Methods to Control Varroa Mites: An Integrated Pest Management Approach

Varroa mites (Varroa destructor), are the most influential of all of the pests and diseases of the European honey bee (Apis mellifera) today.

Figure 1. The varroa mite, Varroa destructor. Photo by Kate Anton.

These ectoparasitic mites arrived in the U.S. in 1987 and spread throughout the world after they jumped from the Asian honey bee (*Apis cerana*) to the European honey bee.

Varroa mites reproduce in cells with developing workers and drones (Figure 2). Drone brood cells are larger and the post-capping stage is longer (15 days for drones versus 11 days for workers), which allows the mite to produce more offspring per cycle. Varroa mites do not reproduce within queen cells because of the repellency of royal jelly and the very short post-capping period of queens (7 days). When honey bee brood is present in the colony, the majority of varroa mites are in the capped brood reproducing where they can often escape chemical treatments.

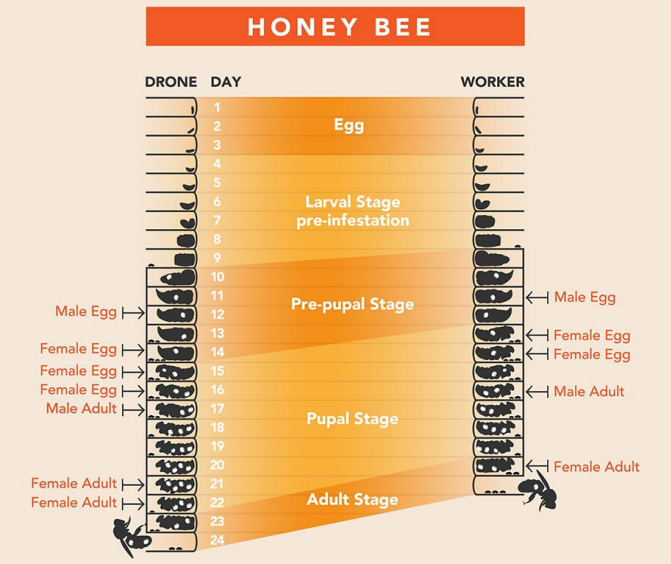

Figure 2. The life cycle of varroa mites and honey bee drones and workers. Varroa mites reproduce in the capped cells of developing honey bees. Because of the slower development of drones, varroa mites preferentially infest drone cells, which can then be used as a trap. Image by Nick Sloff

Varroa mites are believed to feed from the fat bodies of the bees, which is an organ that provides the energy needed during extended non-foraging periods, such as the winter. In addition to weakening the bees' metabolism, varroa mites transmit a number of lethal viruses. Viral titers in honey bees are correlated with varroa mite load, with both rising from spring to fall. Thus, the control of the mite population is a method of controlling viruses. In beekeeping operations, timing of mite control is critical; controlling mites in the fall is a major factor linked to overwintering survival in honey bees.

Monitoring levels of varroa mites in colonies is important for determining the need for and the type of treatment. Beekeepers generally measure the mean abundance of mites (number of mites per 100 bees) on a regular schedule, such as monthly, to determine when the population of mites found on adult worker bees is exceeding a threshold. This can be accomplished through several methods, including sugar rolls, alcohol washes, or through the use of a sticky board. Alcohol washes are the most accurate method for monitoring mite populations, for apiaries with a large number of colonies sampling 20% of the colonies will provide sufficient information about mite

populations. Economic or action thresholds vary but are aimed at keeping mite levels below or around a mean abundance of 2 mites per 100 bees. This is a very low number, which can be maintained using a number of practices that vary from cultural to chemical (Figure 3). Beekeepers can use an integrated pest management (IPM) approach in which they use several different mite control techniques in combination or in rotation throughout the year. A combination of various treatment protocols is effective and it reduces the likelihood that resistance to chemicals will develop, as happens when only one treatment method is used repeatedly.

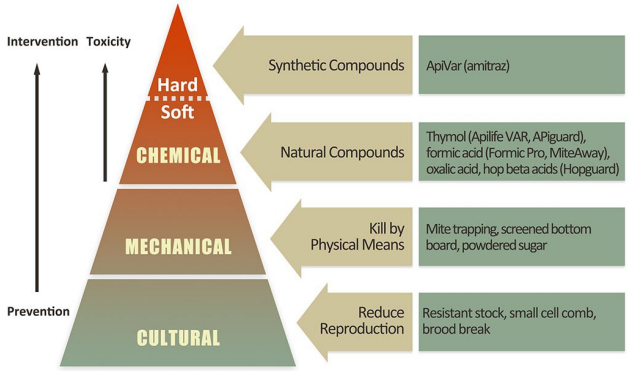

Figure 3. The IPM pyramid for varroa mite control. Image by Nick Sloff.

Here, we review the different levels of IPM practices for varroa mite control and briefly summarize the efficacy (Box 1) and potential negative impacts of each practice.

> Box 1: **Efficacy**: the power to produce an effect. In insect science, the word *efficacy* is used to discuss how effectively a pesticide or practice controls a pest.

Cultural Approaches

Cultural approaches are aimed at reducing pest reproduction. For varroa mite control and prevention, cultural controls include purchasing mite-resistant honey bee stock, providing small cell comb, and providing a brood break.

Resistant Stock

Using mite-resistant bees can limit the reliance on chemicals for varroa mite control. To that end, various bee stocks with mite-resistant traits have been developed. Imports have emphasized European honey bees that have been in contact with varroa mites for a long time.

- *Russian bees* inhibit mite reproduction. Russian bees have a slower varroa mite population increase than other bees, due to an ability to suppress mite reproduction. Russian bees have lower percent brood infestation and fewer multiply-infested cells, and bees inoculated with the mite-vectored deformed wing virus exhibit significantly less viral replication.
- *Varroa Sensitive Hygiene (VSH) bees* can recognize and remove mite-infested pupae. Bees that remove dead brood quickly are hygienic and are thought to be better at removing mites from the hive, as well. Other desirable traits include the recognition by the bees that the mites, themselves, are present and undesirable. This trait is recognized by testing.
- *Ankle biters/leg chewers* will bite the mites, harming their bodies and/or legs. This trait is recognized by looking closely at mites that have dropped through a screen onto a sticky board, determining the proportion of the mites that have been damaged by the bees

Small cell comb

When modern hive equipment was invented in the early 1950s, it started the beekeeping industry down a path of modernization and industrialization. Part of this process involved the production of commercial foundation with hexagons that are 5.4 mm and produce larger bees that could produce more honey. However, in wild conditions, bees tend to build comb from smaller hexagons that are 4.9 mm in size. Some research has suggested that mite numbers decrease as cell size decreases because a shorter post-capping period in a smaller cell translates into fewer varroa mites produced in each cell. The efficacy of using small cell comb as a varroa mite control method is debated in the scientific literature, but there is no harm to honey bees from using this equipment.

Brood break

A brood break in the colony can significantly impact the number of available brood cells for mite reproduction. This break can be accomplished by caging or removing the queen from the colony for approximately 3 weeks. During that time, all of the brood hatches, so the mites are forced out of the cells and onto adult bees. This approach on its own, or in combination with a chemical treatment, can affect varroa mite population growth. In addition, adult bees increase grooming behavior in the absence of brood which can help decrease mite numbers in the colony, especially in combination with a screened bottom board. If a brood break is properly timed, it has the potential to ease the stress of a dearth period while providing the colony with a young queen for overwintering.

Mechanical Approaches

Controlling varroa mite populations via manipulations of the colony or hive can be effective, especially if several (or all) of the methods are used in conjunction. Mechanical controls include screened bottom boards, drone brood removal, and powdered sugar dusting.

Mite trapping

Drone brood removal takes advantage of the mites' preference for drone brood for reproduction, using them as a trap. Varroa mites have higher reproductive success in drone brood than in worker brood due to the post-capping period allowing mites to produce only 1.3-1.4 offspring per attempt in worker cells, but 2.2-2.6 offspring in drone cells. In addition, the period of attractiveness of drone brood is 40-50 hours, as opposed to only 15-30 hours in worker brood. Together, these reproductive advantages of drone brood manifest as a 6-fold increase in mites found under the cappings of drone cells than under worker cells. Adding drone comb to a colony encourages drone production that acts as a trap for mites. Removing that comb prior to drone emergence effectively removes the varroa mites reproducing in the cells. The drone brood can then be frozen and returned to the colony or scraped off of the frame (Figure 4). This practice reduces mite reproduction, which prolongs the length of time before the population reaches the threshold. However, it may not effective enough to act as the only means for controlling varroa mites.

Figure 4. Scraping drone brood from a frame that was added to act as a mite trap. Image by Robyn Underwood.

Screened bottom board

Mites naturally fall off of bees as a result of movement within the colony and honey bee grooming behavior. If a screened bottom board, rather than solid wood one is used (Figure 5), mites fall onto the ground and are less likely to climb back onto the bees. Screened bottom boards decrease mite invasion into brood cells, resulting in a lower percentage of the population being found in the brood reproducing. Mite loads still reach economic thresholds in hives with screened bottom boards, so this physical method to control varroa must be used in combination with other control techniques.

Figure 5. The bottom board on the left is a screened bottom board, whereas the one on the right is a solid bottom board. The floor of the hive can be screened to allow varroa mites to fall through to the ground, where they cannot return to the colony. Image by Robyn Underwood.

Powdered sugar

Sprinkling or applying powdered sugar on bees can serve as a method for mite control as this stimulates grooming behavior, resulting in more mites collected on bottom boards. Its use can be effective on bees removed from the hive equipment, but this is labor intensive, so beekeepers should weigh the costs and benefits when considering this practice. This treatment will not likely control the mite population on its own, but it can be used to increase mite drop in combination with screened bottom boards.

Chemical Approaches

Varroa mite reproduction throughout the spring and summer often leads to a large population in the fall. If the economic threshold is reached, one will have the best overwintering success if a chemical miticide is applied prior to the production of the winter bees. In an IPM system, soft chemicals are used when possible.

Soft Chemicals

Organic acids, essential oils, and hop beta acids are considered soft chemicals because they are naturally derived. These treatments are effective without leaving chemical residues in hive products, such as wax. If chemicals are used in the hive, it is recommended to apply soft chemicals first prior to considering the use of hard chemicals. In addition, colonies should be treated only after monitoring efforts have indicated that they are needed.

- **Formic acid.** Formic acid occurs naturally in the venom of honey bees and is a natural component of honey. This chemical is commonly used because, at high concentrations, this organic acid penetrates the wax cappings and effectively kills reproducing mites. One limitation is that the use of formic acid is temperature dependent and can cause damage to the colony if used at ambient temperatures higher than 85F because it can increase brood mortality and the potential for queen loss. When used below 50F, formic acid results in low efficacy.
- **Oxalic acid.** Oxalic acid is a naturally-occurring compound found in plants, such as rhubarb, kale, beets, and spinach. As a chemical for mite control, oxalic acid can be used in two formulations: vapor and dribble. Because it does not penetrate the cappings, oxalic acid is most effective during broodless periods making it a useful component to an integrated varroa control program as a winter or early spring method. However, it should not be used as a stand-alone treatment. If overused or used at high dosages, oxalic acid can harm bees by crystalizing in the midgut of larvae, increasing larval mortality, and reducing brood area. Overuse of this treatment can also decrease the activity and longevity of workers.
- **Thymol.** Essential oils are natural compounds distilled from plants. The most popular essential oil for varroa mite control is thymol (from a thyme plant). While thymol treatment can effectively control mites on adult bees, it cannot penetrate the cell cappings, so does not control mites in brood cells. Efficacy of thymol is dependent on colony strength as well as ambient conditions. During treatment, the workers react by emptying cells near the product so this treatment can reduce the overall area of brood in colonies when applied in the spring. In addition, thymol treatment can induce robbing behavior and increase aggressiveness of colonies. Efficacy of thymol treatment can be low so it should be combined with other treatment methods.
- **Hops beta acids.** Potassium salts of hops beta acids are derived from the hops plant and it is safe for use any time of the year, even during the honey flow. However, it is more effective as a mite control treatment when there is less brood because it does not go through the cell cappings. Use during brood rearing requires multiple applications. Ambient temperature does not impact Hopguard treatment. Efficacy varies, but it is generally not as high as other soft chemical treatments.

Hard Chemicals

Chemical control of varroa mites can be achieved through the use of various acaricides/miticides. Synthetic miticides are generally effective, killing up to 95% of the mite population. Historically, fluvalinate and coumaphos have been the most widely used mite treatments, but mites have developed resistance to these chemicals and residues persist and accumulate in wax. While these two hard chemicals are still legal to apply, we do not recommend them and will not discuss them here. Miticide residue in wax can harm bees directly and makes bees more susceptible to nosema disease. In addition, these residues can be found in bee products, which makes them less desirable to consumers. Synthetic chemicals should be a last resort for beekeepers practicing IPM.

- **Amitraz.** The most popular synthetic acaricide is amitraz (sold as Apivar(R)). Amitraz does not, in its original form, persist as a contaminant of honey or wax. However, some metabolites of amitraz have been found to persist and there is a synergistic effect of amitraz and viruses that has been linked to increased bee mortality. In addition, resistance to amitraz has been documented, so its efficacy must be monitored closely.

Summary

There are many available options to control varroa mite populations in honey bee colonies. Each option has advantages and disadvantages, but understanding the implications of each choice is an important part of decision-making. In an IPM approach, beekeepers should heavily rely on cultural and mechanical practices for mite control before using soft or hard chemicals. Mite monitoring and rotation of treatments is critical for effective management and reduction of resistance to chemicals in these pests. Understanding and considering all of the options before deciding on how to proceed will help to improve the success and the well-being of the honey bees.

Northeastern IPM Center

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Authors

Robyn Underwood, PhD
Assistant Research Professor
underwoodrm@gmail.com
610-301-4283

Margarita López-Uribe, Ph.D.
Assistant Professor of Entomology
mml64@psu.edu
814-865-8245

extension.psu.edu

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