Managing Varroa Mites in Honey Bee Colonies

The varroa mite (Varroa destructor) *is the most serious pest of honey bee colonies worldwide. This parasite was first detected in North Carolina in 1990, having been introduced to the U.S. just three years earlier. Virtually all feral (or "wild") honey bee colonies have been wiped out by these mites, and beekeepers continue to struggle with varroa infestations in their hives. In North Carolina alone, the number of managed beehives has dropped by an estimated 44 percent since the invasion of the mites. It is vital, therefore, to understand the varroa mite and the options available for its control.*

MITE BIOLOGY

The varroa mite is an external parasite that attacks both adult bees and the developing honey bee larvae. The adult mites have a flattened oval shape, are reddish-brown in color, and are about 0.06 inches wide, about the size of the head of a pin (Figure 1). The mated female mite enters the cell of a developing bee larva and lays as many as six eggs. The developing mites feed on the bee pupa and, depending on the number of mites, may kill it, cause it to be deformed, or have no visible effect. While the male mite dies in the cell, the adult daughter mites climb onto an adult worker bee and feed on its hemolymph (a fluid known as "bee blood"). The female mite can then repeat the cycle by entering cells of other developing larvae. Mites prefer drone larvae over worker larvae, but they will infest worker larvae and eventually kill the colony if preventive measures are not taken.

The mites can also harm the bees indirectly. In addition to the obvious effects of mites feeding on developing and adult bees, the mites can also serve as transmitters of several viruses that can kill bees. These secondary infections are facilitated when the mites compromise the bees' immune systems. They can cause a condition known as *parasitic mite syndrome* (PMS), which can kill colonies within months of infection.

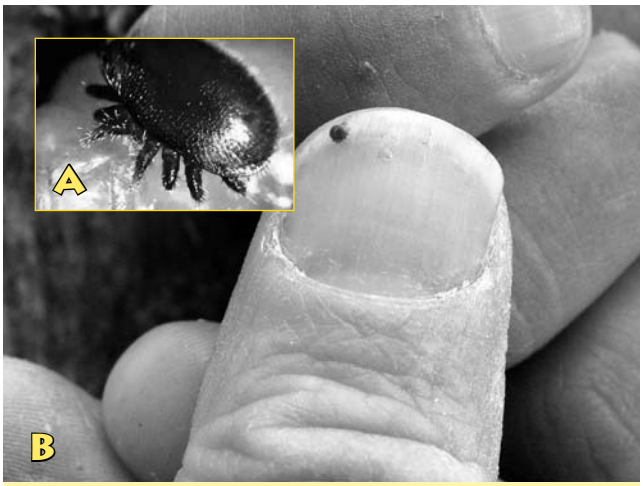

Figure 1. The varroa mite, *Varroa destructor*, the most insidious pest of honey bee colonies. *Photo A: courtesy of NCDA&CS. B: N.C. State Apicultural Program*

Figure 2. The sugar shake method for estimating mite levels. *N.C. State Apicultural Program*

DETECTION METHODS

Many bee colonies that succumb to varroa infestations will do so in the late summer or fall. It is difficult to simply inspect a colony and determine if it has a high level of mites. It is important, therefore, to sample beehives to estimate the degree of infestation.

Sugar shake method

This method estimates the mite *prevalence* within the colony (the percentage of adult bees with mites).

1. Obtain a clear 1-pint jar or other container with a lid made from 1/8-inch hardware cloth or similar mesh material. If you can't find a jar with a mesh lid, make a mesh lid for your container.
2. Brush or shake approximately 200 adult bees from a frame with an emerging brood into the jar.
3. Close the mesh lid on the jar, and add 2 to 3 tablespoons of 6× powdered sugar through the lid.
4. Set the jar aside for several minutes to allow the bees (and mites) to be covered in sugar.
5. Shake the sugar (and dislodged mites) out of the jar onto a clean, flat surface (preferably white). The bees, although covered in sugar, are not killed and can be returned to the colony.
6. If 10 or more mites are found per 200 bees, take appropriate measures to control the mite population (a magnifying glass may be necessary to see the mites).

Sticky board method

This method estimates the total mite *load* of the colony (the total number of mites in the hive).

1. Purchase a commercial sticky board from a beekeeping supply company. A sticky board has a pre-applied adhesive and sampling grid drawn on the surface. Alternatively, a sticky board can be constructed with a stiff sheet of white paper.
2. Spray the upper surface of the paper (facing the bees) with an aerosol cooking spray, or apply a thin layer of petroleum jelly to the upper surface of the paper to create a homemade sticky board.
3. Place the board or paper between two 8-mesh wire covers (with one cover on the top and one on the bottom) so that the bees do not adhere to the sticky surface.
4. Place the sticky board on the bottom floor of the hive. A portion of the mites will fall off the bees, fall through the mesh screen, and stick to the white board.
5. Remove the board 24 hours later, and count the total number of mites on it. If the number of mites is between 60 and 190 (depending on the size of the colony), then appropriate control measures should be taken.

Alcohol wash method

Similar to the sugar shake, this method requires that the beekeeper brush or shake adult bees from a frame into a clear container to measure the prevalence of varroa mites.

Figure 3. The sticky board method for estimating mite load. *N.C. State Apicultural Program*

1. Pour 1 to 2 inches of rubbing alcohol (isopropyl alcohol) into a clear 1-pint jar or container with a solid lid.
2. Brush or shake approximately 200 adult bees from a frame with emerging brood into the container.
3. Vigorously shake the container for at least 30 seconds, and then examine it for dead mites sinking to the bottom. If you see 10 or more mites per 200 bees, then you should treat the colony.

Drone brood inspection

Because of the variation in sampling, this method is not always a reliable indicator of mite levels in a colony. However, it can be used to verify the relative degree of varroa infestation.

1. Find any capped drone brood within the hive, which is typically located on the periphery of the brood nest.
2. Uncap the cells and gently remove the pupae.
3. Closely inspect the drone pupae for adult varroa mites. If 10 percent or more of the drones are infested, then you should take appropriate measures to reduce the mite population.

Current recommendations are to monitor each honey bee colony for varroa mite infestation several times over the course of a season to determine if and when treatment is necessary. Use different sampling techniques for your monitoring efforts to make sure that an accurate measure is obtained for each hive.

CONTROLLING VARROA MITES

Traditional methods for varroa mite control have been to hang plastic strips impregnated with chemical pesticides between the wax combs of beehives (see "Chemical treatments" below and Figure 5). Unfortunately, the mites are rapidly developing resistance to many of the common treatments, which has prompted researchers to develop alternative methods to prevent and treat varroa mite infestations. These methods range from structurally or mechanically modifying beehives, to obtaining new stocks that are more tolerant of mites, to using new biopesticides that are valuable alternatives to the standard synthetic treatments.

Mechanical control

Certain control methods involve changes in beekeeping management practices. The benefit of such mechanical control measures is that they do not use chemicals to reduce mite levels, thus they may be employed when the bees are collecting and producing honey. They may, however, be more laborious or require new equipment, and they may not be as effective as other control measures.

Screened bottom boards. Research has shown some benefit from replacing the wooden bottom of a standard beehive with a wire-mesh screen or other non-solid surface. Several studies have shown decreases in mite levels within colonies where hives have screened bottoms compared to solid bottoms. While the reasons for the decreased mite populations are unknown, the decrease may be due to better hive ventilation or to the loss of mites dropping through the floor of the hive. The benefits of bottom screens are minimal, however, and such hives usually require additional methods of treatment.

Drone-brood trapping. Varroa mites prefer to infest the drone brood in a hive, which consists of developing male honey bees. This is because drones are larger and take longer to develop, so female mites can produce more offspring per generation. Beekeepers may take advantage of this preference by placing special combs with drone-sized cells in their hives to attract mites to the brood. These combs can then be removed before the drones—and the mites—emerge from their cells. Depending on the time of year, this practice can dramatically reduce the mite populations within colonies.

Inert dusts. Adult mites move through the hive by clinging to the backs of adult bees. Some research has shown that covering all the adults in a colony with fine dust particles, such as powdered sugar or certain pollen substitutes, can cause the mites to lose their grip and fall off their hosts. This technique can be laborious and quite disruptive to a colony, but it requires no chemical pesticides.

Mite-tolerant stocks

Some of the more exciting advances in varroa mite control have been in honey bee genetics. In recent years, much work has been done to develop particular strains of honey bees that have shown tolerance to the varroa mite. Though the mechanisms are not completely understood, some behavioral and physiological traits probably play a role in varroa resistance. Today, several strains of bees are available that have been shown to reduce the number of varroa mites within their colonies.

Russian strain. Researchers at the USDA Honey Bee Research Lab in Baton Rouge, Louisiana, have imported bees from the Primorsky region in far-eastern Russia because they co-exist with the original host species of varroa, the sister honey-bee species *Apis cerana*. Because these Russian bees have been exposed to the varroa mite for a greater number of generations compared to other strains of bees, they may have developed a tolerance to the mite. Indeed, research has shown that they are more than twice as tolerant of varroa as other commercial bee stocks. Moreover, for reasons that are yet unclear, this stock appears to be highly resistant to the tracheal mite, a second parasitic mite that infests honey bee colonies. The Russian strain has been made available for commercial purchase in the U.S. after a protracted period in quarantine.

Hygienic behavior. Many queen breeders have actively bred for colony brood-nest *cleanliness* or hygienic behavior. Much research has demonstrated lower levels of numerous diseases in colonies selectively bred to uncap and removed diseased or parasitized brood (such as the Minnesota Hygienic stock). Although these stocks are not immune to varroa parasitism, they may significantly reduce the need for control methods.

VSH stock. Previously known as the SMR strain (for *suppression of mite reproduction*), this genetic trait was selected for by USDA researchers using classical bee breeding and instrumental insemination techniques. Bees of this stock exhibit high levels of hygienic behavior specifically towards varroa-parasitized pupae (hence *varroa-sensitive hygiene*, or VSH), causing the mites to have reduced rates of reproduction. This stock has been crossed with other, more common commercial stocks in an attempt to integrate this useful trait into other bee strains.

Biopesticides

Biopesticides are naturally occurring organisms or their by-products, and several have been registered for controlling varroa mites in honey bee colonies. The efficacy of many biopesticides can equal that of conventional chemical pesticides. The delivery of these chemicals, however, can be quite different, and understanding these differences is important to ensure successful control of varroa.

Apilife VAR. This product contains a combination of the essential oils thymol, eucalyptol, and menthol. It has been approved by the U.S. Environmental Protection Agency (EPA) for use in North Carolina to treat both varroa and tracheal mites. Several studies have shown that if used as instructed by the manufacturer, it destroys between 65 and 97 percent of the varroa mite population within a hive. The delivery medium of this product is a vermiculite tablet, which must be broken into four pieces and placed in the four corners of the hive between the brood chambers. Each piece must be wrapped in wire mesh to prevent the bees from chewing it and removing it from the hive prematurely. New tablets must be used every week for three weeks for complete effectiveness. The effectiveness of Apilife VAR depends on the temperature. This product can be used effectively only in temperatures above 60°F and below 90°F. It may cause significant mortality of bee brood, thus it may be most useful as a fall treatment when brood rearing naturally declines. Though Apilife VAR is considered an organic pesticide, it is a restricted-use chemical and can only be purchased and applied by individuals who have a valid N.C. Pesticide Applicators License.

Sucrocide. The biopesticide sucrose octanoate, derived from the tobacco plant, has recently been developed for varroa control under the trade name Sucrocide. It is delivered by spraying adult workers with the substance once every week for three weeks to kill mites as they emerge from brood cells. Some recent studies have shown that it is highly effective at killing mites when applied properly, but other studies sug-

Figure 4. Apilife VAR. *N.C. State Apicultural Program*

gest a more moderate level of control. This method requires significant time, labor, and hive manipulation, making it difficult to use in large-scale beekeeping operations. Nonetheless, it is a good alternative to other control methods that are either less effective or that utilize more stringent pesticides, particularly when dealing with only a few hives.

Formic acid. The EPA has recently permitted the use of formic acid for the control of varroa mites in the U.S. (under the trade name Mite-Away II). This method has been used by beekeepers in Canada and Europe for many years, and it is the only chemical pesticide that can be used for organic honey production. There are several delivery methods for formic acid, such as placing pads soaked with liquid formic acid on top of the hive. The product cannot be used during a honey flow, and the daily high temperatures must be between 50°F and 79°F. If temperatures exceed 82°F during the first week of treatment, it must be removed from the hive as it may result in significant losses of brood and adult bees. In small colonies (fewer than 6 to 20 frames), the bees can be overwhelmed by the fumes. Care must also be taken by the beekeeper while applying formic acid, as it is highly corrosive and poisonous to humans. The proper precautions must be taken to avoid exposure.

Chemical (synthetic pesticide) treatments

Conventional means of varroa control involve synthetic pesticides being administered to a colony by placing plastic strips impregnated with the active chemical within the hive. While these treatments have traditionally provided very high levels of control, the varroa mite is becoming increasingly resistant to these chemicals, which makes them less reliable in some areas.

Apistan. One of the first pesticides to be registered by the EPA for the control of varroa mites was Apistan, with the active ingredient fluvalinate, a synthetic pyrethroid. It is sold as a plastic strip impregnated with the pesticide, and the strips are hung between the frames of a hive just outside of the brood nest. Fluvalinate is a contact pesticide and provides up to 100 percent control of varroa mites when properly used. In recent years, however, there have been increasing reports of varroa mites developing resistance to this pesticide. It is highly recommended, therefore, that Apistan be rotated with other treatments to reduce the development of resistance to chemical control by the mites and to ensure its efficacy.

Checkmite+. The EPA registered another synthetic chemical as a Section 18 emergency-use pesticide for varroa control. Checkmite+, the trade name for coumaphos, is also sold as a plastic strip impregnated with the active pesticide. When the bees and mites come into contact with the pesticide, it can provide up to 100 percent control when used properly. Coumaphos is a member of the organophosphate group of pesticides, and residues can accumulate in wax and be harmful to bees at high levels. As with Apistan, there have been documented cases of varroa mites developing resistance to this pesticide, so it is important to use it according to label directions and to alternate its use with other approved treatments. Checkmite+ is also registered for the control of the small hive beetle (*Aethena tumida*), and its sale in North Carolina is restricted to those individuals who have a valid N.C. Pesticide Applicators License.

Figure 5. Administering chemical pesticides. *N.C. State Apicultural Program*

SUMMARY

1. Varroa mites are currently the greatest pest threat to honey bees and their colonies, and infested colonies will probably perish if action is not taken to control the mites. Thus, they are a significant threat to a beekeeper's income and satisfaction.
2. Monitoring hives for mite levels enables beekeepers to determine whether treatment is necessary and to make informed decisions about when to take action.
3. The exclusive and continual use of one chemical product is more likely to result in resistance by the pest. Several different products should be used on a rotating basis.
4. **Do NOT**, under any circumstances, **experiment with nonapproved chemical treatments. Such practices are *illegal*** and may result in bee death, the contamination of honey and wax, and severe harm to the beekeeper.
5. Because of the inherent risks with the use of chemical pesticides, and the fact that some of the available treatments can only be obtained by individuals with a current pesticide certification, it is recommended that all beekeepers receive training and certification through the N.C. Department of Agriculture and Consumer Services (NCDA&CS) Pesticide Licensing Program.
6. For additional information or assistance, contact your local NCDA&CS bee inspector, your local county Cooperative Extension center, or the Apicultural Program at North Carolina State University: **http://entomology.ncsu.edu/apiculture**

Table 1. Management practices for varroa mites in honey beehives.

Management Method	Chemical (if applicable)	Relative Effectiveness	Degree of Manipulation	Other Pests Controlled	License Required
Screened bottom board	—	Low	Low	—	—
Drone brood trapping	—	Moderate	Moderate	—	—
Inert dusts	—	Moderate	High	—	—
Mite-tolerant stocks	—	Moderate	Low	TM‡	—
Apilife VAR	Thymol	Moderate-High	Moderate	TM	Yes
Sucrocide	Sucrose octano-ate	Moderate-High	High	—	—
Mite-Away II	Formic acid	High	Moderate	TM	—
Apistan	Fluvalinate	High*	Low	—	—
CheckMite+	Coumaphos	High*	Low	SHB	Yes

** In areas where resistance has not developed; TM=Tracheal mite; SHB=Small hive beetle;*
‡ For Russian strain only

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For access to online Beekeeping Notes, visit the following Web site:
http://www.cals.ncsu.edu/entomology/apiculture/Beekeeping_notes.html

Recommendations for the use of chemicals are included in this publication as a convenience to the reader. The use of brand names and any mention or listing of commercial products or services in this publication does not imply endorsement by North Carolina State University, North Carolina A&T State University or North Carolina Cooperative Extension nor discrimination against similar products or services not mentioned. Individuals who use chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage regulations and examine a current product label before applying any chemical. For assistance, contact an agent of North Carolina Cooperative Extension.

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