Control of Mites in Honey Bees

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Varroa mites (two strains of *Varroa destructor*), which parasitize the Western honey bee (*Apis mellifera*) over much of the world, can seriously weaken and even kill honey bee colonies. These mites, which were long thought to be *Varroa jacobsoni* but are now known to be a separate species, are natural parasites of specific strains of the Asian hive bee (*Apis cerana*). Around 1940, they transferred from *A. cerana* to *A. mellifera* and have since spread to Europe, the Middle East, North and South America (including some Caribbean islands), select parts of Africa and more recently New Zealand. Australia is the only major beekeeping country that is free of the mites. These mites have a much more damaging effect on *A. mellifera* than they do on their native hosts, the Korea and Japan/Thailand strains of *A. cerana*.

Varroa mites are the most serious problem for beekeepers in the United States. In Europe, infested colonies die within 3-7 years. The mites can be seen with the naked eye (see Figure 1). To determine if your hive is infested with *Varroa* mites, put a piece of white paper on the bottom of the hive and blow tobacco smoke into the hive. Close up the hive for five minutes. Remove the paper after an hour to check for mites. *Varroa* mites look like small brown dots on the paper, and can also sometimes be seen on the bodies of adult bees. *Varroa* mites feed on the haemolymph (i.e. insect blood) of adult honey bees. The mites mate and reproduce within capped honey bee brood cells, and during this time they feed on the developing pupae. In the process, they may transfer any of several different viruses to honey bees. As a result of mite parasitism, many pupae are deformed when they emerge as adults. Thus, another clue that *Varroa* mites have infested a hive is the presence of adult bees with deformed wings or abdomens.

Varroa mites are often controlled by chemical poisons. In North America fluvalinate-impregnated strips are hung in the hive for six weeks. In many countries beekeepers use non-approved chemicals which can and do leave residues in honey. Such residues may be dangerous to human health, but could also jeopardize the beekeeping industry. To avoid contamination, chemicals should not be used during nectar flows (times of heavy flowering) or for four weeks prior to a nectar flow.

Extended use of chemical pesticides can result in mite resistance to the chemicals. In addition, chemical acaricides (i.e. chemicals used specifically to kill mites) are costly and may be unavailable to beekeepers. No method is totally effective in controlling *Varroa*. However, several techniques can help to

Figure 1: Varroa mites seen on a honey bee pupa. Photo by Jim Kalisch, University of Nebraska, Department of Entomology.

keep *Varroa* infestation at a manageable level.

Neem for Control of Mites

In the search for less toxic and cheaper acaricides, neem oil has emerged as a possible candidate for the control of *Varroa* mites. Neem (*Azadirachta indica*) is a tree that is related to mahogany and is rapidly becoming common in many tropical countries. Oil from seeds of the tree has been found to be an effective control against hundreds of different agricultural pests, while being harmless to mammals and relatively non-toxic to beneficial insects. The main effective ingredient in neem is a compound called azadirachtin.

Adony P. Melathopoulos and colleagues at Simon Fraser University in British Columbia studied the effectiveness of neem oil in controlling mites. Their results, published in the *Journal of Economic Entomology* volume 93(2) and 93(3), demonstrated that neem was an adequate acaricide against *Varroa*, though not as effective as chemical acaricides such as fluvalinate. After frames were sprayed with neem oil, *Varroa* showed a 50-90 percent mortality. The effectiveness of the neem oil varied between batches used at the same concentration; this is because batches were from different sources and probably contained varying amounts of azadirachtin.

Melathopoulos discovered that neem also affected tracheal mites. Tracheal mites (*Acarapis woodi*) are microscopic mites which infest honey bee tracheae (breathing tubes). They are another serious pest of honey bees. Neem spray did not kill tracheal mites in the experiment, but it did prevent transfer from host to host and thus seemed to prevent further infestation by *A. woodi*.

Neem oil caused some negative effects upon experimental hives, and these effects must be taken into account before deciding to use neem. Some queen loss was experienced after treating hives with neem. The effect seemed to be dependent on the concentration of neem oil used. In the studies at Simon Fraser University, half of colonies sprayed with 10% neem oil (as an emulsion in water) lost queens. No queens were lost in colonies sprayed with 5% neem oil.

Neem spray also reduced the area of sealed brood (i.e. pupae in cells, capped over by wax), by 50%. This figure remained the same at different dosages. Loss of half the hive's pupae would reduce the population of adult honey bees once the surviving pupae began to emerge, but if a hive was so badly infested by Varroa mites that you would otherwise likely lose the whole hive, you might decide to risk losing half the hive's pupae in order to get rid of the mites.

Unfortunately, neem is more labor-intensive to use than many chemicals. In the study, the most effective treatment was to use neem oil as an emulsion in water (see *Amaranth to Zai Holes*, p. 200 for information about how to extract neem oil from the seeds. *Amaranth to Zai Holes* is also on our website). Two percent by weight Tween-20 (strong detergent) was added as an emulsifier. Another detergent such as dish washing detergent could be used instead as an emulsifier, but keep the concentration of detergent at 2% since higher concentrations could harm honey bee brood and adults by blocking their spiracles (breathing holes). Frames were moved to make a 5 cm (2 inch) gap, and about 20 ml of the emulsion were sprayed over the length and depth of each frame (10 ml per side). In the experiment, a backpack sprayer was used; a spray bottle might work as well. Multiple applications (six applications at four day intervals) were necessary. When applied in a sugar syrup feed, neem was not effective in controlling mites. The bees did not seem to like the taste. They ate more of the neem sugar syrup when the neem oil was debitterized, but it still had little effect.

Laboratory experiments by Melathopoulos and his colleagues suggest that mineral and vegetable oils such as grapeseed, peanut, or canola oil will work as well as neem. The oils can be applied in a similar way.

Biotechnical Control of Mites

In Vietnam, *Varroa* mites cause problems in *Apis mellifera* hives. Beekeepers there are able to control the mites without using chemicals. Instead they use a series of management techniques or biotechnical methods, described in an article in *Bee World* 78(2) by Nguyen Van Dung, *et al* ("Control of honey bee mites in Vietnam without the use of chemicals"). In order to use these techniques successfully, the life cycle of *Varroa* needs to be understood.

Varroa mites reproduce only inside capped honey bee brood cells, so removal of infested brood is one way to control the mites. Mites prefer drone brood to worker brood. Although Varroa is able to reproduce within both worker and drone brood of *A. mellifera*, drones have a longer development time than workers, so *Varroa* mites have more time to reproduce and mature within drone brood cells. If a frame without comb foundation is put into a strong colony, often the workers will build drone comb on the frame. Drone comb is easily recognizable because the cells are larger than those used to rear worker brood or for honey storage. Beekeepers will remove the frame when it is full of drone brood larvae up to four days old. They introduce the frame into a heavily infested colony and remove it once the brood is capped over. Cell cappings are cut off, and the brood is removed and eaten (it is a good protein source). The empty comb can be reused to trap more *Varroa* mites.

In another somewhat labor-intensive method, often used during the season when new colonies are established, *Varroa* is treated cooperatively using two hives. In each colony, a broodless period is created. This means that any *Varroa* mites remaining in the hive will be on adult bees. They can then be trapped and removed in the next brood comb that is produced. We will call the two hives colony A and colony B. All brood is removed from colony A and placed in colony B, creating a broodless period in colony A. The queen in colony A will continue to lay eggs. Once those eggs hatch and the larvae begin to pupate, the first resulting two combs with capped brood are removed and destroyed (or the brood can be eaten). The *Varroa* mites within the capped brood are removed at the same time.

In the meantime, colony B has received the original brood from colony A. The queen in colony B is removed and replaced with a recently capped queen cell. There will be a period of a week or so before the new queen emerges, mates and begins to lay eggs. Once the pupae from the old brood hatch out, a broodless period will be created. After the queen begins to lay eggs, the first two resulting combs of sealed brood are again removed and destroyed/eaten, along with remaining *Varroa* mites.

Because of the broodless periods that are created in the hives, this method has the advantage of also controlling another parasitic mite called *Tropilaelaps clareae* (found in Asia) which cannot survive on adult bees for more than two days. *Tropilaelaps* mites can be killed by creating a short broodless period in the colony.

A final biotechnical method involves destroying capped brood at the end of the main honey harvest each year. *Varroa* mites will invade the remaining uncapped brood, which can be removed several days later once it is newly capped. This method, although it weakens a colony, has two additional benefits. After the nectar flow, fewer bees in the colony means a beekeeper will have to feed the colony less sugar water. And, as mentioned, brood can be eaten as a good protein source.

In some cases, these management techniques can be combined with chemical control for a more effective treatment. When very little sealed brood is present in a colony, chemicals that are applied will affect more of the *Varroa* mites that are present.

Essential Oils for Control of Mites

Jorge Murillo-Yepes in Grenada reported in *Beekeeping and Development* Issue 46 about the use of essential oils to kill mites. Researchers in Grenada have used an oil cream to target *Varroa* mites. They use 170 g beeswax, 450 g coconut oil (or other vegetable cooking oil) and 15 g essential oil (they have tried eucalyptus, nutmeg, peppermint and spearmint). To prepare the cream, they melt the beeswax and oil together in a double boiler. Once the wax is completely melted, they allow the mixture to cool until it just starts to harden at the surface, but is still quite fluid. Then the essential oil is mixed in until it is thoroughly blended.

To treat a hive, one or two teaspoons of the cream are spread evenly onto a strip of bamboo, cardboard, plastic, plywood or tin measuring 2 to 5 cm (1 to 2 inches) wide and 20 cm (8 inches) long. The strip is pushed into the entrance in the morning, preferably on a hot, sunny day. If the weather is hot and dry, the treatment should begin to work within two to four hours (dead Varroa mites should be seen on the bottom of the hive) and treatment should be complete after 24 hours. Murillo-Yepes recommends that essential oil treatments not be used within one month of a heavy nectar flow. Since colonies in tropical conditions seem to be particularly susceptible to *Varroa* during periods of heavy rain, treatment might be well timed just prior to the rainy season.

An article written by Adony Melathopoulos for *Bee Culture* gives an overview of the use of essential oils for mite treatments in Europe and North America. Over 150 essential oil compounds and blends have already been evaluated for *Varroa* control. Most of these have been found unsuitable for use in colonies, because they are toxic to honey bees as well as to *Varroa* mites. However, the essential oil thymol has been tested extensively and used successfully. For treatment to be successful, ambient temperatures must be higher than 15°C (59°F) and the colony must have only low amounts of sealed brood. Thymol is effective against both *Varroa* and tracheal mites, and causes little or no harm to bees. Residues in wax do not persist, and residues will not be a problem in honey if thymol is applied outside of the honey-producing season. Plants which contain thymol include *Thymus vulgaris* (thyme) and *Monarda punctata* (horsemint).

Open Mesh Floors for *Varroa* Control

Several new designs for the bottom boards of hives have been proposed as a method of controlling *Varroa* mites. Some of these designs were described in recent issues of *APIS*, a publication by Malcolm T. Sanford providing “Apicultural Information and Issues from IFAS/University of Florida, Department of Entomology and Nematology”.

One of the designs uses a bottom board made from parallel transparent 34 mm tubes, separated by 3.5 mm. The tubes are in a wooden frame which becomes the hive stand. Information about this “anti-*Varroa* bottom board,” developed by M. Legris, can be found in English, French and German at the website (http://www.apiculture.com/ (http://www.apiculture.com/plateau-anit-varroa) plateau-anti-varroa). On the website, Mr. Le Pabic from France describes the reasoning behind the bottom board: “The principle of the anti-*Varroa* bottom board has come from the fact that wild colonies of honey bees can be found, free of *Varroa*, in highly infested areas. The assumption is that many *Varroa* mites fall from the colony and are eliminated in this way, having no means to climb back. On the contrary, in [an ordinary] hive they do not have any difficulty joining up with their initial environment from the classic bottom boards. The Legris anti-*Varroa* bottom board is designed so that they fall through the tubes under the hive.

“According to my experience on my colonies, this bottom board eliminates any need for chemical treatment. The *Varroa* mites are not fully eliminated, but they remain in such a small number that they are no longer harmful. In the worst case, only one treatment per year might have to be done, which is enough to economically justify it.”

A second modified bottom board, described in *APIS* 17(6), separates the bee nest from the hive floor with the use of wire mesh (#8 hardware cloth). With this kind of design, it would probably work to use sticky papers under the mesh to actually trap the *Varroa* once they fall through. Papers could be made sticky with petroleum jelly. They would need to be removed and replaced periodically.

A third design is described in *APIS* 17(8), with a summary of Dr. Helmut Horn's article, "Observations on the Overwintering of Honeybee Colonies in Hives with Open and Solid Floorboards" (published in German in A.D.I.Z., November 1987, and translated by A.E. McArthur for *Bee Craft* in July 1990).

Dr. Horn's open mesh hive floor uses a sturdy wood frame with wire mesh (8 wires per inch), instead of the usual solid bottom board. Because of better ventilation, a smaller entrance hole can be used above the mesh floor and less fanning will be necessary. The constant exchange of air means that less condensation is likely to occur, so there is less likelihood that fungus will grow on the combs. The open floor also enables *Varroa* mites and debris to fall out of the hive. One drawback in Dr. Horn's experiments was that food consumption was 10-15% higher with the use of the wire mesh floor, but there were no adverse effects on colonies. Although this open mesh floor is designed for colder climates where bees need to overwinter, the design may also benefit those keeping bees in tropical areas.

In addition to the benefits already listed, an open mesh floor might help to control small hive beetle. Small hive beetle (*Aethina tumida*) is another honey bee pest that was recently introduced to North America. The beetle larvae burrow through the comb within a hive, feed on stored honey and pollen, and very quickly cause honey to spoil. Small hive beetle larvae must leave the hive to pupate in the soil. Perhaps a container with soil in it could be placed beneath the open mesh floor to catch the beetle larvae. The soil could be sifted regularly, and the beetle pupae fed to chickens or destroyed.

Other Methods of Control

Certain populations of honey bees seem to be more resistant to *Varroa* mites than others. For example, Africanized bees and Russian bees seem to have a higher level of natural resistance to *Varroa* than most European bees. Selective breeding is also being done by scientists to confer specific characteristics on honey bees. For example, a shorter pupal stage for workers would mean that *Varroa* would have less time to mate and reproduce in capped cells. Bees are also being selected for hygienic behavior, in which bees groom each other to remove the mites.

Other alternative methods of control for *Varroa* mites are also published. These methods, like the biotechnical methods, can best be utilized when the mite's life cycle is understood. In an earlier EDN (58-4), we wrote about using smoke from dried grapefruit leaves to remove mites. The smoke does not seem to kill the mites, but rather makes them fall off of the bees. If a sticky paper were placed under a screen on the bottom of the hive (as aforementioned), this method could provide some control of the mites. But it would have to be done numerous times, because *Varroa* mites reproduce within capped cells containing honey bee pupae. Smoke would be ineffective against these sealed mites until they were again exposed with the newly emerging honey bee.