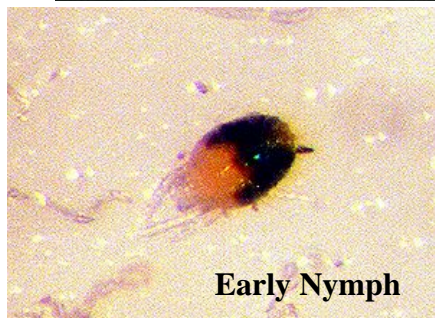
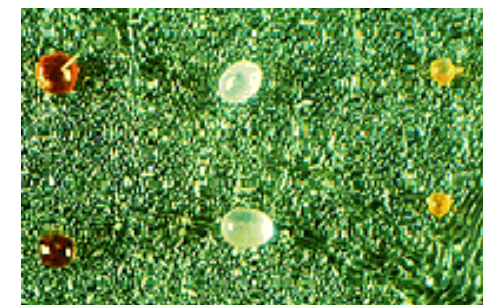
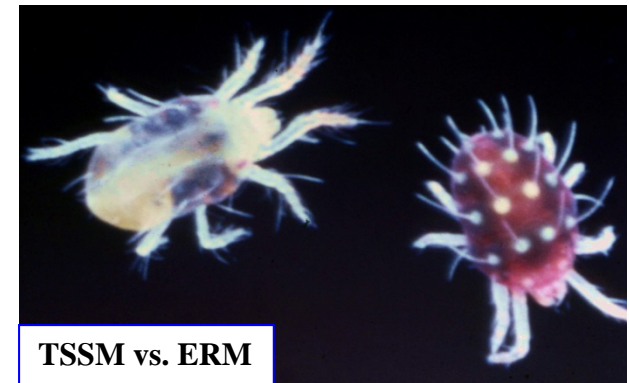


**W = Species of
insect killed.**

**Mating Disruption,
Codling Moth Virus**



European Red Mite

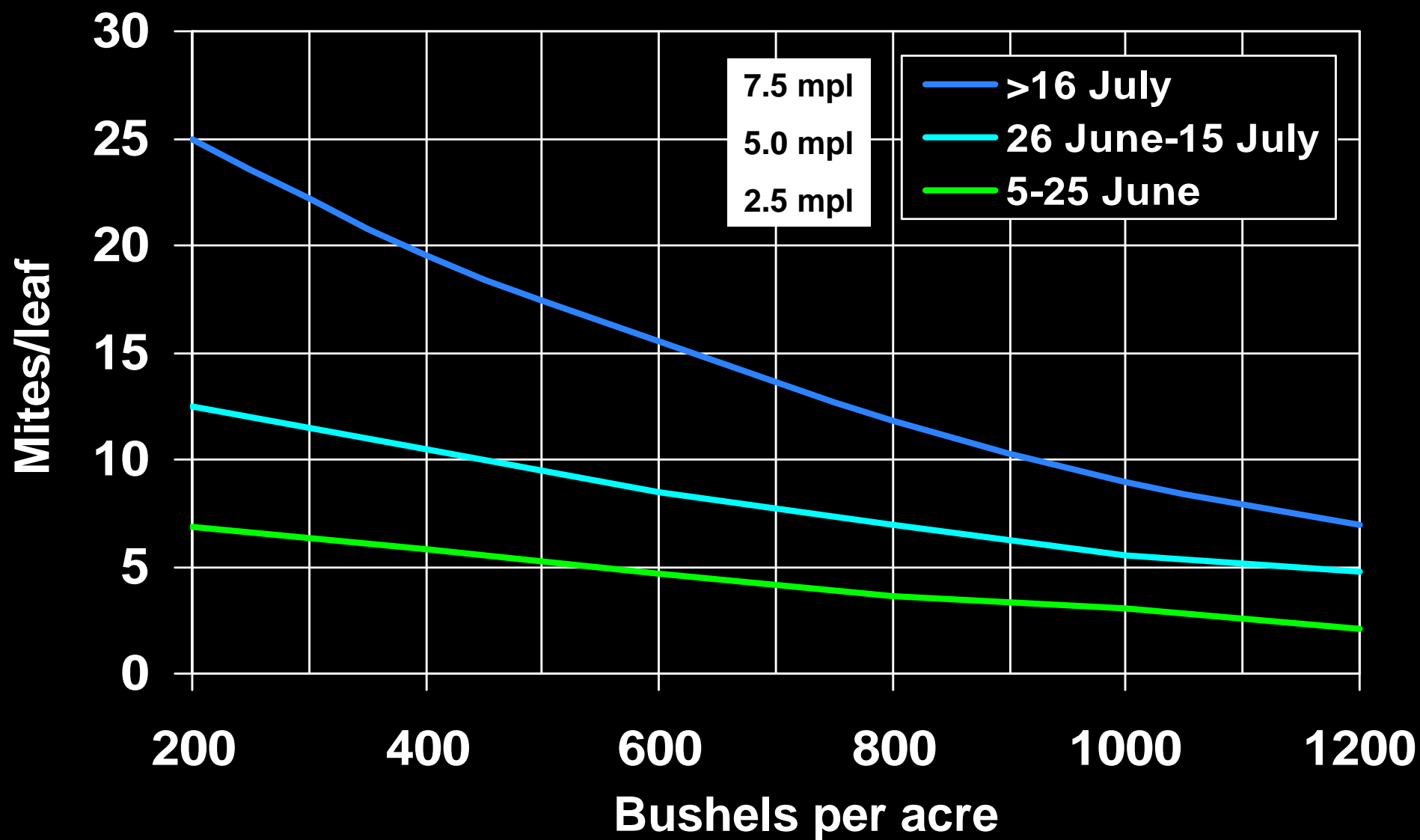


European Red Mite & Two-spotted Spider Mites



- **Bronzing** occurs at 20-30 mites/leaf depending on stress level of trees & time of year.
- **Can reduce fruit quality, color, and size and reduce return bloom the following season.**
- **Rapid development of resistance & high cost of miticides.**

Action Thresholds for Mites on Apple



Stethorus punctum

- Reduced miticide use by 50% in PA from late 1970s to mid 90s.
- Saved growers \$20 million over 15 year period.
- Reduced miticide use by over 2.2 million pounds.

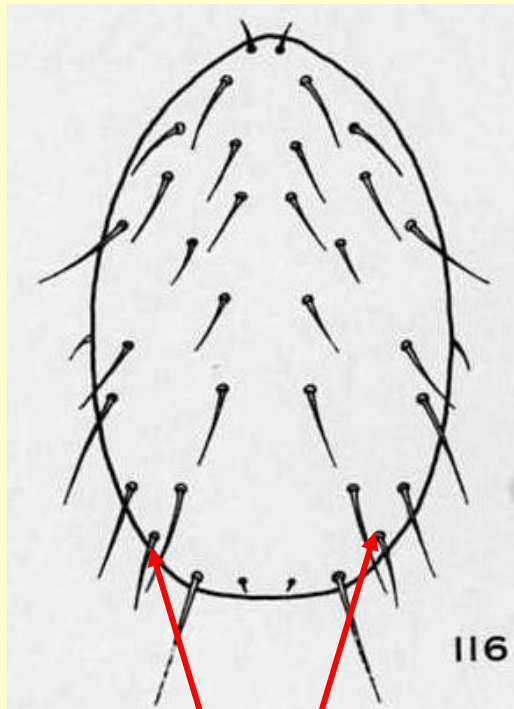




***Phytoseiid predator mites returned after Confirm/Intrepid replaced Lannate for leafroller control.**

Identification

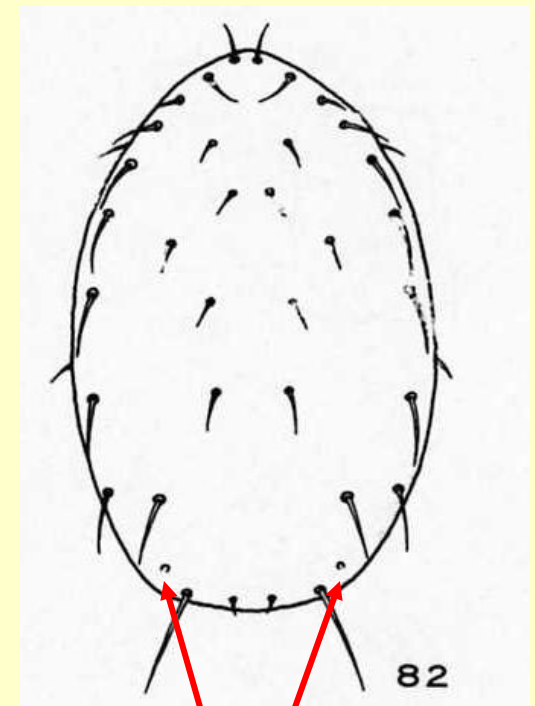
Neoseiulus fallacis



**Hairs
Present**



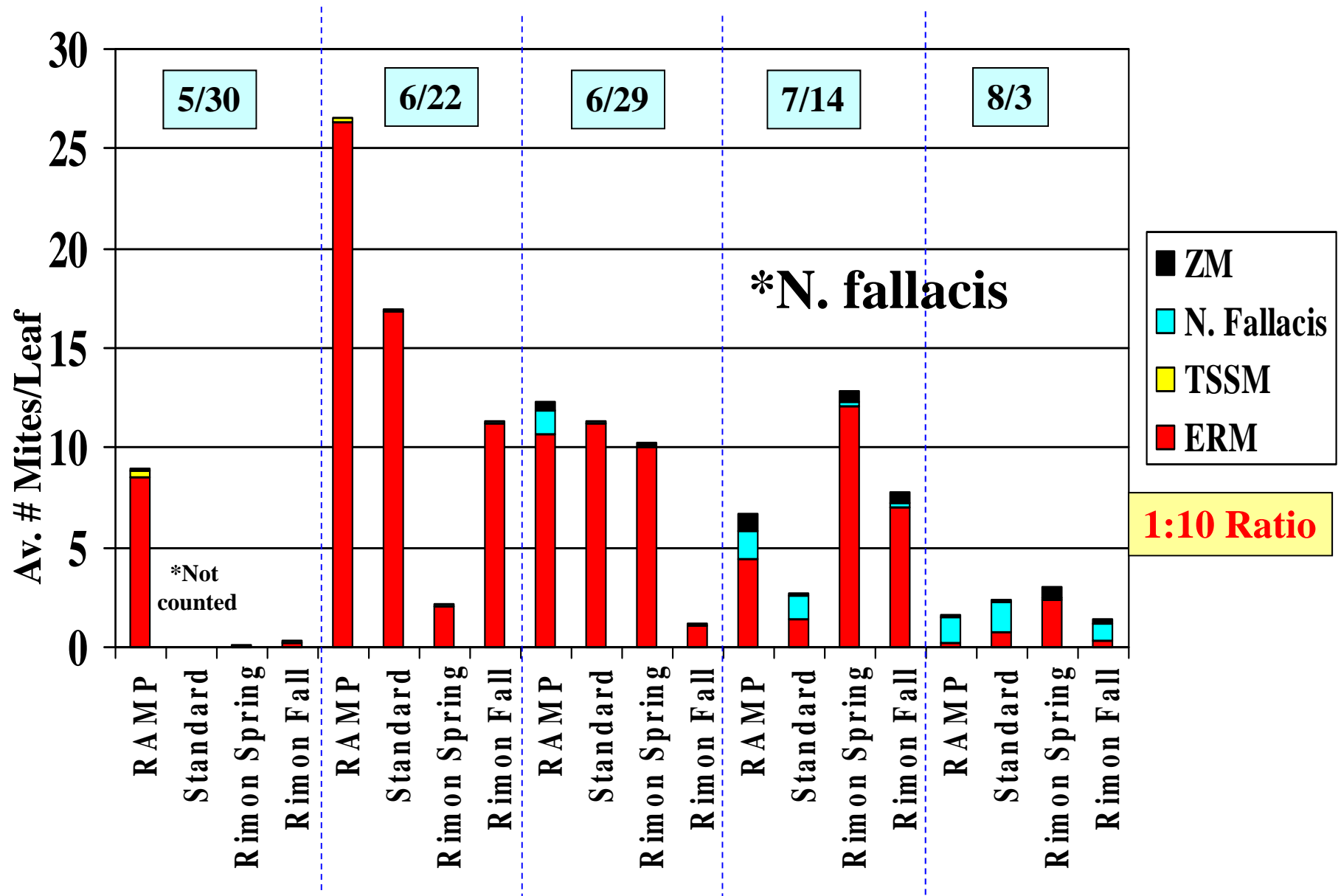
Typhlodromus pyri



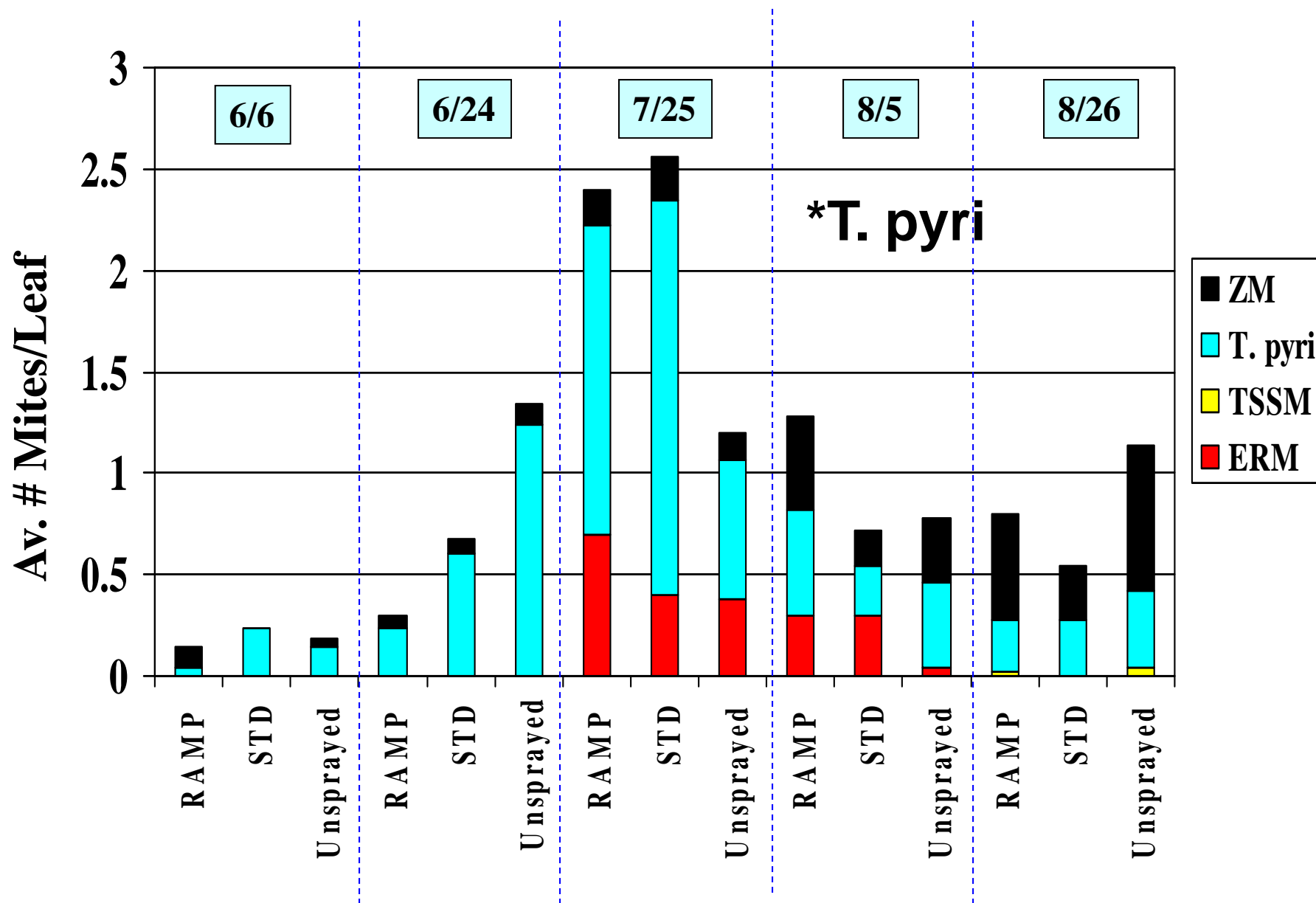
**Hairs
Missing**

*** 200X slide mounts
necessary for ID.**

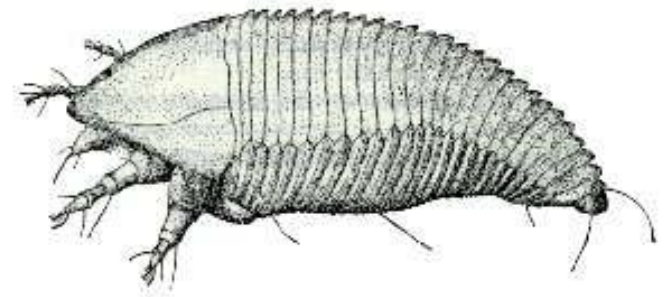
RAMP 2006 Mite Data – Grower #4



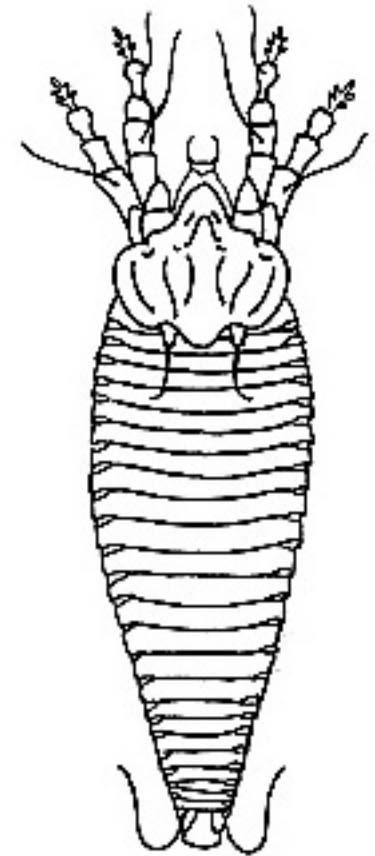
RAMP 2003 Mite Data – Lerew Orchards



Apple & Pear Rust Mites



Apple Rust Mite on Fruit



Pear Rust Mite



Apple Rust Mite

Pesticide Toxicity to *T. pyri*

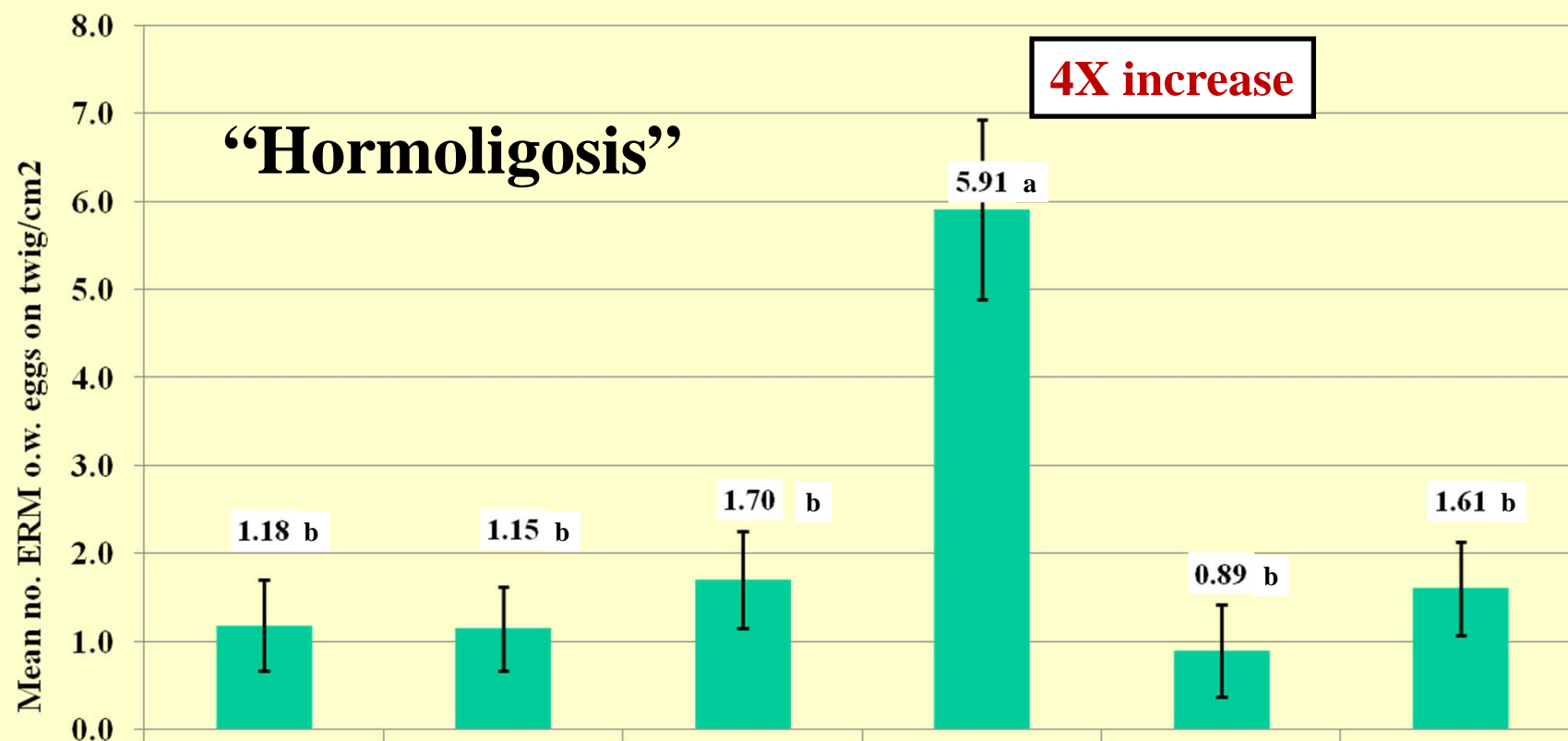
Highly Toxic

- **Pyrethroids**
 - Warrior, Asana, Danitol, Decis, Proaxis etc.
- **Carbamates**
 - Lannate, Vydate
 - hi rates of Sevin
- **Miticides**
 - Pyramite/Nexter, Portal, Fuji Mite
- **Lime-Sulphur**

Moderately Toxic

- **Fungicides**
 - Mancozeb
 - past bloom at 3 lb/A
 - past ½ in green at 6 lb/A
 - Benlate?
- **OPs – Lorsan after ½ in green**
- **Miticides**
 - Agrimek, Acramite, Vendex
 - Zeal after July 15
- **M-Pede, Endosulfan**

BMSB Summer Spray Trial - Overwintering ERM eggs 10 twigs/tree (5 reps)

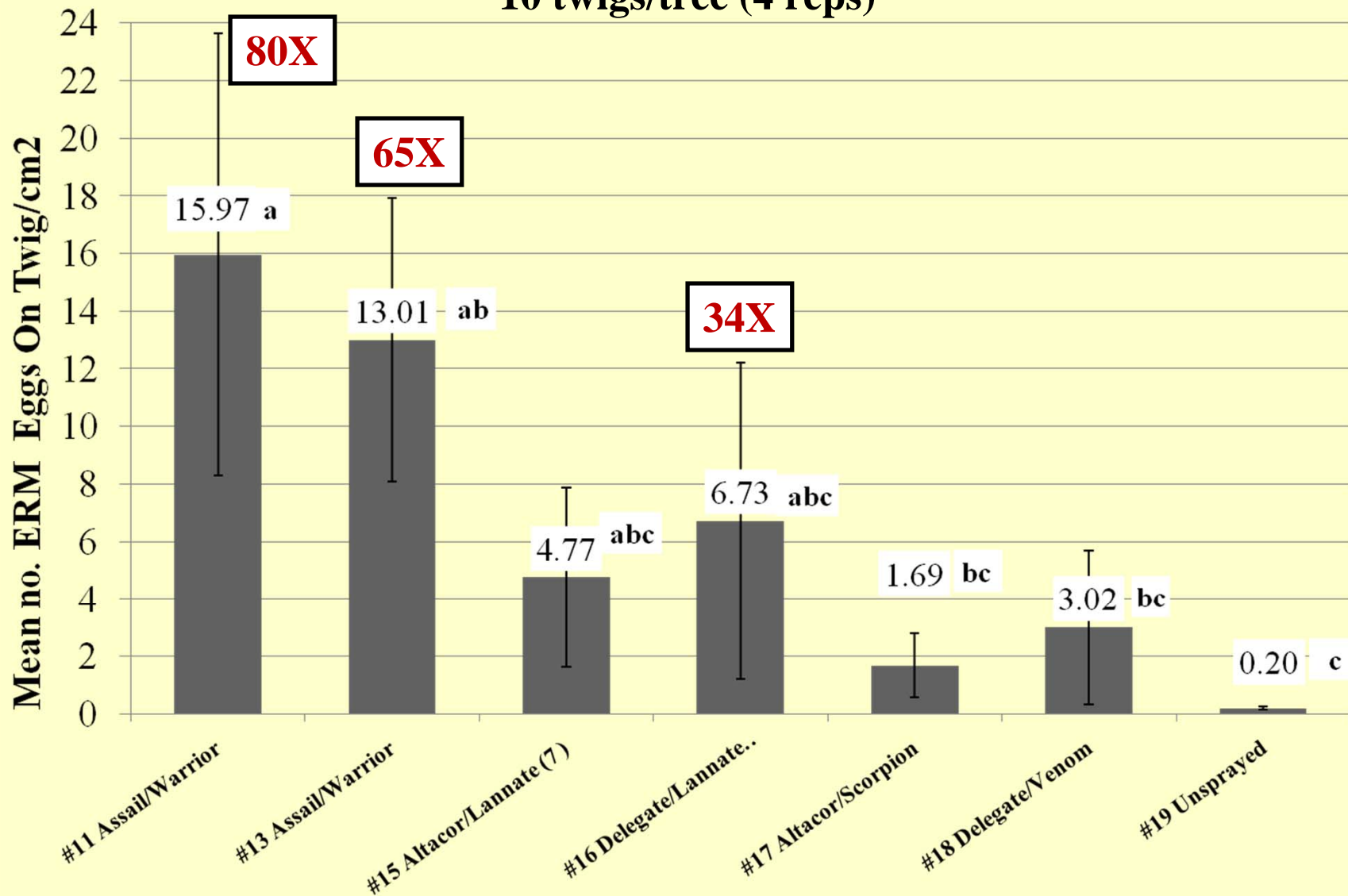


Trmt No.	10	11	12	13	14	15
Treatment	Lannate SP	Lannate SP	Thiodan	Warrior	Scorpion	Unsprayed
Rate/A	0.5 lb (227 g)	1 lb (454 g)	2 lb (907 g)	2.5 fl oz (74 ml)	5 fl oz (148 ml)	--
Rate g/10 gal	23 g	46 g	91 g	7 ml	15 ml	--
All treatments applied 31-Jul						

* Means followed by the same letter(s) are not significantly different (Fisher's Protected LSD, $P \leq 0.05$)

Raff Block Overwintering ERM Eggs

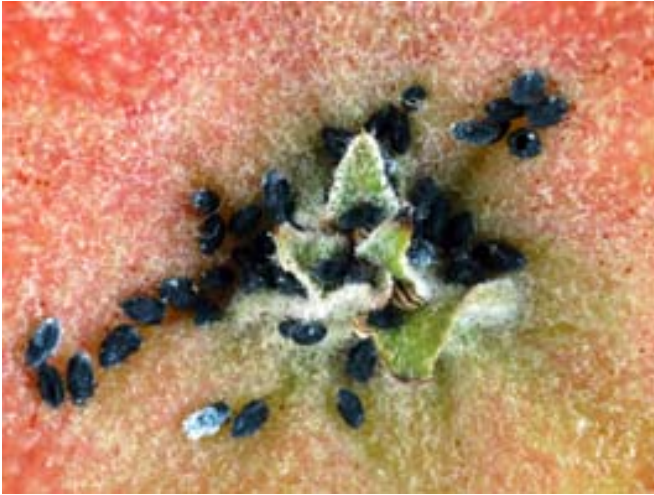
10 twigs/tree (4 reps)



* Means followed by the same letter(s) are not significantly different (Fisher's Protected LSD, $P \leq 0.05$)

D. J. Biddinger 2013

Woolly Apple Aphid



WAA Resistant Rootstocks

- Resistance in the Malling-Merton (MM) rootstocks developed from the resistant cultivar 'Northern Spy'.

• Some varieties are also resistant to WAA and slow the growth & reproductive rate which allows for better biological control.

Varieties most susceptible: Fuji, Rome, Greening, York, Ginger Gold

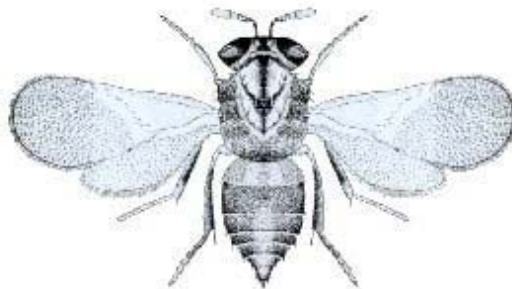
Least susceptible: Granny Smith, Yellow Delicious

Rootstock Rating for WAA

Very Susceptible	Susceptible	Moderately Susceptible	Resistant
M.9	M.7	G.11	MM.106
M.26	M.27	G.65	MM.111
Ottawa 3	MARK		MM.104
	G.16		CG.210
	G.30		CG.179
	P-Series		Bemali
	Bud-Series		Geneva 202



**Woolly Apple
Aphid Parasitoid**
Aphelinus mali



Syrphid Predators of WAA



Eupeodes americanus



Syrphus rectus

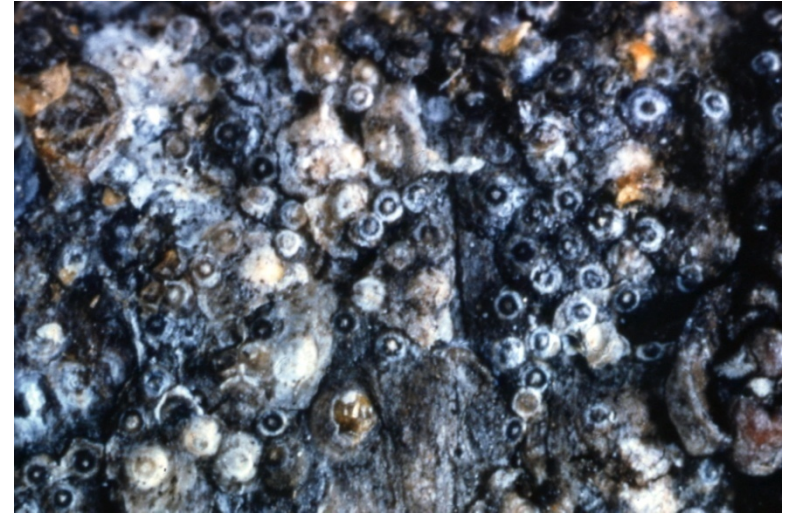
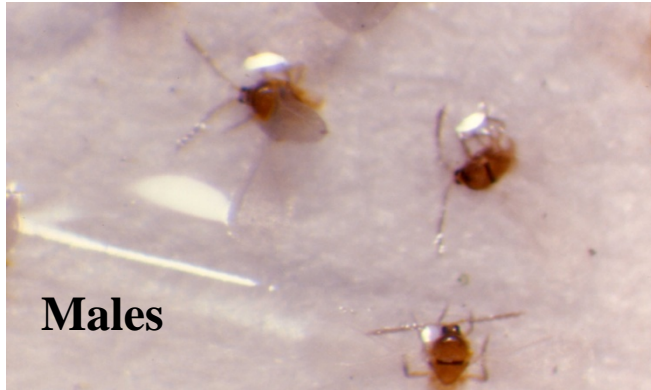


Heringia calcarata



San Jose Scale

- Multiple generations
 - Dormant oil
 - Summer generations



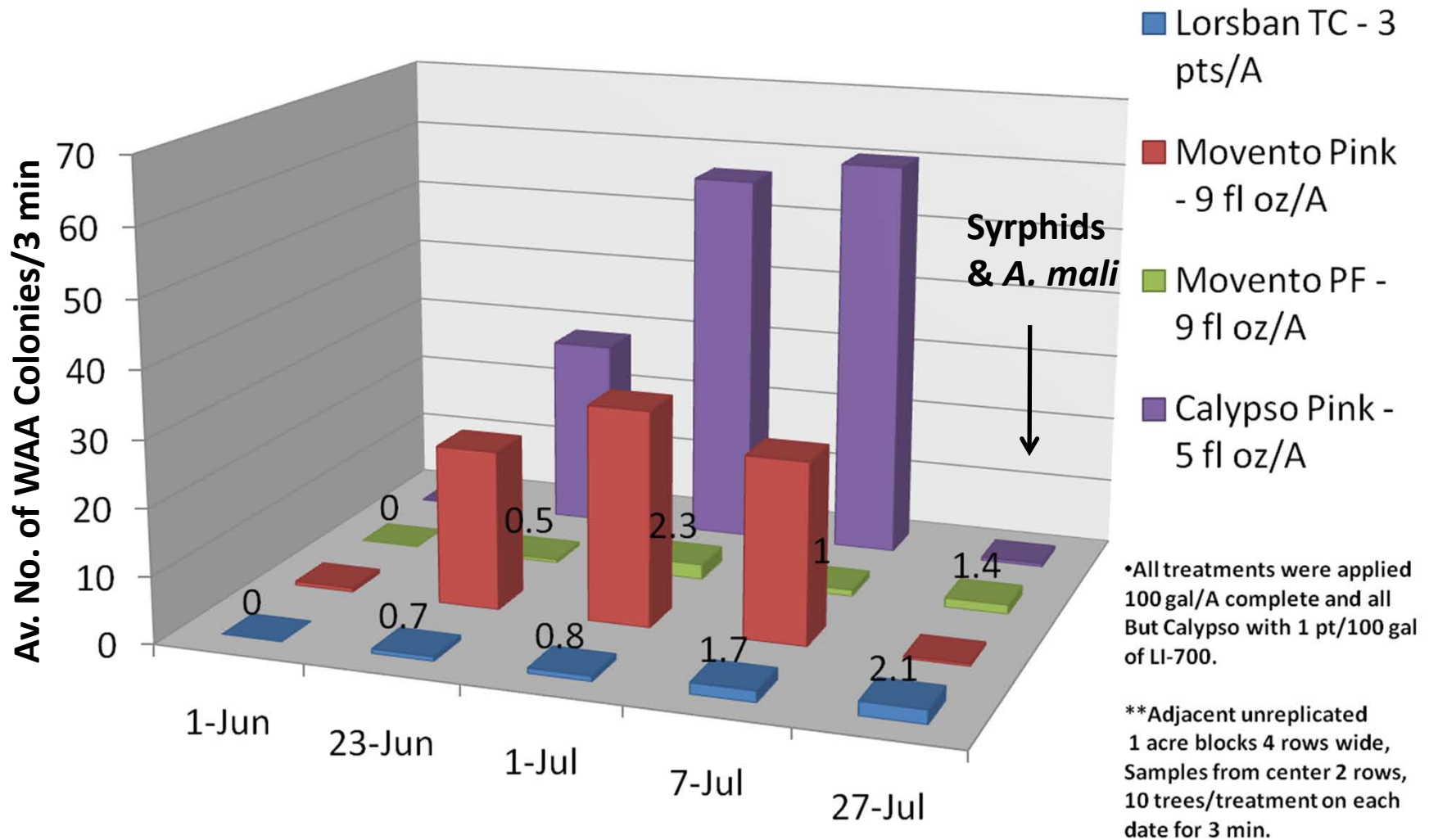


San Jose Scale Parasitoids



Early Season Preventative Sprays for WAA

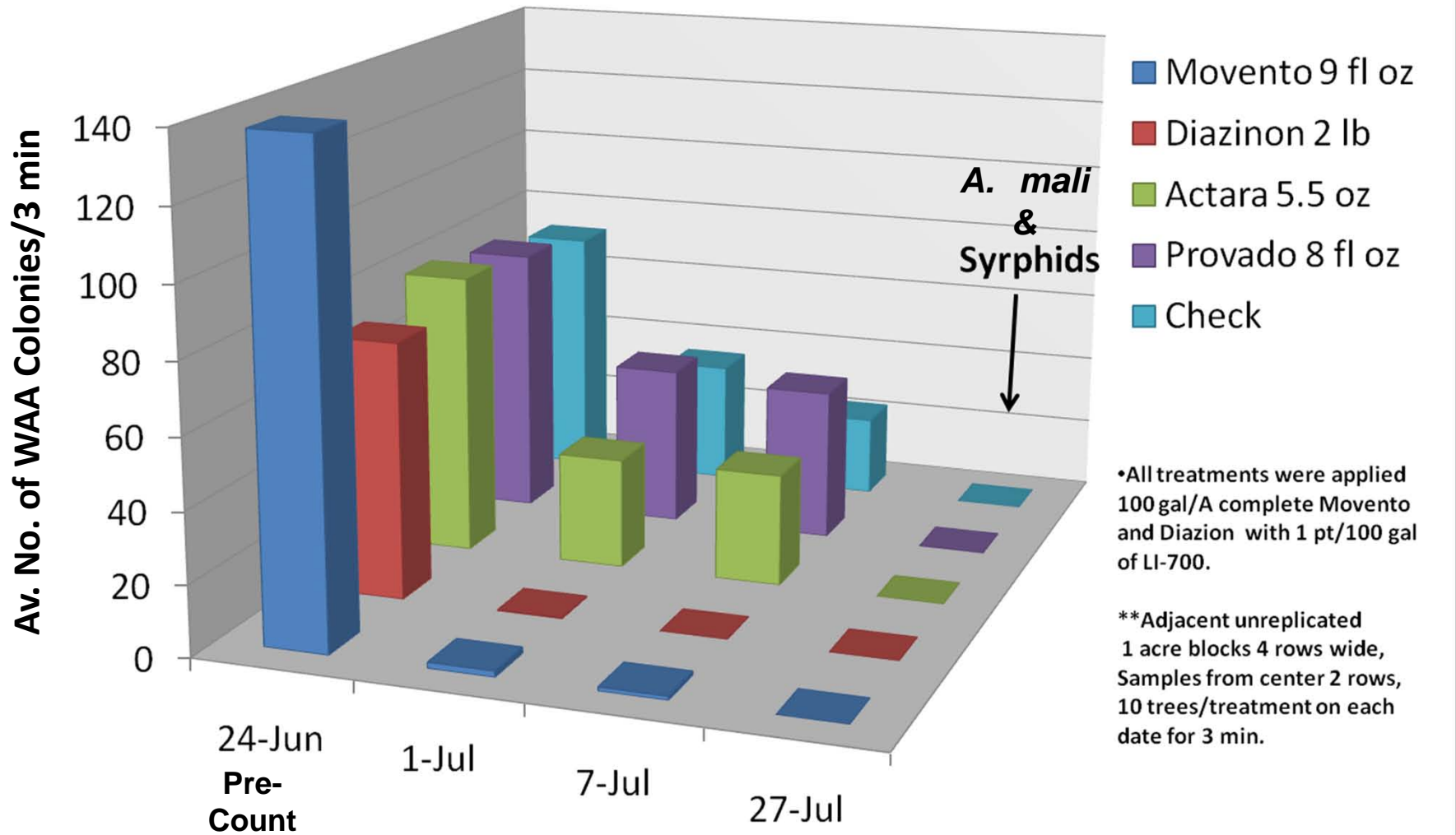
Lerew 2009 – Fuji on M7A



WAA Early Summer Control

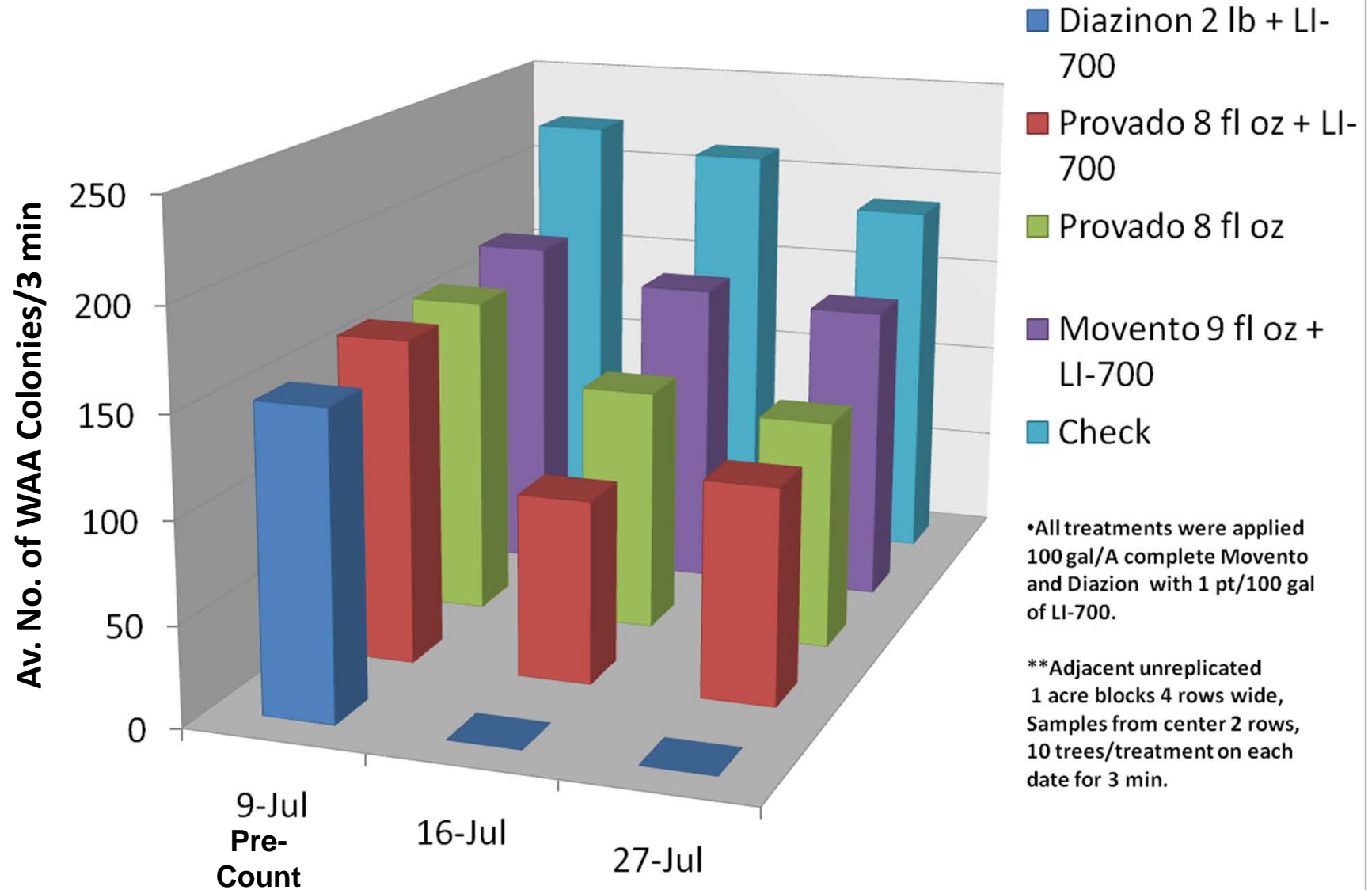
Lerew 2009 – Fuji on Ottawa 3

Resistance??



WAA Summer Control

Pulig Farm Greenings – Seedling 2009



A close-up photograph of a Brown Marmorated Stink Bug (Hemiptera: Pentatomidae) resting on a textured, brownish leaf. The bug's body is mottled with brown and tan spots. It has long, segmented antennae with distinct light and dark bands. The legs are also mottled. The background is solid black.

Brown Marmorated Stink
Bug 2010

Brown Marmorated Stink Bug

How we manage this pest?

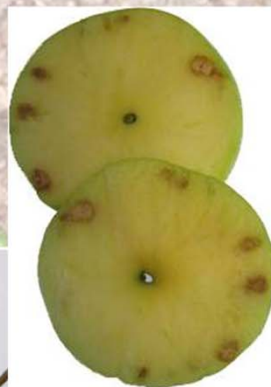


Effective chemicals to date:
Pyrethroids and Methomyl –
Toxicity of Dinotefuron to NE's?

40 + years of IPM



Photo by A. R. Biggs



BMSB monitoring attempts



Brown Marmorated SB (*Halyomorpha halys*) vs. Predatory SBs

DJB-2005



White bands on
antennae & legs,
white striping on
abdomen edges.
Pronotum smooth.



4,700 species
300 are predatory

Predator w/ no
White bands,
pronotum toothed.\



Generalist Predators



Sand Wasp Stink Bug Specialists

Alex Surcica



by Alex Surcică



Alex Surcică



Trichopoda sp.

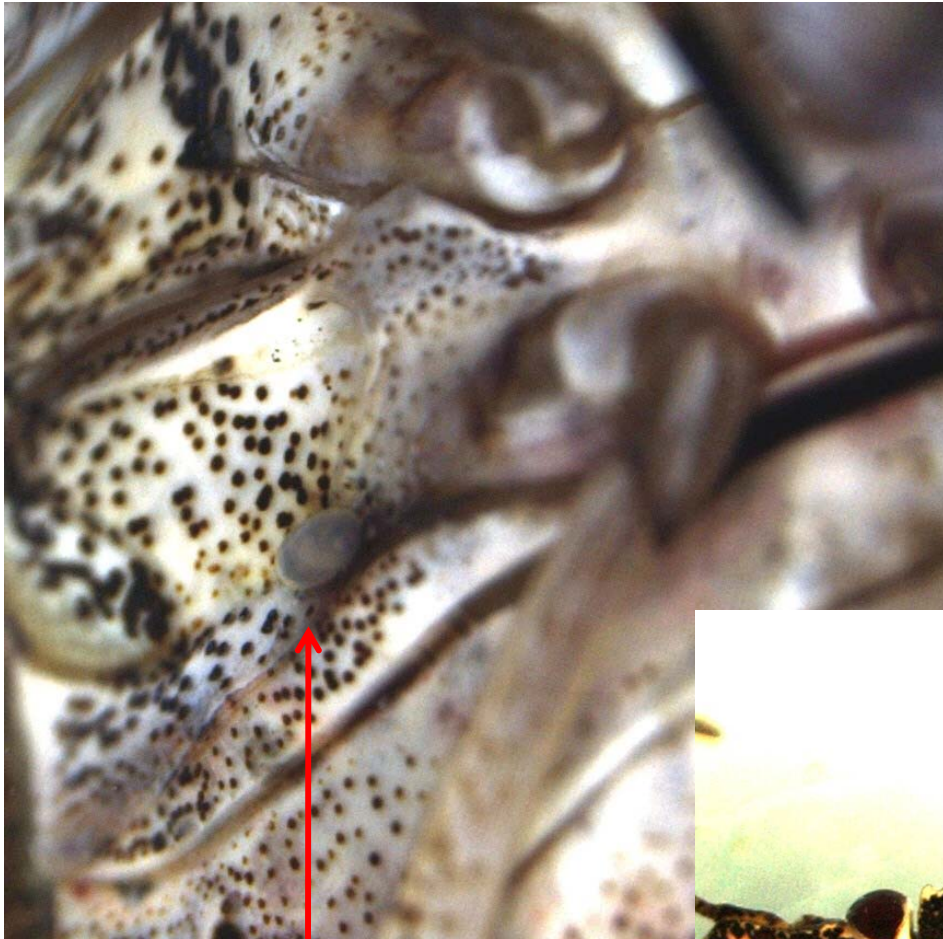


Gymnosoma sp.



Gymnoclytia sp.





Tachinid Egg

Tachinid Egg





Trissolcus basalis
Scelionidae



D Biddinger 2011



D Biddinger 2011

Conclusions

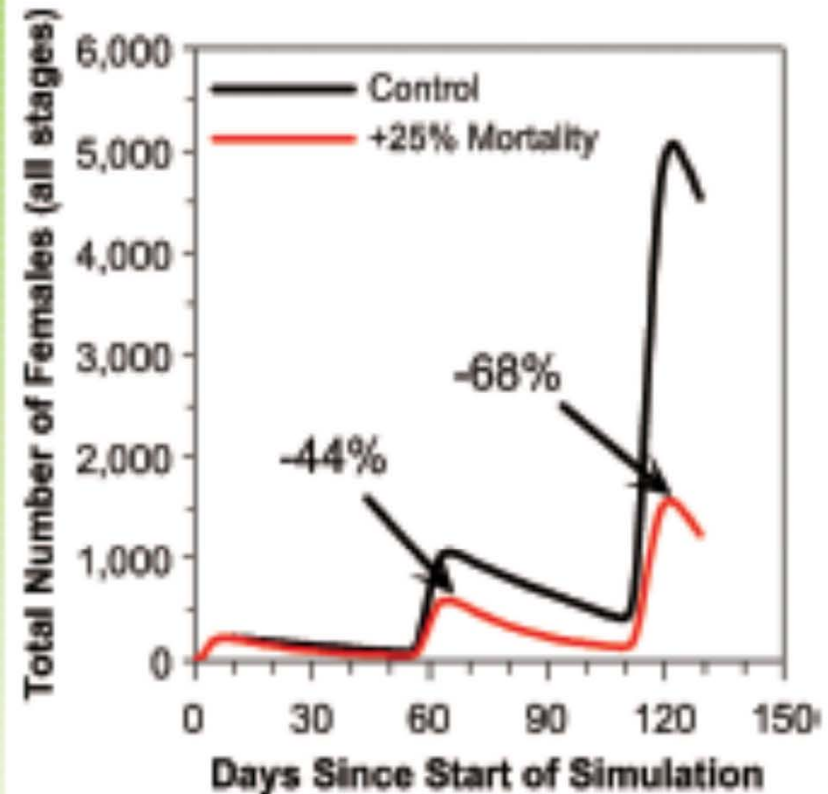
- Brown Marmorated SB will greatly impact our IPM programs in tree fruit if we revert to broadspectrum insecticides.
- **Best hope for long term population regulation is with biological control outside of orchards.**
- Need better monitoring methods to predict movement into orchards and when to spray.
- **Sprays to the borders of woods next to orchards for BMSB are off label, probably ineffective & could greatly impact native fruit pollinators.**

FIGURE 1 The effect of low levels of mortality on population growth

The population model is started using 16 fertile female codling moths. We ran the model twice, the first time using mortality rates observed in the laboratory (the control) and the second time using the same mortality rates but with an additional 25 percent mortality at the larval stage, to simulate natural-enemy induced mortality. We then plotted the size of the control population and the one with the additional larval mortality.

Both populations increase rapidly, but the one with 25% mortality added increases slower than the control population. After a single generation, there are 44% fewer individuals in the population and after two generations 68% fewer in the 25% mortality treatment compared with the control.

The effect in each generation is the result of not only killing the additional 25% of larvae, but also eliminating all the progeny of those individuals. Another way to think of this is that the additional mortality acts similarly to compound interest in a savings account. As the savings grow because of interest paid, the greater the interest earned the following period.



* V. Jones, T. Unruh, D. Horton, & J. Brunner. Improving Apple IPM. Good Fruit Grower. Dec. 2006.

Questions ?



Selective Insecticides/Miticides

Currently Registered on Tree Fruits

- Neonicitinoids
 - Actara
 - Assail
 - Calypso
 - Belay/Clutch
 - Provado
 - Scorpion/Venom
- IGRS
 - Confirm -> Intrepid
 - Esteem
 - Rimon
 - Centaur
- Bacillus thuriengensis
- Cydia virus
- Miticides
 - Apollo/Savey
 - Nealta
 - Zeal
 - Envidor
 - AgriMek
- Neem Oil - Azadiractin
- Pheromones
 - CM, OFM, Borer Ties
 - Sprayable OFM
- Avaunt
- Spintor -> Delegate
- Altacor/Belt
- Movento