Investigating navel orangeworm (*Amyelois transitella*) resistance to pyrethroid insecticides through neonate and adult bioassays

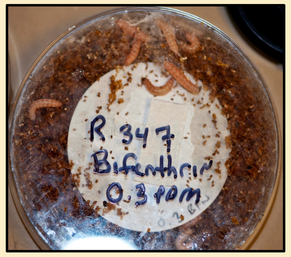
Mark Demkovich*, Joel Siegel† and May Berenbaum*
* Department of Entomology, University of Illinois at Urbana-Champaign
† USDA, Agricultural Research Service, Parlier, CA

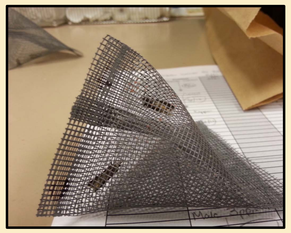
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Introduction

- Navel orangeworm resistance to pyrethroid insecticides was first reported at Paramount Farming Company (B. Higbee: personal communication) in June 2013.
- Previous research on the mechanism for resistance to pyrethroids concluded that overexpression of cytochrome P450 monooxygenase and carboxylesterase genes are likely responsible for a 10-fold difference in pyrethroid tolerance relative to a susceptible strain.[1]
- Removal of selection pressures exerted through insecticide use may result in pest populations regaining sensitivity.[2]

In these experiments, two sets of bioassays were conducted on a bifenthrin-resistant (R347) and a susceptible (CPQ) strain of navel orangeworm that focused on contact toxicity at the neonate and adult levels. Resistance to the pyrethroid insecticide bifenthrin was also tracked through 12 consecutive generations to determine if resistance in the R347 is stable in the absence of bifenthrin selection pressure.





Methods

- Insecticides were tested against a resistant colony of *A. transitella* (B. Higbee: Paramount Farming), which was maintained at conditions of 28 ± 4ºC in the absence of a light cycle.
- Filter papers were sprayed with bifenthrin at concentrations of 0.3 ppm, 3 ppm, 30 ppm, and 300 ppm using a spray tower.
- Eggs from the resistant (F_{11}/F_{12}) and susceptible strains were placed on sprayed filtered papers and assessed for survivorship after 14 days.
- Adults were separated by strain and sex, placed into mesh bags, and sprayed at concentrations of 0 ppm and 3 ppm. Survivorship was recorded after 48 hours. F_{12} adults were used in R347.
- PROBIT analyses were conducted to determine the median lethal concentrations that would kill 50% of the sample population at 48 hours (LC_{50}) across successive generations.
- Data were analyzed with dummy-variable regression, using JMP Pro Version 10 (SAS Institute, Cary NC).

Results

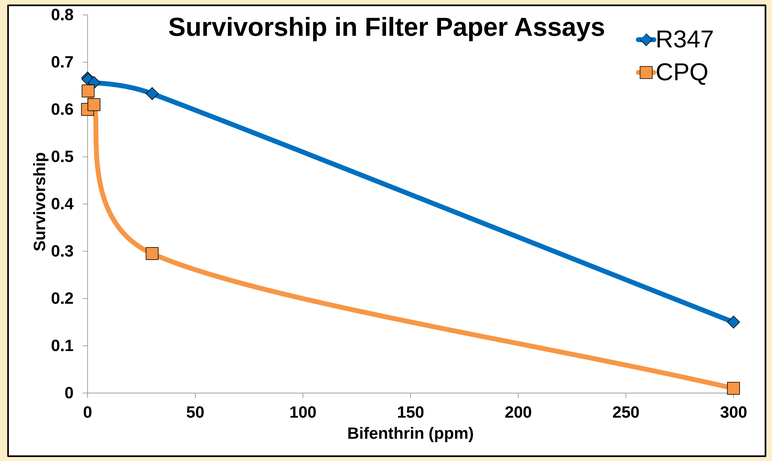


Figure 1. Navel orangeworm survival 14 days after eggs were placed on filter papers sprayed with bifenthrin at 0 ppm, 3 ppm, 30 ppm, and 300 ppm in a resistant colony (R347) and a susceptible colony (CPQ).

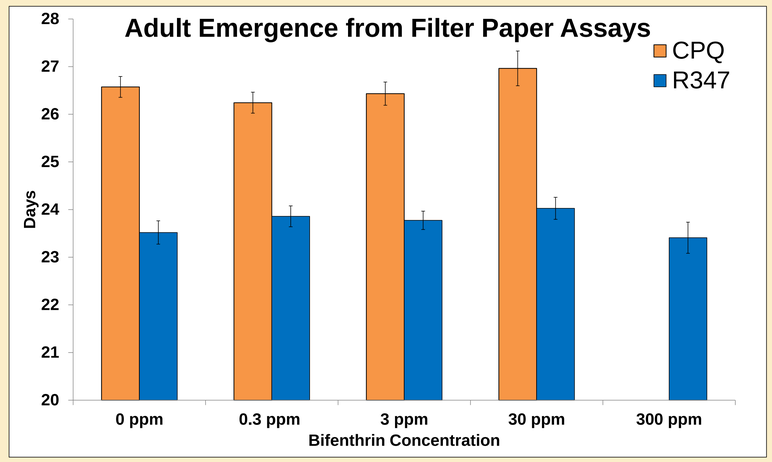


Figure 2. Navel orangeworm days to adult emergence from survivors of bifenthrin filter paper assays in a resistant colony (R347) and susceptible colony (CPQ).

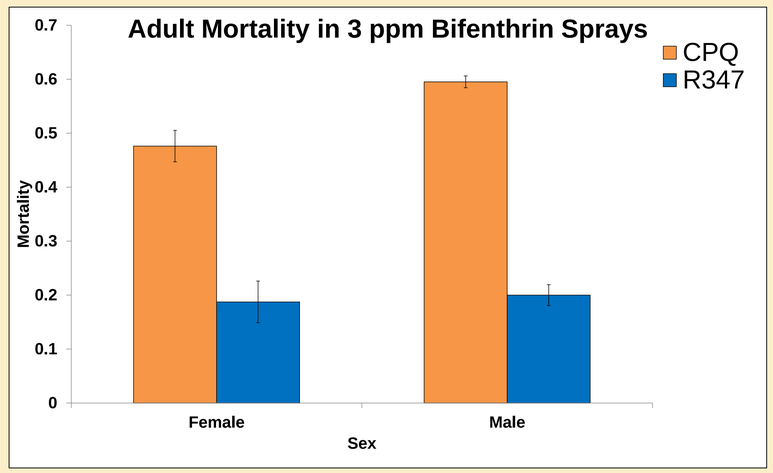


Figure 3. Mortality of adult navel orangeworm sprayed with bifenthrin at 0 ppm and 3 ppm in a resistant (R347) colony and susceptible colony (CPQ). Water was used as the insecticide carrier.

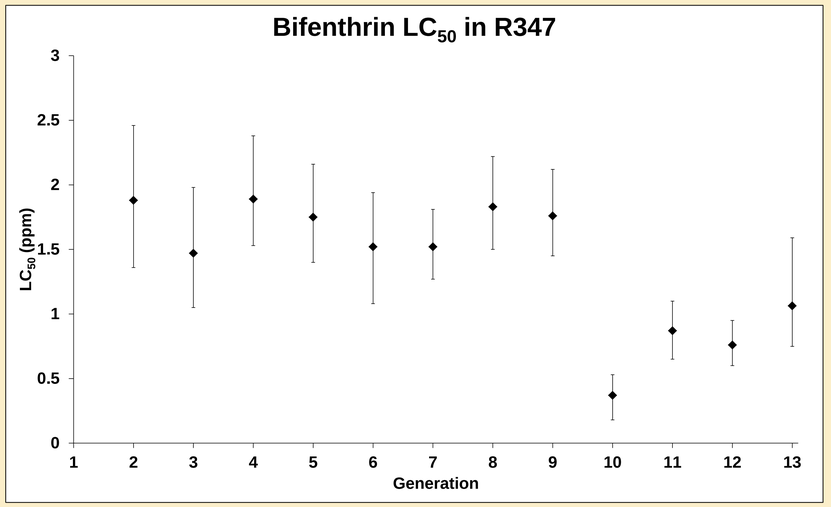


Figure 4. Median-lethal concentration data sampled across 13 generations for R347 neonates exposed to bifenthrin.

Discussion and Significance

- The recent decline in bifenthrin LC_{50} values suggests resistance is not stable long-term in the absence of bifenthrin selection pressure.
- If the bifenthrin-resistant strain can complete its development faster than susceptible strains under field conditions, then an additional generation could potentially emerge during the growing season.
- Although filter paper assays and adult spray assays were conducted with F_{11} and F_{12} individuals in the R347 colony (see Figure 4), survivorship was still significantly greater at the neonate and adult levels compared with CPQ after exposure to bifenthrin.

This research may generate insights that improve chemical management strategies for navel orangeworm. A decline in resistance over time in the absence of selection pressure suggests that a reduction in the use of pyrethroids could restore efficacy of the chemical class. Our future research will investigate the ability of this resistant line to detoxify insecticides with newer chemistries (Intrepid, Altacor), and their efficacy as alternatives to pyrethroids.

References

1. Demkovich, M., Siegel, J., Higbee, B., and Berenbaum, M. 2014. Mechanism of resistance acquisition in navel orangeworm (*Amyelois transitella*) exposed to pyrethroid insecticides and potential associated fitness costs. *Journal of Eenvironmental Entomology* (in preparation).
2. Khambay, B., and Jewess, P. (2005) Pyrethroids. *In Comprehensive Molecular Insect Science* (Gilbert, L. I., Iatrou, K., and Gill, S. S. eds.), vol. 6, pp. 1 – 29, Elsevier, Oxford

Acknowledgments

We thank the Almond Board of California and California Pistachio Research Board for research funding.

Contact Information

Mark Demkovich – mdemkov3@illinois.edu
Joel Siegel – joel.siegel@ars.usda.gov
May Berenbaum – maybe@illinois.edu