

Organic Acids as Alternative Controls and Resistance-Management Tools in Parasitic Honey Bee Mite IPM

Lead investigator: Nicholi Vorsa, Rutgers University

Team members: Michael Stanghellini, Rutgers University; Dennis vanEngelsdorp and Robyn Underwood, Department of Entomology, Penn State University

States involved: Pennsylvania and New Jersey

Years funded: 2004-2006

Funding Amount: \$54,875

Nontechnical Summary

The project helped develop novel strategies to manage varroa mites, a serious parasite of honey bee colonies. The effectiveness of and treatment methods for two biopesticides, formic and oxalic acids, were tested. These organic acid treatments have the potential to reduce our reliance on standard pesticides, and provide an alternative for varroa mite populations that have become resistant to pesticides.

Introduction

As the only reliable commercial pollinator for over 80 crops grown in the United States, the honey bee (*Apis mellifera* L.) is an indispensable aspect of agriculture. The beekeeping industry has been extensively damaged by the varroa mite, *Varroa destructor* Anderson & Trueman, an ectoparasitic mite of the honey bee. In Pennsylvania alone, there are over 2,000 beekeepers affected and the value of honey bee pollination is valued at \$60 million per year for crops such as apples, peaches, soybeans, and pumpkins. Without intervention, bee colonies typically die within two years after initial varroa infestation.

For over 15 years, effective varroa control strategies in the US have centered on the use of conventional pesticides. However, the consistent and exclusive use of these products to control varroa mites has led to the development of varroa populations that are resistant to fluvalinate (Apistan[®]) and coumaphos (Checkmite+[®]), as well as the potential for contamination of hive products with pesticide residues.

Alternative strategies for varroa control are numerous and exhibit a wide range of efficacy and practicality. Physical and cultural controls such as screen bottom boards and drone brood trapping are options that can be incorporated into an IPM program. Selective breeding and bee stock importation programs show some potential. The use of biologically-derived compounds may offer beekeepers practical and effective means of parasite control, and are therefore strong candidates for varroa IPM and pesticide-resistance management programs. A considerable amount of research has been conducted with organic acids (formic, lactic, and oxalic acid) and essential oils (thymol, eucalyptol, etc.) in Europe, the US, and elsewhere. Formic and oxalic acids are natural constituents of honey, so residues are not as big a concern.

Formic acid fumigation is a mite control technique that shows considerable potential, partially because it provides control for other honey bee parasites. In addition, despite long-term use in Europe, mite resistance to formic acid has not been reported. However, application techniques can be a problem because mites reproduce beneath the cappings of older brood and thus are protected. Formic acid treatments must either be present for a long period of time and control mites on bees as they emerge from the brood cells, or penetrate the cappings.

Continuous release of a formic acid treatment over time would be preferable to the necessity of repeat applications. Our preliminary evaluation of an experimental formic acid delivery system (MiteGone™, Kelowna, Canada) demonstrated that, over a 30-day period, these evaporation pads have potential to serve as an effective varroa mite control tool. We also found in a preliminary study, that at higher concentrations a formic acid gel is able to kill mites under cappings. With a short-term treatment, we were able to kill over 60% of varroa mites in worker brood cells.

Oxalic acid treatment is another varroa mite control method that is increasingly being tested by researchers and beekeepers. This treatment has been shown to kill up to 99% of mites on adult bees but is unable to control mites under the brood cappings. Thus, oxalic acid is most efficacious when used in broodless colonies because mites rely on adult bees for food during that time.

Objectives:

1) Define optimum conditions, dosage rates, and timing of applications of formic and oxalic acid treatments to optimize their efficacy in controlling mite infestations in managed honey bee colonies.

Several application techniques, dosage rates, and timings of application were tested with formic acid alone, and in combination with oxalic acid.

2) Evaluate the implementation of IPM tactics based on the use of organic acids and a physical control barrier for parasitic mite control.

Organic acid treatments and a physical control barrier (sticky boards) were tested in honey bee colonies. In 2004, formic acid treatment was compared to a “standard” pesticide treatment. In 2006, the standard treatment was eliminated because varroa populations in Pennsylvania are now resistant to one or both acaricides.

3) Determine organic acid treatment effects on colony health status and hive product quality.

Capped brood area was estimated and queen status was determined immediately before formic acid treatment (September 2006), after formic acid treatment (October 2006), and at the end of the experiment (April 2007). Colony survival was monitored from September 2006 to April 2007.

Approach:

Replicated field experiments evaluated the potential of two organic acids (formic and oxalic acid) for the control/suppression of the parasitic honey bee mite (*Varroa destructor*). The efficacy of differing numbers of formic acid evaporation pads (MiteGone™) was evaluated, where increasing pad number was expected to increase formic acid vapors in the colonies. Treatments of 0.5, 1.0 or 1.5 pads were placed in the hives for 28 days, beginning on September 2, 2004. The three formic acid treatments were compared with Apistan (standard treatment) and untreated (control) colonies, with 10 replications of each. Mite mortalities were measured weekly using sticky boards.

In another study, honey bee colonies were treated with a high dose of a formic acid gel in September 2006 in an effort to kill mites under the cappings. Once the gels were in place, the hives were sealed for 24 hours. Two rates of formic acid gel were tested, with untreated colonies as a control. In January 2007, half of the colonies from each formic acid rate received an additional treatment of ‘trickle’ oxalic acid. Varroa mite levels, capped brood area, and queen

survival were monitored to determine the efficacy of the treatments and their effects on the honey bee colonies.

Progress: Trials were conducted in 2004 and 2006 and the project is now complete.

Results:

Significant differences in mite mortality were found for all 28-day formic acid evaporation pad treatments compared to the control group; and the formic acid treatments also differed significantly among themselves. Mean mite mortality for the control (untreated), and formic acid treatments of 0.5, 1.0 and 1.5 pads were 26%, 44%, 59%, and 82%, respectively (see Appendix 1).

For the 24-hour formic acid gel treatment, large numbers of varroa mites were killed, but this treatment was not effective in keeping mite levels low for the spring. In combination with oxalic acid treatments, however, colonies were able to go into the spring with reduced varroa mite populations. None of the treatments significantly affected honey bee fitness over the long term (see Appendix 2).

Impacts:

1. *Safeguarding human health and the environment:*

Using formic and oxalic acid instead of synthetic acaricides would reduce exposure of beekeepers and bees to pesticides, and reduce pesticide residues in bee products, such as honey and wax. In an IPM program, an organic acid treatment might be alternated with a hard chemical, reducing the use of conventional pesticides by 50%, and serving as an important tool to combat mite resistance. Because bees are such a critical component of ecosystems and farming systems, anything that improves their fitness could have a positive impact on the environment.

2. *Economic benefits:*

Beekeeping today requires a substantially greater investment of time, labor, and money than in previous decades, largely due to the *continual* battle against mites. Based on a conservative estimate of \$7 per colony, it can be calculated that American beekeepers are spending over \$19 million dollars per year for parasitic bee mite control with conventional pesticides and current recommendations. If the organic acid treatments tested in this study are developed into registered products for American beekeepers, they have the potential to provide more economical mite management. The evaporative pad formic acid delivery system (MiteGone™) is currently being used in Canada. The gel formulation of formic acid used in this study could be mass produced and sold to beekeepers. It is easy to use, safe, and can be altered for better efficacy.

3. *Implementation of IPM:*

Numerous beekeepers and related personnel were addressed regarding organic acid treatments and alternative mite control strategies. Following are some estimates:

- New Jersey Beekeepers Association (70 beekeepers)
- Two county chapters of the NJBA (50 beekeepers)
- Eastern Apicultural Society (250 beekeepers)
- State Bee Inspectors Annual meeting (25 professional bee researchers; state university, and federal)

Overall, the impact of this project was to demonstrate that various delivery methods of these organic acids work on an acceptable level to control parasitic mites and have potential as part of an IPM program. Control is typically not as high as conventional pesticides (tau-fluvalinate, Apistan[®]), but high enough to suppress mite populations to levels below the economic threshold. Although these alternative compounds are currently being used in Europe and Canada, it is essential that they be evaluated and adapted to regional environmental conditions (e.g., temperature) and bee management practices (e.g., beehive design). No formulations of formic or oxalic acid are currently approved for use in the US, leaving a gap in the beekeepers' arsenal of known anti-mite products. Additional work needs to be done to make these products available to beekeepers, i.e. formulation, registration, and marketing.

Appendix 1

Publication in American Bee Journal, M. Stanghellini & P. Raybold, 2004, Biopesticides for the late fall control of Varroa mites in a northern temperate climate. 144:475-480.

Appendix 2

PowerPoint presentation: "Short-term fumigation of honey bee colonies with formic acid for the control of varroa mites" presented by Robyn Underwood.