Beekeeping for Extension Agents: Fundamentals, Crop Pollination and Pest Management

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Honey bees have been managed by humans for thousands of years, primarily as a source of honey. Today we know that honey bees are most valuable as pollinators of many important crops. Unfortunately, over the past two decades beekeeping has become more difficult and expensive as several new pests have emerged. Agricultural educators should be kept informed on the most recent advances in honey bee pest management. This publication provides an update on the tools and techniques for managing honey bee pests with an emphasis on the *Varroa* mite, as well as basic information on honey bee biology and beekeeping, and the role of honey bees in crop pollination. The information reflects conditions in the southeast US and exact timing of events and manipulations can vary based on local weather conditions.

The Honey Bee Colony

Honey bees are social insects, existing in colonies that consist of tens of thousands of individuals. A colony is made up of three castes: a queen, workers and drones. The queen is the "mother" of the colony. She lays eggs (all of the workers and drones in a colony are her daughters and sons) and emits pheromones which "tell" the workers whether she is healthy or not. A queen may live for several years, although beekeepers interested in maximum production may replace queens every year. Like the queen, workers are females and, as their name implies, do all the work to maintain the colony including cleaning, feeding the bee larvae, guarding the colony and foraging for food (nectar and pollen), water and propolis (bee glue which is made from plant resins). Drones are males; their important role is to mate with virgin queens. At the end of the season as the weather cools and food becomes scarce, drones are expelled from the colony by workers.

Queen (in circle) surrounded by workers

A healthy colony with a healthy queen is most actively growing in spring when plenty of nectar and pollen is available. By mid-summer a colony usually contains over 50,000 workers, however, by late summer or early fall, egg production is reduced or stops. A colony entering winter should have adequate honey stores (and sugar syrup, if they have been fed) and cluster size (worker population) to survive the many cold days ahead. Inadequate food stores, small cluster size and/or a pest infestation may spell doom for the colony during winter.

Beekeeping Basics

To fully appreciate beekeeping, you should become familiar with the fundamentals of honey bee colony management. Although pest management is necessary to maintain healthy bee colonies, there are many other aspects of beekeeping that are just as important. The purpose of this section is to expose you to some of the most important beekeeping principles and practices.

Obtaining colonies. There are several ways for beekeepers to obtain colonies. Entire colonies can be purchased [the bees including the wooden ware (hive) that holds the colony], or they can purchase a package of bees which is 3 to 5 pounds of workers plus a young, laying queen. The package is installed in existing wooden ware. A nucleus or nuc colony, which consists of several frames containing bees, laying queen, bee brood (immature bees) and usually some pollen and honey stores, can be purchased. Or a colony may be started by collecting a swarm. Packages

About to install a package of bees (in circle) and nucs should be established in the spring to allow them to grow to a size large enough to survive the winter.

Apiary location. Care should be taken in choosing the location for an apiary (bee yard). An ideal location should be accessible by vehicle (hives are heavy), be near food sources and a clean water source (but not in a low, damp area), have windbreaks (but still have good air circulation), face the east for morning sun, and have afternoon shade. Human interactions should be minimized; bees shouldn't be located where humans can walk into the bees' flight path. Fences of wood or shrubbery can be used to direct flight up and away.

Equipment. Of course, wooden ware (hive bodies, frames, inner and outer covers and bottom boards) is essential for keeping bees. Other basic required equipment includes protective gear (gloves, veil and/or bee suit), a hive tool, a smoker, smoker fuel, and matches or a lighter. Smoke is used to calm and manipulate bees while working with a colony. Other items that may be needed in the apiary are extra frames and hive bodies, queen excluders, entrance reducers, jars or sealable bags to collect bees for mite testing or comb for disease identification, queen cages and marking paint, a sting kit (Epipen™) for allergic reactions (use with caution under a physician's direction), first aid kit and other medications for the beekeeper. Most of these items can be purchased from beekeeping supply companies which are listed on the UT apiculture webpage (http://eppserver.ag.utk.edu/Bees/test).


Using a smoker to puff smoke into a hive entrance


Two commonly used types of hive tools

Colony management. Basic beekeeping activities and when they are usually performed appear in the table below. (Timing of activities will vary depending on local climate.) Beekeepers are busy year-round. Even during winter they are cleaning and repairing used equipment and constructing new wooden ware. Feeding sugar syrup to colonies can be done throughout the winter, although it is most important to feed in early fall. As soon as weather permits in late winter or early spring (depending on your location), colonies are inspected. Treatments for pests (see pest mgmt. section below) can be applied at this time. Colonies may be united or split depending on their size. Extra hive bodies (supers) are added before the nectar flow begins. During nectar flow and in to the summer, colonies must be regularly inspected to make sure the queen is healthy, and she has room to lay. If she doesn't, the colony may swarm. Hive bodies can be added or the colony can be split into two to provide more space. Honey is usually harvested in early to mid-summer. Pest treatments, if necessary, are made in late summer/early fall. (Do not put treatments on colonies while they are making honey.) Colonies can be requeened from spring until early fall, and are usually fed sugar syrup from late summer to early fall.


Inspecting colonies

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Clean, repair, paint equipment	■	■									■	■
Feed bees with sugar syrup	■	■	■						■	■	■	■
Install packages				■	■	■						
Check for swarm cells; add brood chamber, if necessary			■	■	■	■						
Requeen				■	■	■	■	■	■			
Check queen, brood, colony health		■	■	■	■	■	■	■	■	■	■	
Add honey supers			■	■	■	■	■					
Harvest honey						■	■	■				
Treat for *Varroa* mites		■	■					■	■	■	■	■
Treat with terramycin (for American foulbrood)		■	■					■	■	■		
Treat for tracheal mites (menthol crystals)								■	■			
Treat for tracheal mites (grease patties)			■	■	■	■	■	■	■	■		
Treat with Fumidil-B (for Nosema)	■	■	■					■	■	■		

The Importance of Honey Bees as Pollinators for Crops

Pollination is the transfer of pollen, the male gamete, from the anther (a part of the male structure of the flower) to the receptive female structure of the flower, the stigma. A pollen tube is formed if the pollen is viable and compatible with the female tissue. This tube grows down into the ovary where fertilization of the ovule occurs, leading to the formation of a seed. The fruit usually forms around the seeds.


Squash yields are substantially increased by honey bee pollination

Many crops require insect pollination to produce an adequate yield; and the yields of some may be increased, sometimes substantially, when honey bee colonies are provided during bloom. Several factors must be considered, however, before a grower pays a beekeeper to move honey bee colonies to a crop for pollination.

- Timing: Bee colonies should be in place just after the crop begins blooming. If bloom of the target crop has not begun, the bees may begin foraging on other (non-crop) plants, perhaps reducing pollination of the target crop.

- Placement: Although honey bees may fly several miles in search of pollen and nectar, they prefer to forage within 300 feet of their colony. Ideally, colonies should be placed in small groups of 4 to 8 colonies with 300 to 450 feet between groups. But this may not be feasible in all field situations. Avoid placing colonies in low, damp areas.

- Colony strength: Colonies should be above a "minimum" size to provide a foraging force necessary for adequate pollination. Colonies provided for pollination may be maintained in one deep hive body with a least one extra super (medium or shallow hive body) on top, or two deep hive bodies with or without extra supers. There should be enough bees to cover at least six to eight deep frames, and there should be at least six deep frames of bee brood. Colony size may be smaller early in the season (April). During warm, sunny weather, flight activity in and out of the hive should be heavy, and returning bees should be carrying loads of pollen on their hind legs. A grower should be allowed to inspect some of the colonies being rented to insure they are of adequate strength.

- Colony number: The number of colonies required depends on the type and acreage of crop being pollinated. Recommended number of honey bee colonies required for improved pollination and yield (based on published research) for some crops that benefit substantially from honey bee foraging follow.

Crop	Average no. of colonies per acre
Apples	1.2
Blueberries	4
Cantaloupe	2.4
Cucumber	2.1
Pumpkin, Squash	1.5
Watermelon	1.3

The yield of cotton, lima bean, muscadines, peppers and strawberry may be improved enough to warrant the renting of colonies for pollination. Some crops, such as corn and tomatoes, benefit little from honey bee foraging, and renting colonies for these crops is not recommended.

- Pesticide applications: Ideally, pesticides, especially insecticides, should not be applied to crops that are in bloom, particularly to those for which honey bee colonies have been rented to pollinate. Insecticides vary in their effect on honey bees. The safest are those with low toxicity (that is, a high LD_{50}) and a short residual time. Many insecticides are toxic to bees when first applied, but degrade within hours to a safer level. Because bees forage only in daylight, pesticides hazardous to bees can be applied in early evening to minimize risk. Also, granules and solutions are safer than wettable powders and dusts. The issue of pesticide applications must be negotiated between the grower and the beekeeper in a pollination contract which is a written agreement signed by a grower and a beekeeper defining specific needs of both to optimize pollination. The contract should require the grower to give the beekeeper a 24- to 48-hour notice of a pesticide application. See UT Extension publication PB 1516, "Making a Pollination Contract," at the UT apiculture webpage (http://eppserver.ag.utk.edu/Bees/test)

Managing Pests of Honey Bees

As you may have noticed, many beekeeping activities pertain to managing honey bee pests. In addition to the *Varroa* mite, there are several pests and diseases that beekeepers must be aware of and, if necessary, treat for. No treatments or medications, however, should be applied or be in place when making honey for human consumption.

Tracheal mites. The tracheal mite, *Acarapis woodi,* is a microscopic parasite which lives in the tracheae (breathing tubes) of honey bees, feeding on the host's hemolymph (blood). Heavy infestations can weaken colonies, making them susceptible to stress. Bee colonies with heavy infestations will usually die during winter. Because they are difficult to detect, beekeepers usually treat prophylactically for tracheal mites with a fumigant, menthol crystals. Fifty grams of crystals, usually purchased pre-packaged, are placed above the brood cluster when temperatures are 60-80° F. Because of temperature requirements, menthol is usually applied in late summer/early fall. Above 80°, crystals are placed on the bottom board beneath the cluster. The treatment period is 4 to 6 weeks, and menthol should be removed 2 weeks prior to making honey for human consumption. A slower-acting treatment is the long-term application of 1/4-pound shortening patties consisting of three parts granulated sugar and one part vegetable shortening. A patty is kept in place on the top of the uppermost brood frames from spring until fall. Patties will have to be replaced during the treatment period. The vegetable oil gets on the bees and is thought to interfere with the mite's ability to detect hosts of suitable age. Tracheal mite-tolerant bee stocks, such as Buckfast and New World Carniolan, are commercially available.


Tracheal mites in honey bee trachea


Shortening patty for tracheal mite control

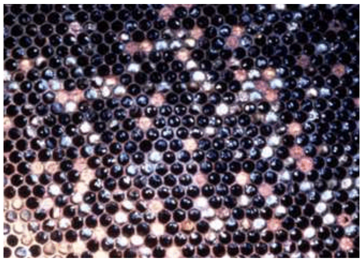
Small hive beetle. The small hive beetle, *Aethina tumida*, is a relatively new pest, discovered damaging honey bee colonies in Florida in 1998. Beetle larvae feed on bee larvae and stored pollen and honey. In strong bee colonies, beetles rarely cause damage; however if a colony becomes weak, due to a failing queen or mite infestation, for example, the beetles become more abundant and may cause the colony to die or abscond (leave the hive). Beetle feces cause honey to ferment and spoil; therefore, harvested honey should be extracted as soon as possible after removal from the colony. Treatment: CheckMite+™ strips (also used for *Varroa* control) are cut in half and attached to corrugated cardboard. This is placed on hive bottom boards. Strips can also be hung near the bee cluster during cooler weather. An insecticidal soil drench (GardStar™) is available for treating the ground around hives where the beetle pupates.


Adult small hive beetle

Wax moths. The greater wax moth, *Galleria mellonela,* is a ubiquitous pest of bee colonies, but does not cause damage in strong ones. If a colony is weakened, wax moth populations increase and the larvae can cause significant damage to wax comb, destroying entire frames. Stored comb is most susceptible. Moth crystals (NOT moth balls), para-dichlorobenzene, are placed in supers of empty stored comb to kill existing wax moth adults and immatures and to prevent infestation. There are no live-colony treatments. Maintaining healthy, strong bee colonies is the best defense.

Wax moth larva, adult and damage

American foulbrood. American foulbrood (AFB) is a disease of bee larvae caused by the bacterium *Paenobacillus larvae*. Symptoms include a spotty brood pattern; concave, punctured capped brood cells; discolored larvae; dried, shrunken brood (called scales) stuck tightly onto the bottom of cells; and an unpleasant odor. The disease is spread by long-lived, hardy spores transmitted by bees, on beekeeping equipment, in honey and in other ways. Because of spore persistence and the disease's devastating effects, the recommended action for American foulbrood is burning of the infested colony, including bees and woodenware.


Honey bee brood infected with American foulbrood

AFB can be prevented with treatments of the antibiotic terramycin, sold as TM25™ or Terramycin Soluble Powder. Terramycin can be applied as a powder or in shortening patties. Treatments are usually made in March and again in October. To apply as a powder, combine an entire TM25™ packet with 2 lbs. powdered sugar to produce enough to treat 12 colonies (3 dustings of 1 oz. each made at 4-5-day intervals). Shortening patties are made by mixing an entire TM25™ packet with 4 & 3/4 cups granulated sugar; this is then mixed with 1 & ½ cups vegetable shortening to make 12 patties. One patty is used per colony and treatment period. Premixed terramycin/sugar powder and shortening patty formulations are commercially available.


A terramycin/sugar powder application for American foulbrood

AFB resistance to terramycin is increasing. We caution its routine use as a preventative when there has not been any recent incidence of AFB in the local area. Honey for human consumption should not be produced for 30 days after terramycin treatment. Bee stock selected to be hygienic (remove diseased and dead brood), such as the Minnesota Hygienic bee, is commercially available to reduce incidence of AFB.

Nosema. Nosema, caused by the spore-forming protozoan *Nosema apis*, is an infection of the adult bee's digestive tract. Damage to the digestive tract produces dysentery, causing bees to defecate on the outside of the hive, and in severe cases, on the inside. Workers become weak and less food is collected. Queens' egg production and life span are reduced. Infected colonies produce less honey and may perish during winter. An antibiotic, Fumidil-B™, is fed to bees in sugar syrup as a preventative. Strong colonies with young, vigorous queens and plenty of honey is the best defense against winter mortality due to Nosema.

Symptom of Nosema infection: a feces-stained hive

Other pests. Other diseases affecting honey bees are European foulbrood (EFB), sacbrood and chalkbrood. EFB, caused by a bacterium, affects larvae (especially young larvae), causing them to turn yellowish, then brown, and finally grayish-black before dying. It is usually not prevalent enough to warrant concern or treatment. Sacbrood, caused by a virus, affects older bee larvae. Larvae change from pearly white to dull yellow or gray, and finally to black. The head of the larva becomes black and larvae die in a stretched-out position with their heads raised. The body appears to be filled with fluid. Sacbrood is rarely a problem as workers usually detect and remove diseased larvae quickly. Chalkbrood is caused by a fungus and kills older larvae. The fungus fill the dead larva with white filaments (mycelium) giving the cadaver a white, chalky appearance with black splotches. Chalkbrood can be a problem, especially in humid areas. It can be reduced by improving air circulation in the colony and/or requeening with a young, vigorous queen .

Head of bee larva killed by sacbrood

Vertebrate pests include mice and skunks. Mice enter hives, usually in winter, and can cause severe damage to comb by feeding and nest-building. Hive entrance reducers or covering entrances with screen will prevent mice from entering colonies. Stored comb should be "mouse-proofed" as well. Skunks feed on bees as they come to hive entrances to defend the colony. A persistent skunk can cause substantial worker mortality, induce greater defensive behavior and damage the hive entrance when it paws on it to attract workers. Skunks may be trapped and relocated, or killed in severe cases. Placing hives a least a foot above the ground will expose the skunk's sensitive belly as it paws at the hive entrance, making it more susceptible to bee stings.

Managing *Varroa* Mites

The Varroa mite, *Varroa destructor*, is the most damaging pest to honey bees in the United States and most of the world. Since its discovery in the U.S. in 1987, the pest has spread rapidly throughout the country aided by the movement of infested, commercial honey bee colonies. *Varroa* is so widespread and its affect on bee colonies is so serious that beekeepers must routinely treat or their colonies will likely perish. Resistance to traditional chemical miticides has developed in recent years. Fortunately, the number of management tools and strategies for *Varroa* has recently increased, providing beekeepers with a wider array of options for more sustainable mite management. Here we provide an update on *Varroa* management options, and information on the pest's biology, the damage it causes and how infestations can be detected and monitored.

Biology

Varroa is an external parasite, feeding on the hemolymph of immature (brood) and adult bees. They live either on adults or within brood cells. A mated, adult female mite (called a foundress) enters a worker brood cell 15 to 20 hours prior to capping (40 to 50 hours pre-capping for drone brood) and feeds on the larva after the cell is capped. She lays her first egg about 60 hours later and may lay as many as six eggs at 30-hour intervals. Her young feed on the bee prepupa and pupa, taking 7 to 8 days (females) or 5 to 6 days (males) to mature. Mating occurs in the capped cell. Although several eggs are laid, the average number of mature, viable female mites produced per foundress in a cell is less than two.

Adult *Varroa destructor* on honey bee pupa

When the bee emerges from the cell, the new female(s) may stay attached to the bee or may attach to another bee. They feed on these bees and may stay on them for a few days to a few months depending on the time of year. Eventually they will enter a brood cell to begin the reproductive cycle over again. The original foundress may survive to infest and reproduce in another cell.

Damage

Symptoms of *Varroa* infestation may not be obvious until mite numbers have reached damaging levels. Adult bees parasitized by mites as brood may exhibit deformed legs and twisted wings which is thought to be caused by a virus transmitted by mites. Infested colonies will appear weak, the brood pattern may be spotty, bees may be overly defensive and may be seen discarding larvae and pupae. A colony may abscond (leave the hive) if heavily infested. Colonies entering winter with a *Varroa* infestation may not survive. A colony dying from *Varroa* during the winter may be found with a small amount of dead bees and perhaps a moderate amount of honey. There may be no bees remaining.

Deformed wings caused by *Varroa* feeding on the immature bee

Monitoring

Monitoring (also known as sampling) and detection should be a component of any *Varroa* management program. Beekeepers need to know if their bees are infested and, if so, to what extent. Preventative treatments of legal *Varroa* miticides are used by most beekeepers because prevention insures that losses are kept to a minimum. Treatments may not be needed, however, if *Varroa* isn't present or if mite populations are low. Several methods for determining the extent of *Varroa* infestation are described below, including how to interpret the results of your monitoring in relation to treatments.

Casual inspection. During routine inspection of colonies, *Varroa* adults or symptoms of an infestation such as twisted wings, may be noticed. If *Varroa* are readily seen on bees, or damaged bees are numerous, a heavy infestation is likely and a treatment should be applied immediately. The sampling methods described below are easy to do but require more time and specific equipment.

Ether roll. The ether roll method involves the collection of approximately 300 bees from a hive into a jar, spraying them with two squirts of ether starting fluid, sealing and rolling the jar, and then counting the mites on the side of the jar which have fallen off the bees. Bees should be collected from the brood cluster by raking the mouth of the jar through the bees so that they fall into the jar. Make sure you do not collect the queen. Quickly cap the jar, knock the bees to the bottom, remove the lid and add the starting fluid, and replace the lid. This will quickly kill the bees and cause the mites to dislodge from the bees. Vigorously roll the jar for 30 seconds to collect the dead mites on the side of the jar. Then count the mites. If eight or more mites are found, treatment is recommended.


Varroa adults collected on inside of jar during an ether roll sample

A modification of this method uses powdered sugar, rather than starting fluid, to dislodge mites from bees without harming many bees. The same method described above is used to collect the bees. However, a canning jar should be used so that the solid lid can be replaced with 1/8 inch screen mesh. After collecting bees and capping the jar, 1 tablespoon of powdered sugar is poured through the screen lid and onto the bees. The jar is gently rolled without spilling any of the sugar, then left to sit for a few minutes. Gently shake the sugar and mites from the jar. Brief shaking will recover about 70% of the mites; more shaking will recover 90%. The sugar and mites can be sieved again through a finer screen to separate mites from the sugar and make detection easier.

Capped brood inspection or pupal pull. The inspection of older capped brood (pupae) requires the uncapping of about 100 cells per hive and inspecting them for mites. Older capped brood can be distinguished by the darker color of the capping and by the dark color of the compound eyes of the pupa beneath the capping. Also, drone brood should be used because *Varroa* prefers to infest it rather than that of worker brood. Use worker brood if drone brood is scarce or unavailable. Brood can be uncapped individually with tweezers or forceps; a capping scratcher can be used to uncap several cells at once. Try to inspect brood from different parts of the brood nest. If 10% or more of the cells inspected contain *Varroa*, treatment is recommended.

Using a capping scratcher to inspect capped brood for *Varroa*

Bottom board sticky traps. Another method involves placing sticky traps onto hive bottom boards to collect mites which naturally fall from above. Before inserting the sticky trap, the bottom board should be cleared of propolis and burr comb. A sheet of sticky material, set in a frame, is placed within the hive on the bottom board. Mites drop from above onto the sticky material where they are trapped and counted later by the beekeeper. This method is less time consuming than the others, and does not harm the bees or require disturbance of the brood cluster. But it does require the purchase or construction of the trap and a return trip to the apiary. Traps should be left in place for 3 days. Because mites are collected from the entire colony, colony size must be taken in to consideration when interpreting collection results. Based on our research results, we recommend treatment if 25 or more mites are collected in 24 hours from a medium-sized colony during mid-August to mid-September (using the UT-designed sticky board, seen in photo above). If using a commercially available sticky board, the treatment threshold is 50 mites in 24 hours.


Bottom board sticky trap partially pulled from hive

Treatment Options

Chemical miticides. There are only two synthetic chemical miticide treatments available in the U.S. for *Varroa* control. Apistan™, a pyrethroid (fluvalinate)-impregnated strip, has been used for over 13 years. A similar product, CheckMite+™, an organophosphate (coumaphos)-impregnated strip, became available in early 1999 under a section 18 emergency exemption granted by the EPA. Strips are inserted into the brood cluster (one strip per 5 deep frames of bees) and left in place for 42-56 days (Apistan™) or 42-45 days (CheckMite+™). The strips kill by coming into contact with mites and both provide greater than 95% control of susceptible *Varroa* populations. In recent years, resistance of *Varroa* to both products has become widespread in the U.S. As with all honey bee medications, Apistan™ and CheckMite+™ can not be in place while making honey for human consumption. CheckMite+™ must be removed 14 days prior to adding honey supers.


Inserting CheckMite strip in to cluster

ApiLife VAR™. This product became available to beekeepers in most states in early 2004 under a section 18 emergency exemption. It consists of an absorbent foam wafer containing a mixture of essential oils (plant extracts) including thymol, menthol, eucalyptus and camphor; and acts as a fumigant, directly killing mites or irritating them so that they drop from the bees. A wafer is cut into four equal pieces; a piece is placed in each corner of the top hive body (on the frame top bars). Wafers should not be placed directly above brood. Replace wafers twice at 7-10-d intervals, leaving the last ones on for 12 days. Then remove remaining wafers. Enclosing wafers in 1/8-inch hardware cloth will prevent bees from gnawing on them. Control varies depending on temperature and size of the colony. Best results occur at average daily temperatures of 60 to 70°F. Do not use at temperatures of 90°F or above. Treating smaller, compact colonies (no larger than 20 deep frames or their equivalent) gives better results. It should be removed 30 days before making honey.


Correct placement of Apilife VAR treatment

Sucrocide™. This miticide also became available in 2004. It contains a sugar ester that is diluted with water and sprayed over frames containing bees. Frames must be removed and the bees on each side must be sprayed. All frames containing adult bees must be treated. Sucrocide™ is most effective when brood is not present. If brood is present, the manufacturer recommends three applications should be made at 7-day intervals. Although labor intensive, treatments can be made during honey production, but probably shouldn't be made in cool weather. The product enters the mites' breathing tubes and suffocates them, and dissolves the waxy coating of their exoskeleton. Bees may be killed if Sucrocide™ is applied at greater than recommended concentrations.

Treatment rotation. The constant use of Apistan™ over many years is believed to have resulted in *Varroa* developing resistance to this product. Use a variety of treatments to offset the problems associated with the overuse of one miticide, such as resistance development. For example, to begin a rotation use Apistan™ in the spring, then ApiLife VAR™ or Sucrocide™ the following fall. The next year, use CheckMite+™ in the spring, then ApiLife VAR™ or Sucrocide™ in the fall. Use the same rotation the following year. Because of the way these products kill mites, there is little chance that *Varroa* will develop resistance to ApiLife VAR™ or Sucrocide™.

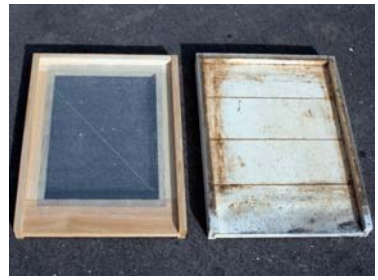
Varroa Management Tools and Tactics

Mite-resistant bees. In response to development of resistance to chemical miticides, and in order to provide more sustainable mite management, honey bees have been selectively bred for resistance to, or tolerance of, *Varroa*. The primary known mechanism of resistance is hygienic behavior which is the removal of diseased (including mite-parasitized) brood by workers.

A Carniolan queen possessing the SMR trait introduced into an Italian colony

Three types of resistant queens currently commercially available are: the Minnesota Hygienic, the Russian and the SMR. The Minnesota Hygienic, as the name implies, has been selectively bred to be hygienic against diseases such as American Foulbrood and against mite parasitism. Russian bees, originating from far-eastern Russia and developed by the USDA, reduce *Varroa* numbers by being hygienic. SMR bees, also developed by the USDA, were once believed to reduce *Varroa* numbers by physiologically interfering with mite reproduction. However, the SMR trait is now considered a more specialized form of hygiene in which resistant workers detect brood cells containing mite families (a foundress and her young) and remove them.

In 2003, production queens possessing resistant traits were commercially available from several queen breeders. However, queens advertised as resistant that we purchased from several producers and evaluated in our apiaries did not always prove to be more tolerant of *Varroa* when compared to non-resistant queens. These production queens (Russians and SMRs) were open-mated, and reduced resistance in their workers (daughters) or the majority of their workers may have resulted from the queen mating with non-resistant drones. But in 2002 we conducted a similar study using instrumentally inseminated SMR queens that produced only resistant workers. Using these queens in combination with other non-chemical management tactics (see the Integrated Management section below) substantially suppressed *Varroa* populations, indicating that resistance can be an effective management tool. Queen breeders may insure they maintain resistance in their queens by improved isolation of mating yards and saturation with resistant drones in or near these yards.



An open bottom board (left) and a conventional closed bottom

Open bottom boards. The use of open bottom boards takes advantage of the natural fall of *Varroa* from the colony to reduce mite numbers by exclusion. Mites continually fall from bees and when exiting capped cells. Many fall to the bottom board where they are likely to re-attach to bees. But if the floor of the bottom board is screened rather than solid the bees will fall to the ground below where they perish. Open bottom boards have been shown to reduce *Varroa* numbers by about 15-25%. And they can enhance the performance of treatments by removing mites that fall from bees during a treatment, but are not killed directly by the treatment (such as with ApiLife VAR™).

Removal of drone brood. The preference of *Varroa* for drone brood can be used to help delay buildup of mite populations. Wax drone brood foundation, which encourages bees to build larger cells and the queen to lay drone eggs, can be purchased. After capping, the entire frame can be discarded, or the brood can be destroyed (with a capping scratcher or by freezing) and the frame can be used again. Drone brood foundation should be inserted in early spring within or directly next to the brood cluster and it must be removed before drones begin emerging. Removing naturally occurring drone brood may not be practical because it is usually scattered throughout the cluster and is not numerous enough to affect *Varroa* numbers if removed.

Apiary isolation. Even if you are diligent about managing your colonies, they can be re-infested if *Varroa*-infested colonies are located nearby. Workers or drones with mites can “drift” to other colonies; and workers from stronger colonies can rob weak, mite-infested colonies, and bring *Varroa* back with them. The greater the distance between apiaries, the less likely re-infestation will occur. This tactic is not always feasible because worker bees may fly several miles from their colony when foraging, and, of course, you probably will have no influence on the management of your neighbor’s colonies.

Integrated management. Reliance on traditional chemical mite treatments may be reduced by using a combination of management tactics. For example, combining resistant bees and open bottom boards may maintain *Varroa* below damaging levels and thereby reduce the number of treatments required. In a 2002 study we conducted, bee colonies that were somewhat isolated (no closer than ½ mile to the nearest apiary), headed by resistant queens and maintained over open bottom boards had greater than 40 times fewer mites than non-resistant colonies over closed bottom boards located adjacent to mite-infested colonies.

Perhaps the most important component of an integrated management program for *Varroa* is monitoring. Before development of resistance to Apistan™, few beekeepers considered monitoring mite populations because they knew this product would provide control. Now control is not certain, and monitoring has become a necessity. At the very least, monitoring should be conducted after treating to determine treatment effectiveness. When using control tactics which require more time to affect *Varroa* numbers, such as open bottom boards or resistant bees, monitoring should be conducted about once a month over the course of a season. Regardless of your management program or mite monitoring schedule, colonies should be sampled for *Varroa* in late August so that if a treatment is necessary, it can be applied and affect mite numbers before cold weather sets in.