PURDUE UNIVERSITY

PURDUE EXTENSION

E-201-W

Beekeeping

Department of Entomology

PARASITIC MITES OF HONEY BEES

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VARROA MITES

Varroa mites (*Varroa destructor*) can be seen on the surface of both adult and immature honey bees, and they can move about quickly. The adult female Varroa mite is a shiny, reddish-brown, shield-shaped object about 1.5 mm wide and 1 mm long (Figure 1). They can be seen crawling on the surface of bees or on hive parts. Sometimes a few dead mites can be found on the bottom board of the hive. They feed on both brood and adults by puncturing the body and sucking the body fluids of the bee. Varroa reproduce in sealed brood cells (Figure 1). They spread rapidly from one hive to another as bees drift into the wrong hive or when bees rob honey from the colonies that are too weak to defend themselves. It is safe to assume that all of your hives have some of these mites!

Current situation

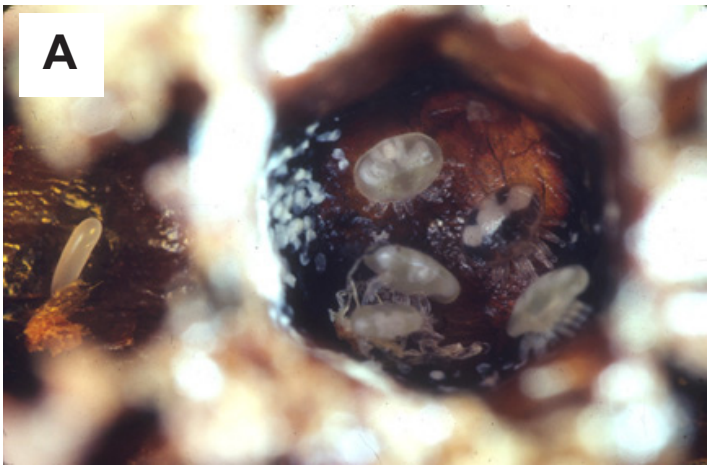
Varroa mites are the biggest problem for beekeepers throughout the world. They are now in every U.S. state except Hawaii. These mites have nearly wiped out the wild honey bee populations that live in hollow trees and other cavities, and, unless hives are treated to control mites they eventually weaken and die.

Where did they come from?

Varroa mites were originally parasites of the Asian honey bee, *Apis cerana*, and were first discovered in the U.S. in Wisconsin in 1987. It seems that the European honey bees we use in the U.S. have little resistance to this pest.

Symptoms of infestation

The symptoms of Varroa mite infestation can easily go unnoticed until it is too late. Although the mites on the backs of bees are large enough to see with the naked eye, they are easily overlooked. During the summer the majority of mites are in the sealed brood cells - especially the drone brood (the larvae that will develop into males). Heavily infested colonies may appear quite healthy at first, and may even produce lots of honey, only to dwindle and die suddenly in the fall or winter. This situation can be accelerated by lack of a nectar



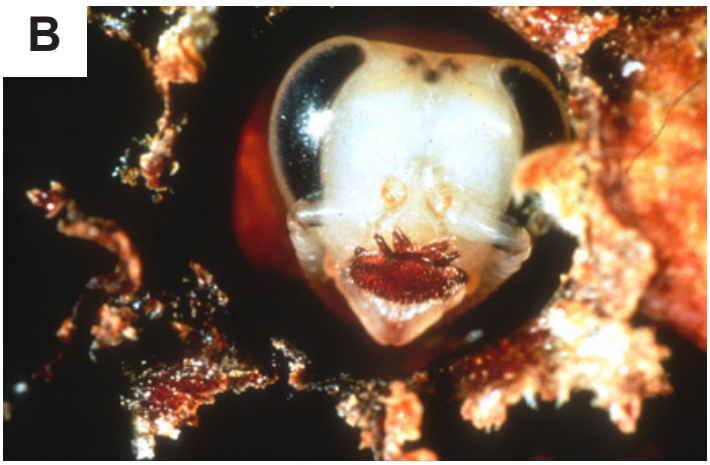


Figure 1. Varroa mites in the brood cells of the bees. A) The cell was uncapped and the honey bee pupa was removed so that you can see immature mites in the brood cell on the right, and a honey bee egg in the cell on the left. The mites must mature before the bee emerges. B) Another cell was opened to expose a mature mite on a honey bee pupa. The pupa has dark eyes and would emerge as an adult in several days. (*Photo credit: Hairy Laidlaw*)

flow from flowers caused by drought or constant rain and cold weather.

You should expect that your queens will stop laying eggs in October or early November. If your colonies have eggs in the cells in late summer or fall but do not have healthy larvae, this could be a sign of "parasitic mite syndrome." Careful inspection of highly infested colonies often reveals unhealthy looking brood, and mites can be seen after removing the cappings of the sealed cells. Bees infested with Varroa mites often have other diseases. Mites increase the severity of diseases such as viruses, European foulbrood, and American foulbrood. Often brood will die in both the larval and pupal stages. The pupal stage occurs after the bees seal the brood cell. If holes are chewed in the cappings of some brood cells, it is probably because the bees smelled dead brood and they are trying to remove it. Bees with deformed wings may be seen, a symptom associated with deformed wing virus. This combination of symptoms is known as "parasitic mite syndrome" (Figure 2). Bee colonies that are not treated for Varroa mites usually die within 1-3 years. When the colony finally dies, the collapse appears to happen rapidly.

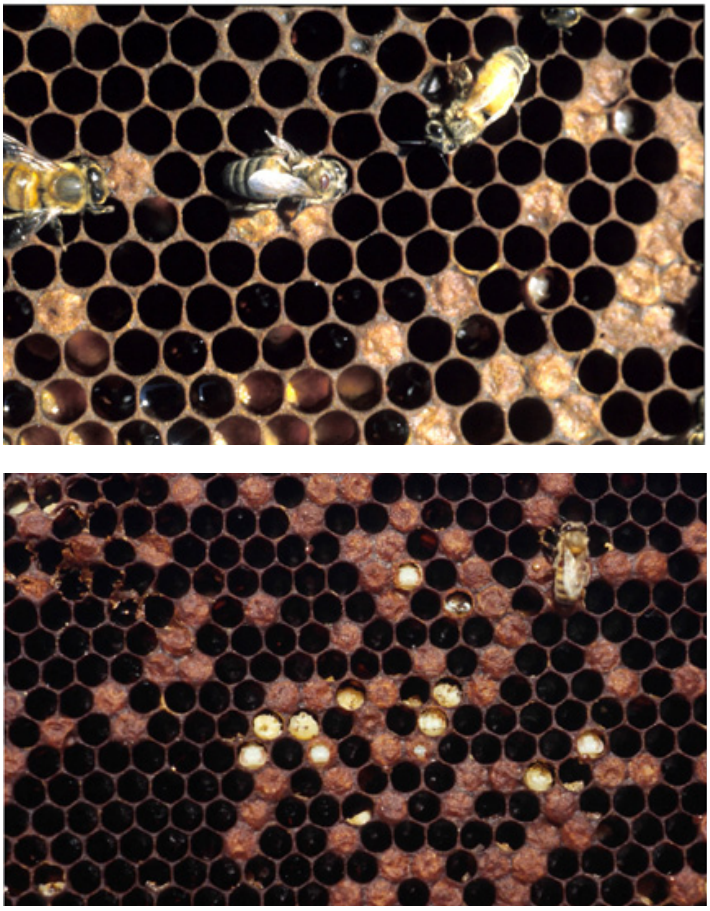


Figure 2. Parasitic mite syndrome. A Varroa mite can be seen on the back of a bee in the upper picture, and two worker bees have deformed wings. The lower picture shows dead brood in uncapped cells, and the brood has been chewed by the bees trying to remove it from the comb. A mite is crawling between cells near the top of the figure. Dead larvae but no live larvae can be seen in this picture, indicating that the bees are unable to rear healthy brood.

Life cycle

The male Varroa mite is about half as large as the female, and is seldom observed. Males and immature mites are found only inside the capped brood cell (the bees cap the cells when the larva is old enough to become a pupa). The immature mites appear white inside the cell (Figure 1A). The female mite enters the brood cell of a 5 day old larva right before the worker bees cap the cell. Then, she immerses herself in the liquid brood food at the bottom of the cell. The honey bee larva eats the food from around the mite. After about 70 hours, the female mite lays the first egg and continues to lay one egg every 30 hours or so. The first egg usually develops into a male, and the other eggs become females. The immature Varroa feed on the body fluids of the immature bee as the bee is transforming into its adult form. In order to survive and reproduce, the Varroa must develop to maturity and mate before emerging from the cell. This maturation takes 5-8 days for a female and a few days less for a male. Usually, 1-4 females develop to maturity and emerge from the cell with the adult bee. The females will ride on the surface of adult bees until it is time to invade another cell and lay eggs.

Our honey bees (*Apis mellifera*) have few natural defenses against the Varroa mite. Their original host, the Asian honey bees (*Apis cerana*) are better able to remove the mites from each other by grooming, and biting the mite. In the Asian bee, the mite reproduces almost completely in the drone brood (feeding on the immature male bees). The Varroa mites that enter worker brood usually fail to reproduce. Reproduction of mites that is limited to drone brood is less harmful to the colony. In our honey bees, which are descended from European races, the mites do have a strong preference for drone brood (see Detection), but they also reproduce in worker brood.

Detection

Uncapping brood

There are several ways to check for mites. Monitoring helps you decide when to treat. If you are not monitoring, the safest practice is to treat with a miticide as soon as you remove honey supers in the summer to control Varroa. It is good to monitor at least 20% of the colonies in each bee yard at least once a year, especially during the summer. Because Varroa are large enough to see, you can look for mites on bees in the hive, but most of the mites are hidden in the brood cells and this is where you should look. When sealed brood cells are present, about 80% of the mites will be in the brood cells and especially in the drone cells. One method consists of uncapping 100 drone cells, removing the prepupae or pupae with tweezers or a cappings scratcher, and counting the mites you see. About 10% infestation is enough to start damaging your colony. Often, drone cells are broken open when you remove the top box because the bees make drone cells in between the boxes (Figure 3). This offers many exposed drone larvae that can be quickly checked for mites.

Ether roll test

The most accurate methods of mite detection rely on taking a sample. A fast method involves trapping about 300 bees in a glass jar that has been fitted with a screen top. Then, spray carburetor starter fluid into the jar. Shake the jar with dead

Figure 3. Drone pupa with adult mites on it. Drones can be recognized because they are larger in size and have larger eyes than workers. Varroa prefer drone cells over worker cells.

bees vigorously, and count the number of mites that stick to the sides of the glass. This method, sometimes called the "ether roll test," is very fast, and gives you a rough idea of how many mites are present. If you see 15 or more mites in the sample, it is probably time to treat for mites (see Control). Varroa mite populations grow rapidly during the summer.

Sticky board test

Probably the best sampling method involves inserting a sticky board at the bottom of the hive (see Figure 4). Mites are constantly falling off and climbing back onto bees, and this method will sample those mites. The method is fairly easy because it can be done without even opening the hive. But it involves two trips to the apiary, and you first need to make a sticky board.

Some sticky boards are commercially available. To make your own sticky board, buy some 3/8 inch wooden door stop material, and make a frame that is almost as big as the hive bottom board but that can still fit into the hive entrance.

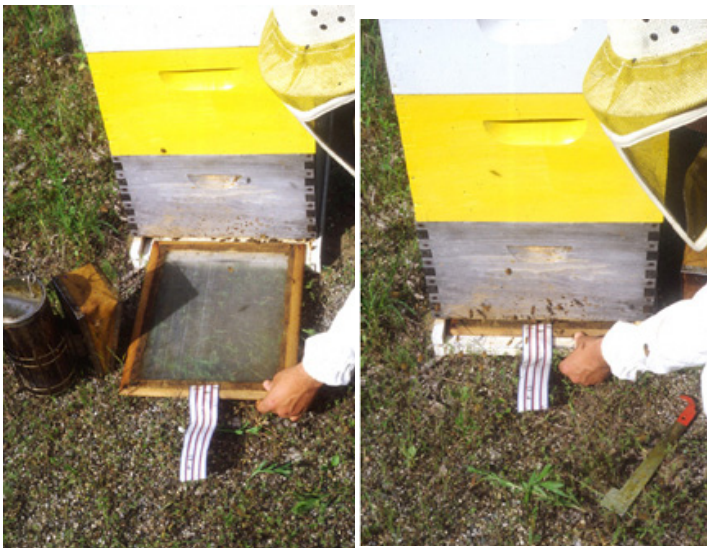


Figure 4. Inserting a "sticky board" to check the population of Varroa mites in a colony.

Staple galvanized, 8-mesh screen to the top of this frame and cover the bottom with clear contact paper (the kind used for shelves). Shove the sticky board into the bottom of the hive and leave it for 24-48 hours to allow mites to fall through the mesh onto the contact paper. Then, remove the whole thing and count the number of mites that fell off the bees onto the sticky contact paper. It is advisable to spray the contact paper with vegetable oil because mites can still crawl on the sticky surface. The oil will suffocate the mites.

The number of mites can be used to decide when to treat your hives. If you see 50 mites or more on any of the hives you checked, you should probably treat your hives as soon as possible. If there are not many mites, you can wait until after the main nectar flow or perhaps until spring. If you test all your colonies and only one or two have this many mites, you may get by with just treating those colonies. When to treat for mites is a decision that should be based on the Varroa mite populations in your colonies, but if you are not monitoring the population you should treat at least once a year.

Control

Some of the control measures are covered here, but other methods are also very effective. Some control measures not covered here are Sucralose, formic acid, and oxalic acid treatments. Oxalic acid treatment appears to be one promising alternative. To learn about these and other methods that may be developed, you should look in beekeeping supply catalogs and in trade journals such as the American Bee Journal and Bee Culture for the most up-to-date methods.

Fluvalinate (Apistan strips)

For a long time, Apistan was the only product registered to control Varroa mites in the U.S. These plastic strips are hung between the brood frames and contain a synthetic pyrethroid compound called fluvalinate. Apistan can be effective for killing the mites without harming the bees. About 90-98% of the mites (that are not protected beneath the cell cappings) are killed within 24 hours when the mites are susceptible.

Unfortunately, mites that are resistant to fluvalinate are spreading and are currently widespread in the Midwest, so in some areas this product is no longer effective. You can test whether Apistan is working in your area by putting sticky boards in the hive before inserting strips and again with the strips in. You should see many more mites falling once the strips are in if it is working. Put one strip for every 5 frames that are covered with bees. This means you may need 1 or 2 strips per box, or just one strip per hive, depending on the colony strength. Keep the strips in hives for as long as the label instructs, so that the mites will be exposed to the miticide as they emerge from the brood cells. Brood cells remain sealed for about two weeks and the mites in those cells are protected until the bee emerges.

Label instructions make it illegal to keep the strips in the colonies while the honey supers are on to prevent contamination of the honey. But you can replace supers as soon as the strips are removed, even in the same operation. The need to avoid having strips in during the nectar flow makes it important to time your Apistan application. Whenever you treat hives for mites, you should treat all of the colonies in an

apiary together unless you have monitored all of them and determined which need treatment. Mites spread rapidly from colony to colony, and some hives will have more mites than the ones you checked.

Coumaphos (Checkmite strips)

Relying on a single compound to kill mites has caused mites to become resistant to Apistan. To solve this problem, Checkmite strips containing coumaphos have been made available (Figure 5). These strips will work to control varroa mites even if they are resistant to Apistan and currently they are very effective. Be sure to use gloves because Coumaphos is an organo-phosphate (a nerve toxin). All of the cautions about not leaving Apistan strips in colonies when the honey supers are on also apply to Checkmite strips, but it is also illegal to harvest comb honey from a hive that had been treated with Coumaphos. Coumaphos can also harm developing queens. Never use checkmite strips in a colony that is rearing queens. The label states that maximum efficacy can be obtained by leaving strips in the colony for 42 days. However, to avoid excessive exposure of this pesticide to the bees and contamination of wax, consider leaving the strips in for just two weeks (the time that brood remains sealed), rather than the maximum time specified on the label.

Figure 5. Checkmite strip hanging between frames. Notice how bees initially avoid the strip.

Apilife VAR and Apiguard

Apilife VAR is a product that contains 74% thymol as the principle active ingredient for killing mites, plus some other aromatic oils. Apiguard contains only thymol as an active ingredient. Although the thymol is a synthetic version of naturally occurring oil of thyme, always wear gloves when applying it because it is somewhat toxic in this concentrated form.

Apilife is usually applied by breaking a tablet into 4 pieces and placing them above the brood nest and in the corners (Figure 6A). When applying Apilife, be sure that extra ventilation holes are taped shut. It may also be advisable to partially reduce the entrance unless the weather is very hot (80-90°F). This product works best when temperatures are moderate (60 to 70°F) and should not be applied when the outdoor temperature is above 90 F. Like all controls that rely on evaporation of the product, the efficacy of control depends on the temperature and ventlilation of the hive. Make sure there are no excess ventilation holes in the hive. Replace the tablets 2 more times about a week apart. When used properly Apilife can give up to 90% control but effectiveness will vary from hive to hive.

Figure 6. Treating a colony with Apilife VAR or Apiguard to kill Varroa mites. A) Apilife application. Break up tablet, and distribute it around the brood nest. Alternatively, enclose the Apilife in an 8-mesh wire screen to allow more airflow around the tablet and makes it easy to remove. The bees will try to propolize them. Replace the Apilife 2 more times about a week apart. It is important to tape up any holes in the colony to keep the thymol vapors inside. B) Apiguard application. Place the open apiguard container on the frames. There needs to be at least a quarter inch above the apiguard, which can be achieved with an empty super or better yet, a wooden rim. Replace the apiguard once more according to directions.

Apiguard is applied in a way that is very similar to Apilife application, except that it is put on in a tray or on a small board above the brood (Figure 6B). As with Apilife, read the label and only apply when outdoor temperatures are in the right range. One advantage of Apiguard over Apilife is that it only needs to be applied twice, one disadvantage is that

one quarter inch of space is required above the top of the tray. This can be obtained by using a wooden rim around the top of the box, by using an old fume board top, or an empty shallow super.

Timing applications

Timing is important for applications to control mites because mite populations grow very fast and you cannot apply miticide when the honey supers are on the hive. Learn when the nectar flows occur in your area by watching your hives and talking to local beekeepers. These flows will vary somewhat in their timing from year to year. The safest practice with Apilife VAR is to treat twice a year, although once in late summer should be enough if mite populations are not too high in the spring (less than 50 mites dropping on the sticky board in one day). Only one treatment is needed with Checkmite. During warm days in the winter when there is little or no sealed brood, Apistan and Checkmite strips will kill more of the mites because they are not protected in the cells. But the residual mites that are not killed can build up rapidly during the summer to damaging levels.

The mite population in hives seems to vary from year to year. The most common mistake that can result in heavy winter losses is to treat too late in the fall. It is a good rule of thumb to try to treat your colonies before September 1. In Indiana, the honey flow often diminishes in early August, and the harvest can be made from Aug 1 to Aug 14. This will vary from year to year, so you need to observe when the honey flow decreases. You can recognize the end of the nectar flow by the decline in foraging activity at the colony entrance and increased tendency for bees to rob from other hives. Some beekeepers can expect a honey flow in September, depending on the location and the weather. Often though, it is possible to take off honey early August, get the mite treatments in the hives, and still get supers back on in case of a fall nectar flow. It is simpler to leave the fall flow to replenish the bees' honey stores so that it may not be necessary to feed them before winter.

TREATMENT THRESHOLD

In order to have timely control of mites, the best way to proceed is to monitor the mite populations with sticky boards or the ether-roll method in the spring, and again in mid summer in all your hives. If the mite levels are low in the spring, you may be able to avoid this treatment. Some recommendations for treatment have been made based on detecting mites with either sticky boards or the ether roll method. For a late season treatment of average-sized colonies (25,000-34,000 bees), you should treat when mite populations reach about 3,000 to 4,000 mites per colony. This translates to treating if you see 15-40 mites in an ether roll or about 50 or more mites dropping onto a sticky sheet in 24 hours with no treatment (Delaplane and Hood 1999).

POSSIBILITY OF MITE-RESISTANT BEES

There are several characteristics that may make bees more resistant to the Varroa mites, among them are:

1) Development time: There is a small amount of variation between bees for the duration of the capped stage of the brood. If the bees develop faster, fewer mites will make it to maturity and the mite population will grow slower.

2) Grooming behavior: Some bees are better at grooming the mites off of each other and will actually bite the mites.

3) Hygienic behavior: It is possible to select for bees that have good hygienic behavior - the tendency to remove diseased or dead pupae from the comb. Some bees can detect Varroa infested pupae and will remove those pupae. It is desirable to obtain queens with good hygienic behavior. This is one trait that is selected for by some commercial queen breeders and you can select for this trait if you raise your own queens. The best method involves freeze-killing sealed brood and returning it to the bees to clean out.

You can observe the proportion of the killed brood the bees remove within 24 hours. Buying queens from local queen breeders that try to select for good traits increases the chances that you will have queens that are adapted to local conditions and that can better fight off the mites. There has been some progress towards breeding bees that are more tolerant of Varroa mites that partially suppress mite population growth but none of our bees are truly resistant. Mite-tolerant bees may allow us to reduce the use of chemical treatments, but the treatments are still necessary at this time.

TRACHEAL MITES

Tracheal mites (*Acarapis woodii*) are microscopic internal parasites. The honey bee, *Apis mellifera*, and the Asian honey bee, *A. cerana*, are the only known hosts of this mite. They primarily infest the largest breathing tubes, or tracheae, near the base of the bee's wings. They only infest adult honey bees. The mites feed by puncturing the walls of the tracheae and feeding on body fluids. Mites move from old bees to young bees that have just emerged from their pupal cells. Mite-infested bees have shorter life spans and a reduced ability to keep themselves warm during the winter months. These mites can cause winter die-offs of honey bee colonies if most of the adult bees become infested.

Current situation

It is not clear how serious the problem caused by tracheal mites is now. Because of the microscopic size of these mites, infestations usually go undetected by the beekeeper. If more than 20% of the bees in a hive are infested, treatments to control the mites are beneficial. Many stocks of bees have colonies that seldom exceed 15% infestation by mites and require no treatments (see "mite-resistant bees"), but some susceptible colonies are found in nearly all stocks of bees. It is difficult to see the mites because you need to remove the head of the bee and observe the trachea (the bee's breathing tubes) with a microscope.

Where did they come from?

Nobody knows how tracheal mites first came to parasitize bees. The first report of this mite was in 1921 on the Isle of Wight in the English Channel. Their discovery led to the passage of the Honey Bee Act of 1922, which forbids the importation of any honey bee into the United States. (But imports are allowed from Canada, and world trade agreements recently are providing other exceptions to this law.) The first U.S. tracheal mites were found in 1984 in Texas near the Mexican border, and it is likely that they entered the U.S. from Mexico and then quickly spread nation-wide through sale of queens and migratory beekeeping.

Tracheal mite life cycle

Tracheal mites feed by puncturing the tracheal walls and sucking on the body fluids of the bee. They are found in the tracheae of the thorax that you see when you remove the bee's head. Healthy tracheae appear white, but heavily infested tracheae can become discolored. When mature tracheal mites move to a new host, they have a strong preference for young bees less than 24 hours old. Bees that are more than 3 days old are almost immune to being invaded by tracheal mites, but once a bee has mites inside of it the numbers of mites can increase because mites lay eggs within the tracheae of the bee. The proportion of bees that are infested increases when the foragers are confined in the hive during the brood-less period of the year. This situation causes fewer young bees to emerge that could serve as new hosts, and those that do emerge become heavily infested. These two situations occur during the cold months of the year. Infestation levels become very low in summer.

Symptoms of infestation

You should examine bees from November to February. You can only make reliable diagnoses of tracheal mite infestations by microscopic examination of the tracheae, after removing the head of the bee. The tracheae of bees normally appear white, and the mites inside also appear white or transparent. The body of the mite is oval and appears shiny and transparent. Long, thin hairs are present on the body and legs. These hairs are used in moving about in the hairs of the bee when the mites leave the tracheae. The mite has long, beak-like mouthparts for piercing and feeding on its host. The mites live almost exclusively in the largest pair of the bee's tracheae that provide air to the thorax and flight muscles. In highly infested bees, a dark brown staining of the tracheae can sometimes be seen with the naked eye. Infested bees may have disjointed wings, showing what's been called a "K-wing" appearance. They may have a swollen abdomen and be unable to fly. However, they may show no symptoms, and other diseases may show these same symptoms, so microscopic examination is required. Heavy infestations in the winter cause the death of the hive and can be mistaken for symptoms of Varroa infestation.

Detection

With the proper equipment, the procedure for examining bees is not difficult, but it takes time. It is best to use a dissecting microscope. You may sample bees that are crawling in front of the hive, foragers at the hive entrance, or bees from the winter cluster inside the hive. If they are not going to be examined right away, put the bees in rubbing alcohol or ethanol. Do not collect dead bees for examination. You can pull the head of the bee off, along with the prothoracic collar (the segment just behind the head) and you will see mites in the large tracheae inside the thorax.

Another method is to remove the head and cut the front part of the thorax to give you cross sections of the thorax. The large thoracic tracheae are in the thorax. Incubating samples in 8 percent potassium hydroxide solution (KOH) overnight makes the mites easier to see because it clears the surrounding tissue. Studies in Canada suggested that if more than 15% of the bees in a colony are infested with tracheal mites, the colony should be treated to control the mites. Below 15%, there is no need for treatment. In Louisiana, one study suggested that the threshold for treatment should be 25% infestation. Probably 20% is a good treatment threshold for the Midwest.

Control

Since most of our bees now have natural resistance to tracheal mites, a reasonable option is not to control these pests at all. If some colonies die during the winter, simply replace them with new stocks of bees. Some lines of bees are more susceptible than others, though and the situation could change.

Menthol

You can place pure menthol crystals (50 gm) on the top bars of the frames inside the hive when weather conditions permit. The temperature where the crystals are inside the hive should be at least 70ºF during this treatment. Place the crystals above the cluster of bees on top of the frames. In hot weather (~90ºF), put the crystals on the bottom board towards the back of the hive. Elevating the crystals above the frames with a half-inch piece of wood will help to circulate the menthol vapor.

Vegetable oil

Hydrogenated vegetable oil can reduce tracheal mite populations by about 50%. Make grease patties by mixing two parts of powdered sugar with one part of Crisco vegetable shortening. Press this mixture between two sheets of wax paper. Put one patty on the top bars of the frames, with the wax paper. For best results, keep a patty in the hive during the spring, summer, and fall. It appears that the vegetable shortening helps to prevent mites from infesting young bees because the bees with oil do not "smell right" to the mites. Tracheal mite populations are highest in the spring and fall so these are the most important times for control.

Formic acid

Formic acid evaporated from a solution at a concentration of about 60-65% can also be used for controlling these mites. Formic acid is very effective, reportedly giving 100% mite kill. Formic acid can be used at lower temperatures than menthol and gives better control. The daytime temperature should be over 45°F to allow the acid to vaporize and kill mites. Formic acid has the added advantage of controlling Varroa mites at the same time, and should kill most of the Varroa that are not

sealed inside brood cells if properly applied. Multiple treatments will be necessary for good control of Varroa.

Mite-resistant bees

Most stocks of bees are resistant to tracheal mites and do not need treatment. This does not mean that they do not become infested, or that every queen you get from a certain queen breeder will have resistance, but some stocks of bees have lower levels of infestation. Which stocks are resistant can vary from year to year. When tracheal mites were discovered near the turn of the century and were found to cause "acarine disease" of honey bees, Brother Adam of Buckfast abbey began to incorporate many strains and subspecies of bees to produce the Buckfast bee. This strain has some resistance to tracheal mites. Other stocks of bees also are showing resistance to these mites in the U. S. Most of the "new world" Carniolans we tested from one California queen breeder were resistant to tracheal mites.

Because it is possible to find resistance to tracheal mites in many populations of bees, it is advisable to raise your queens from colonies that have low levels of infestation or from colonies that survived harsh winters without treatment for tracheal mites. Buying queens from local queen breeders that select for resistant stocks will increase the chances of getting resistant bees that are adapted to your local conditions.

READ AND FOLLOW ALL LABEL INSTRUCTIONS. THIS INCLUDES DIRECTIONS FOR USE, PRECAUTIONARY STATEMENTS (HAZARDS TO HUMANS, DOMESTIC ANIMALS, AND ENDANGERED SPECIES), ENVIRONMENTAL HAZARDS, RATES OF APPLICATION, NUMBER OF APPLICATIONS, REENTRY INTERVALS, HARVEST RESTRICTIONS, STORAGE AND DISPOSAL, AND ANY SPECIFIC WARNINGS AND/OR PRECAUTIONS FOR SAFE HANDLING OF THE PESTICIDE.

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