DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

POCKET GUIDE TO HONEY BEE HEALTH

MP547P

CONTENTS

Introduction

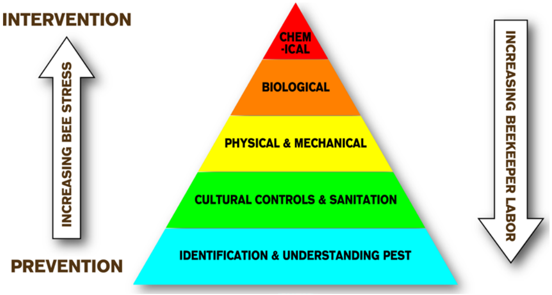
Honey bees and other pollinators have been declining in abundance and species diversity around the world. The term Colony Collapse Disorder was coined in 2006 to describe mysterious, large-scale sudden disappearances of honey bees in North America and Europe. There is no single cause for these declines, but rather a combination of numerous interacting conditions that include parasites, pathogens, poor nutrition, and exposure to environmental pollution and pesticides. Each of these factors can stress individual bees, and their combination results in weakened colonies that may ultimately fail.

Rather than memorizing the symptoms of all potential maladies, beekeepers should understand how a healthy colony of honey bees looks and behaves. New beekeepers should begin with healthy bees in brand new equipment. By starting small and watching colonies grow, a new beekeeper can witness bees drawing comb and storing pollen and honey, and can observe all the various growth stages of honey bee from eggs to adults. Becoming familiar with a healthy colony better prepares a beekeeper to later recognize problems in an early stage, and to intervene before that problem becomes significant.

Beekeepers are encouraged to take an integrated approach to honey bee health. By understanding and minimizing multiple stressors on bees, beekeepers can improve overall colony health and increase hive productivity.

Integrated Pest Management (IPM) incorporates multiple tactics to reduce pest populations while being sensitive to both economics and environmental impacts. This approach integrates multiple tools to find the most effective, least intrusive solution to problems. Because eradication is rarely possible, pests are managed to reduce their negative effects. The overall goal is to improve colony health while reducing dependence on pesticide use. It is not necessarily the same as organic pest control, but many of the same tactics can be employed using strict organic methods.

IPM was developed in response to the over-use of pesticides in agriculture, and the tendency to use them on a calendar schedule regardless of the presence of economically important pests. A combination of IPM tactics reduces the impact of pests, and reduces the impact of pesticides on non-pests. It makes economic sense to treat only when and where pests are a problem. IPM also preserves treatment products for future use by delaying the development of pesticide resistance.



The concept of IPM can be illustrated with a pyramid. Understanding the biology and life cycle of a pest is the foundation for disrupting its reproduction. Also, determining the level of pest or disease present is important for making treatment decisions; therefore sampling the pest population is key.

Cultural controls include beekeeping practices that reduce stress and improve bee health. This begins with placing hives in a suitable environment. Also, management decisions to split, combine, or requeen hives will affect the brood population, and therefore, ultimately, the mite population. Diseases that affect only the brood can also be disrupted by breaking the brood cycle in a colony.

Physical and mechanical controls include any improvements or modifications to hive equipment that prevent or exclude pests, or actively trap pests that have entered the hive. These include screen bottom boards to eliminate fallen mites, and various in-hive traps for small hive beetles. Activities such as drone-trapping of varroa mites, and keeping hives in good physical repair to prevent the ingress of beetles, wax moths, and robbing bees are also important components of physical control.

Biological control includes the selection of genetic stock that can tolerate or resist mites or diseases, as well as nematodes to control small hive beetles pupating outside the hive. Biological control research for mites has focused on fungal and microbial pathogens and the use of mite predators, but delivery and application of these is difficult. Unfortunately no practical biological control agent for varroa mites has yet been discovered.

Reducing pesticide use is a goal of IPM, and so chemical control, at the top of the pyramid, is the smallest tier. When selecting medications and pesticide treatments for in-hive use, consider materials with high specificity for mites but low toxicity to bees, and little potential for chemical residues left behind to contaminate hive products.

The base of the IPM pyramid emphasizes prevention, while tactics near the top emphasize intervention. Though chemical treatment may seem like the easiest solution, these products can also cause physiological stress on queens and colonies. Regularly evaluating hives involves labor, but beekeepers should remain aware of colony conditions and keep pest and disease levels low throughout the season to minimize the need for chemical intervention.

There are many sources of stress that affect honey bee health. Reducing the impact of these hive stressors at every level, and all season long, will result in stronger, more productive colonies with healthier bees that will be better able to take care of themselves.

Parasites and Pathogens

A primary enemy to honey bees is a complex of damaging parasitic mites and the viruses they can transmit. Outbreaks of other pathogens, including bacteria and fungi, can also affect bee health. Overuse of medications causes mites and bacteria to develop resistance to medications, which makes them harder to control. Beneficial microbes inhabit the digestive system of honey bees and competitively exclude pathogens. These beneficials may be negatively affected by medications or pesticide exposure.

Honey Bee Nutrition

The availability of quality food in the landscape affects honey bee health. High floral diversity throughout the year supports the healthiest bees. Natural environments are rapidly being replaced by heavily managed urban areas that may offer reduced floral resources. Agricultural areas may offer large areas of forage for short times, but with severely limited diversity, and high potential for pesticide exposure.

Pesticides and Pollution

Both agricultural and urban areas contain risks of chemical exposure to foraging bees. The dangers of these products varies with the toxicity of the ingredients, formulations, application procedures and drift onto non-target areas. Outside contamination of hive products (wax, honey, pollen) is possible, but the highest levels of detectable contaminants come from products applied in the hive by beekeepers. Over-use of miticides and antibiotics within the hive, as well as misuse of legal products and the off-label use of non-approved chemicals, can all affect honey bee health.

Climate and Weather

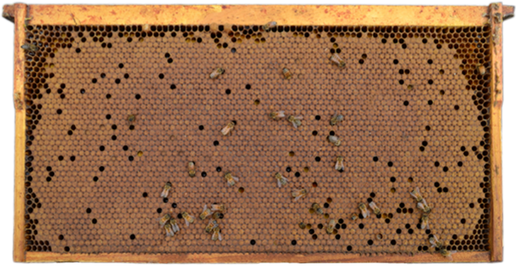
Climate and local weather conditions affect the bloom period and food available for honey bees. Long-term changes in climate and weather patterns will have significant effects on bee health due to changes in resource availability. Unusually wet periods mean that bees cannot fly out to forage, reducing stored resources. Bees consume more resources than they are gathering during periods of prolonged drought. Unusually warm winters lead to increased bee activity and brood rearing during months with little or no floral resources, potentially depleting winter stores early, and causing winter mortality.

Beekeeper Practices

Beekeepers need to make conscious choices to reduce colony stress from all sources. Actively monitor and manage varroa mites and other hive pests and diseases, ensure bees have access to sufficient quality forage, and locate hives in areas protected from pesticide drift.

Reading the Brood Pattern

When inspecting a colony, examination of the brood nest should give satisfactory evidence of queen quality and overall health of the colony. The capped brood is the easiest to see, and therefore its appearance can be used to evaluate the egg production (and the overall quality) of a particular queen.



A **solid brood pattern** indicates a competent, well fed queen has placed an egg in nearly every cell. A few empty cells are expected, as some may not have been clean when the queen was laying eggs, or these could be due to hygienic bees removing pupae infested with varroa mites. As mature brood begins to emerge, it should do so in an obvious pattern, following the ordered pattern where the queen deposited eggs.

A **spotty brood pattern** has numerous random empty cells, lacking pupae, which are not the result of systematic adult emergence. A poor brood pattern may suggest a brood disease, a heavy mite infestation, or an inbred queen. The appearance of spotty brood should prompt the beekeeper to look closely into individual cells for more clues about the problem.

Parasitic Mites

Asian honey bees are natural hosts to several species of parasitic mites. Movement of European honey bees around the world has put them into contact with exotic parasites and pathogens for which they have little or no natural resistance or tolerance, and has helped to spread new pests around the globe. Mites attack and feed on honey bees, physically weakening them and impairing their immune systems, while vectoring viruses and other pathogens. The result is a mite-virus complex that can be more dangerous to bee health than either mites or viruses alone. Because there are currently no practical treatments for honey bee viruses, managing for low mite populations is the best strategy to limit the effects of these bee viruses.

Varroa Mites

The varroa mite (*Varroa destructor*) is considered the greatest threat to honey bees and beekeeping in most of the world, and are widespread across the U.S.

Photo by Gilles San Martin (flickr.com/photos/sanmartin).

While only about 1/16" wide, these parasites are very large in proportion to the body size of their host, and can have a severe impact on honey bee health.

Varroa mites spend most of their lives hidden in cells, and even if they are not apparent, beekeepers should assume they are present. These external parasites feed on fluids and protein reserves in adult honey bees and pupae, and reproduce exclusively within sealed brood cells. Mites severely weaken the developing pupae, and their feeding introduces viruses.

Photo by Gilles San Martin (flickr.com/photos/sanmartin).

Photo by Stephen Ausmus, USDA-ARS.

Life Cycle of Varroa

The life cycle of the Varroa mite has two phases. During the **phoretic** stage, mated female mites attach themselves to adult honey bees, and are carried through the hive. Phoretic mites must enter a honey bee brood cell to begin their **reproductive** phase.

A mature female mite, called a foundress, enters a brood cell just prior its being capped. Once sealed inside, the mite will lay eggs. The first is always male, followed by several female eggs over several days. The foundress opens a feeding wound on the bee pupa, often infecting it with viruses she carries. Offspring hatch and mature, feeding on the same pupa, removing nutrients from the developing bee and picking up viruses that they can later vector to other bees. Sibling mites mate within the brood cell.

When the adult bee emerges, the foundress is released along with her mature female offspring. Male mites and immature females remain in the cell to die, and are removed by housecleaning bees. A male's entire life is spent in the capped cell. Mites that emerge will quickly seek a host bee, which they recognize by odors. Phoretic mites prefer middle-age nurse bees that tend late-stage brood, increasing opportunities to invade larval cells just prior to capping.

Varroa mites prefer drone brood over worker brood. Drone cells remain capped for 15 days, while workers develop in 12 days, allowing for higher reproductive potential in drone cells. Varroa infesting worker brood have an average of 1.5 mature female offspring, while mites on drone brood average 2.5 daughters. Therefore, limiting excess drone comb within a hive can limit the population growth of Varroa mites.

When brood is available, varroa typically spend 4-5 days in the phoretic stage before seeking a suitable cell for reproduction. Mites spend the majority of their lives in the reproductive phase, sealed protectively inside brood cells. However, most treatment options affect only the phoretic mites. Understanding the life cycle of varroa mites is key for beekeepers to effectively treat hives and manage varroa infestations.

Varroa Management Options

So-called **hard chemicals** were among the first successful treatments that U.S. beekeepers found when varroa first appeared in the late 1980s. Synthetic miticides such as pyrethroids and organophosphates act on the central nervous system of the mites. They were formulated for hive use by impregnating plastic strips with pesticides. Strips were placed between brood combs, and phoretic mites were killed as adult host bees contacted the material.

These strips were convenient to apply and reasonably economical for beekeepers to use. However, over-use quickly led to resistant mites requiring more frequent or stronger treatments. Many miticides are also easily absorbed by beeswax with each repeated use. While not readily water-soluble, miticides do not easily leach into honey, but they do accumulate in the wax over time. Because bees and mites develop in beeswax cells, they are both potentially exposed to increasing levels of chemical contamination in older combs.

Bee health can be affected by this exposure, potentially impairing their immune system response, shortening the lifespans of workers, and reducing fertility in both queens and drones.

Due to over-dependence on a narrow range of chemistry, populations of varroa are largely immune to some chemical treatments. Particularly, tau-fluvalinate (Apistan®) and coumaphos (Checkmite®) may no longer be effective treatments in some places. Products containing amitraz (Apivar®, Amiflex®) remain effective at this time, but over-reliance on a single product will potentially render it ineffective as well. To prevent resistance, beekeepers should rotate treatments each time they are required. By alternating products with different modes of action, pests are less able to rapidly develop tolerance than when a single product is used repeatedly.

When using any pesticide product, ***the label is the law***. Read and follow all product directions, including the instructions for removing the product from the hive after a prescribed period of time. This period is often 42 days, or two brood cycles, which insures that mites sealed in brood cells will be exposed to a treatment product at least once, during their brief phoretic phase Following recommended timing insures the product is removed from the hive before it dissipates, exposing the mites to a weak dose, which they are more likely to survive and pass on resistance traits to their offspring.

Due to problems associated with miticide use, many beekeepers are now choosing treatments with **soft chemicals**, including organic acids and essential plant oils. These naturally-derived compounds can be effective against mites, with limited impact on bees when used correctly. Many commercial products are available in convenient prepackaged doses. Be advised that many "natural" compounds can still be dangerous, or even deadly, to bees or to beekeepers when used improperly or at the wrong dose.

Organic Acids

Some concentrated organic acids can effectively kill varroa, without impacting bees or affecting the quality of honey. However, if not used properly, these can cause serious effects on bee health, including queen or brood mortality, or complete colony death.

Formic acid is highly effective at killing varroa mites. Available as a prepackaged formulation (Formic Pro®, Mite Away Quick Strip®), it is placed directly on top of the brood frames, and must volatilize in the hive. It is temperature dependent, and should be applied when the outside daytime temperature will remain between 50-84°F for at least 5 days. If too cool, the product will not evaporate effectively, and if used when too warm, it will evaporate too quickly and cause significant brood or queen mortality. Hives should not be opened for at least 72 hours after application. This product must be handled with ***acid-resistant gloves*** (not leather bee gloves) and applicator should wear an appropriate ***respirator***. See product package for specific details. Formic acid is a natural component of honey, and is approved for use in certified organic production. The vapors are also capable of penetrating cell cappings, and is the only treatment known to kill varroa in sealed brood cells.

Oxalic acid is a naturally occurring compound in many plants that can be used to effectively and inexpensively treat for varroa mites. This compound affects only phoretic mites, and may be applied when honey supers are on hives. Oxalic acid treatments can be applied to hives in two ways:

Trickle method: Dissolve 35 grams of oxalic acid crystals in 1 liter of warm 1:1 sugar syrup to make a 3.5% solution. Measure accurately, as a weak solution may not be effective; and a solution that is too strong can damage bees. Using a syringe, trickle or drench 5 ml (1 tsp) directly onto adult bees in each occupied space between brood combs. Do not use in honey supers. This method works best when bees are clustered in cool weather, and no brood is present. Avoid application to the same bees more than once per year. This method may not be appropriate for use in warm climates, where broodless periods are short. Oxalic acid becomes unstable in sugar solution, so unused material should be discarded.

Vaporization method: When heated, oxalic acid sublimates, going directly from solid to vapor. Numerous applicator devices are available to quickly treat bee hives. Prepare hives by removing any honey supers, sealing screen floors and any other cracks in the hives. All burr comb should be removed from solid bottom boards to prevent fires when using an in-hive heater on the floor. Place 2 grams (1/2 teaspoon) oxalic acid crystals in the vaporizer device, insert the applicator into the flight entrance of the hive, cover the entrance with a towel and turn on the device. Follow the directions for your specific applicator. Honey supers can remain on hives during application. Treatment is most effective when broodless, but application can be repeated after 2 weeks if brood is present. Monitor brood nest for signs of damage.

Extended release strips: Use 1 strip (VarroxSan®) for per 2.5 frames of brood, equally spaced around brood nest. Remove after 42-56 days (2-3 brood cycles). Most effective when no brood is present.

Hops Beta Acids are derived from the hops plant (HopGuard 3®). Treated cardboard strips are placed over frames, and phoretic mites are killed as bees contact the material. Bees may remove paper strips once dried. Treatment should be repeated after two weeks. Product is made with food grade materials and can be used when honey supers are on, but works best when no brood is present for an extended period. Follow manufacturer's label directions.

Essential Oils

A number of plant essential oils have acaricidal properties. Concentrated **thymol**, isolated from the thyme plant, is one of the most effective, but it may be formulated with menthol, camphor, eucalyptus, wintergreen oil, or other ingredients in commercial products. These products must volatilize in the hive, and their effectiveness is temperature dependent. Labels list a recommended temperature range, typically between 65-85°F (18-30 C). Place in hives for an initial treatment period, and then replace approximately two weeks later with a second dose to ensure that mites from multiple brood cycles are exposed. Products may be available in pre-measured doses or in bulk quantities. Some commercially available essential oil products include Apivar®, Thymovar® and ApilifeVar®.

Read and follow the manufacturer's directions. Note that some essential oils can be toxic to honey bees, and experimentation with non-commercial mixtures is done at the beekeeper's own risk to the hive. Volatile essential oils should never be applied to a colony while honey supers are in place because the quality and value of the honey can be severely affected.

Genetic Mite Resistance

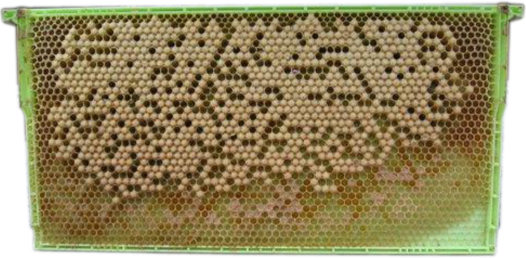
European honey bees have not had a sufficiently long association with varroa mites to develop a stable host-parasite relationship to better withstand this novel pest on their own. Some genetic lines of bees have begun to show resistance to varroa, and queen producers have had some success with breeding these traits into commercially available bee stock. **Russian honey bees** can reduce varroa populations by vigorously grooming mites from themselves and nest mates. Some bees exhibit **varroa sensitive hygienic** (VSH) behavior by detecting reproducing mites in capped brood cells, and removing pupae and mites, thus disrupting mite reproduction. Other lines of bees may also demonstrate some level of mite resistance, but honey bee queens and drones mate in the air at random, far from their hives. Therefore maintaining specific genetic traits can be difficult in areas populated with many unselected bee stocks. When a colony swarms or supersedes, the genetic composition of the bees will change, and desirable genetic traits can be potentially lost or minimized. Eventually, the progeny of strong survivor stock may repopulate wild areas, and begin to reverse the severe losses caused by varroa mites.

Drone Brood Trapping

Varroa mites prefer drone brood over worker brood, and beekeepers can use this behavior to remove mites from the hive without chemical treatments by placing drone-sized foundation into a hive. The cell pattern on this foundation is slightly larger than standard worker foundation, and the colony will draw larger diameter cells into which the queen will place only drone eggs.

When a majority of these drone cells are capped, but before the drones begin to emerge, the entire comb should be removed from the hive and frozen for 2-3 days, effectively killing both the drone pupae and the mites hiding in their cells.

After the frame has thawed and is placed back in the hive, worker bees will uncap and remove the dead pupae and mites, and prepare the cells for the queen to deposit eggs again. Some beekeepers will use two such frames, which can be swapped out as needed.



In the photo above, there are 860 sealed cells on this side of the comb. If we assume that the other side contains about the same amount of sealed brood, and a foundress mite can produce an average of 2.5 viable daughter per cell, then this frame could potentially hold over 6,000 mites which can be removed and eliminated without chemicals. Even if only half of these cells contain reproducing varroa, there is still potential to easily remove a large number of mites. However, if beekeepers fail to remove these combs as intended, the drones will emerge and release their mites, increasing the mite population far more than if drone combs had not been employed.

Sampling for Varroa Mites

To maintain colony health, varroa populations should be kept below a 3% infestation rate, or fewer than 3 mites per 100 bees. Sampling for mites is not difficult, and numerous methods have been developed for beekeepers. For an accurate estimate, count the number of mites in a sample of at least 300 bees (about 1/2 cup). Adult bees should be collected from combs containing open brood, as these nurse bees are most likely to carry phoretic mites. When sampling bees, be sure to avoid the queen!

Bees can be brushed or shaken into a tub, and then a measuring cup can be used to scoop out the appropriate number of bees for a sample. A jar or other container can also be marked to show 1/2 cup, and bees can be sampled directly into it. Hold a comb covered in bees vertically above the hive, and gently move the jar down, barely touching the backs of bees. Many will flip over into the container as it brushes past them. Tap the bottom of the jar to knock the bees down and estimate if additional bees will be needed.

Photo by Sheri Burns (honeybeesonline.com)

A sample of at least 300 adult bees are needed for an accurate estimate of varroa infestation level.

Once mites are counted, divide the number of mites by the number of bees in the sample, then multiply by 100 to determine the infestation level. Varroa estimates are often expressed as ***mites per 100 bees***.

example:

9 mites ÷ 300 bees × 100% = 3% infestation
or *3 mites per 100 bees*

Alcohol Wash

Washing bees with alcohol is the most accurate method to determine varroa infestation level. Shake bees in alcohol for 2 minutes to dislodge mites, then pour the liquid through a mesh screen to separate mites from bees. Liquid is then poured through a fine sieve or white cloth, or into a white tub to make mites visible. For a precise count, bees can be washed again with water until no additional mites are dislodged, but this may be unnecessary if the threshold is clearly exceeded. Commercially available tools make this technique quick and easy to conduct. Effective tools can also be made from simple materials on hand.

Tools for sampling varroa mites by alcohol wash include Varroa EasyCheck® (left), Varroa Sampling Gizmo® (middle) and a homemade device (right).

Photo courtesy Véto-Pharma (vetopharma.com)

Photo courtesy Kelley Beekeeping (kelleybees.com)

Photo courtesy Randy Oliver (scientificbeekeeping.com).

Sugar Shake

A wide-mouth canning jar can be modified by replacing the lid with a circle of 1/8" mesh. Mark the jar at the 1/2 cup level with a permanent marker. Once sufficient bees have been added to the jar, screw on the lid, and add ~2 tablespoons of powdered sugar through the screen lid. Gently roll the jar for about 1 minute to thoroughly coat every bee with sugar, then invert the jar and thoroughly shake out all sugar into another container (usually 1-2 minutes). Varroa are unable to hold onto bees when coated with dust, and the sugar will induce vigorous grooming from the bees, further dislodging mites. Dark colored mites are clearly visible in the white sugar. While not quite as reliable as alcohol wash, sugar generally recovers 75-90% of mites. Extremely humid weather can cause the sugar to clump, making the test less accurate. Beekeepers should be aware of these considerations when making their assessments. Bees survive this treatment (although they will not be pleased) and can be returned to the hive.

Photos courtesy Brushy Mountain Bee Farm (brushymountainbeefarm.com)

CO_2 Sampling

Photo courtesy Daniel Ruck (www.Bienen-Ruck.de)

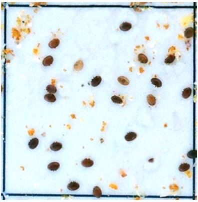
Carbon dioxide is commonly used to anesthetize queen bees for instrumental insemination. It can also be used to quickly knock out a sample of bees and phoretic mites, which can be shaken through a screen to be counted.

This treatment should not harm bees, but they often expel their stomach contents, making the bees and container sticky, so some mites may remain and not be counted. Therefore, when making colony assessments beekeepers should consider that this method may dislodge only about 60-70% of the mites.

Sticky Boards

Some phoretic varroa mites fall from bees on a daily basis. A cardboard or plastic sheet, coated with a sticky or greasy substance, can be placed beneath a hive's screen floor to capture and count the number of mites falling, and indicate their relative population.

Sticky boards cannot estimate an accurate level of mite infestation, since the number of bees cannot be accurately counted. But it can be used to track changes in mite population growth in the same hive over time, so that a beekeeper can be aware if the mite level is increasing from month to month. Sticky boards can also be used to evaluate the immediate knock-down effect of a particular mite treatment.



Sheets of light colored corrugated plastic board work well, and a printed grid makes counting mites easier. Leave the board in place for 3 days for an accurate sample, remove and count all visible mites, then divide by the number of days sampled to determine the **average mite-fall per day**. In the spring, the threshold for varroa should be much lower than in the fall, but the specific number is highly variable with the honey bee population. In early spring, fewer than 3 mites per day may be acceptable. In the late summer, finding more than 30 mites per day should prompt treatment.

Screen Bottom Boards

Using 1/8" screen for the floor of a bee hive can passively eliminate some mites continually throughout the season. As phoretic mites are dislodged, they fall through the screen and are unable to climb back into the brood nest. This may be particularly effective with genetic lines of bees that aggressively groom mites from themselves and their nest mates. While this modification will not eliminate all varroa, it can reduce mite reproduction and may delay their build-up as part of an overall IPM strategy.

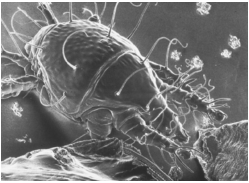


Photo courtesy UK Food and Environment Research Agency (FERA), Crown Copyright.

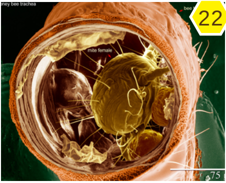


Photo by Ron Ochoa & Gary Bauchan, USDA-ARS.

Tracheal Mites

The tracheal mite (*Acarapis woodi*) is an internal parasite of honey bees. They infest and breed in the tracheal tubes (breathing passages) within the bees' bodies. These mites feed directly through the tracheal walls on a host's hemolymph (blood), causing damage, potentially vectoring disease, and impairing the host's breathing. Young mites must disperse to find adult bee hosts younger than 3 days old to infest. The short-lived bees of spring and summer can only host a single generation of mites, but long-lived overwintering bees can host multiple generations within each host. For this reason, tracheal mites are generally associated with winter losses, especially when colonies are under additional stress. Common symptoms of tracheal mite infestation are nonspecific, but include **K-wing**, and dwindling or generally weakened hives. A microscopic examination of the tracheal tubes is needed for precise diagnosis. Some lines of bees have been bred with good genetic resistance this pest. Formic acid treatment, menthol (Mite-A-Thol®) or any of the essential oil products used against varroa can also help to control tracheal mites, since bees breathe in these vapors for an extended period. Oxalic acid, however, does not remain in a vapor state long enough to affect tracheal mite infestations.

Tropilaelaps Mites

Other species of mites found on Asian honey bees can also infest European honey bees. *Tropilaelaps* mites feed and reproduce on both worker and drone pupae, vector pathogens, and cause damage to colonies similar to that of varroa mites. While their life cycle is similar to varroa, they have a much faster reproductive rate, and can quickly overwhelm colonies during the brood season. They may be observed running rapidly across the comb, rather than phoretic on adult bees.

These tropical mites are unable to feed on adult bees, and appear able to survive only three days with no brood in the laboratory. Because of this, they may be unable to establish in much of the United States where winter conditions create an extended broodless period. However, if these mites are able to adapt and feed on alternate hosts, the extent of their potential range remains unknown.

They are not currently found in North America, but with increasingly rapid global trade, *Tropilaelaps* may be accidentally introduced, as have many other harmful species. Beekeepers should be aware of this potential pest, and immediately report its suspected presence to state entomologists or apiary inspectors.

Comparison of size of varroa mite (left) and tropilaelaps mite (right).

Photo courtesy UK Food and Environment Research Agency (FERA), Crown Copyright.

Aethina tumida, the small hive beetle (SHB) originally from sub-Saharan Africa, has become invasive in many other parts of the world where European honey bees are kept. Adult beetles are about ¼" long and dark reddish brown in color. They are small enough to evade guard bees and often enter honey bee hives.

As long as the colony is healthy and the honey bee population is strong, SHB adults do not cause damage, but mainly constitute a nuisance to the bees. Beetles avoid bees by hiding in inaccessible niches in the hive, and depositing eggs in cracks and crevices. A strong bee colony can usually remove limited eggs or beetle larvae, but if the bee population is insufficient, beetle larvae can quickly overwhelm the hive. This can be due to a gradual or sudden reduction in bees because of diseases, mites, queenlessness, swarming, or beekeeper manipulations such a colony splits.

Photo by Jessica Louque, Smithers Viscient (bugwood.org)

Small hive beetle larvae on a "slimed" honey comb.
Photo by James D. Ellis, University of Florida (bugwood.org)

Hive beetle larvae are scavengers, feeding on pollen, honey bee brood or even their own dead. When feeding on honey, beetles introduce a yeast that causes honey to ferment and run out of cells, and the colony is referred to as "slimed." A high level of slime in a heavily infested colony may cause the remaining bees to abscond and completely abandon the hive. The odor of fermenting honey signals that the colony is weak, attracting more adult beetles from outside.

Beetle larvae can also be destructive pests of the honey house, where combs are stored for processing, and no longer protected by bees. Under ideal conditions, larvae can hatch from eggs in honey supers, and ruin a honey crop within 2 days. Honey should be extracted within a few days of removing it from the hive, and wet cappings should be covered or frozen until they can be processed.

If bees do not consume protein patties rapidly, SHB will readily utilize this food for oviposition. Do not add protein supplements to hives that will not immediately eat them. Any patty found to contain SHB larvae should be remove and discarded immediately.

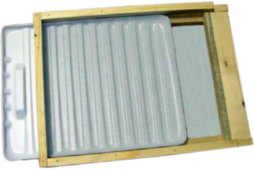
Photo courtesy Pest and Diseases Image Library (bugwood.org)

Beetle larvae feed for 7-10 days, then exit the hive to pupate in the top 4" of soil. Pupation takes 3-6 weeks, depending on soil moisture and temperature. Newly emerged adults locate hives by odor. They are strong fliers and can easily disperse to seek new hives. The best defense against beetles is maintianing strong colonies, which reduce mating and oviposition by SHB.

Physical or mechanical traps and barriers can be used to reduce the population of adult beetles in the hive and limit their reproduction. Many types of traps are available that fit inside a hive, or may modify or replace parts of the hive itself. No traps completely eliminate all SHB, but they can be used as part of an overall IPM strategy.

Physical barriers exclude or reduce the number of beetles that enter a hive while allowing bees to pass freely (Beetle Jail Entrance Trap®, Beetle Baffle®). These devices will not remove or restrict SHBs that are already inside. Beetles are able to fly, and can bypass some barriers. Also, they are only effective if the rest of the hive is in good repair, without gaps or cracks that allow additional beetles to enter.

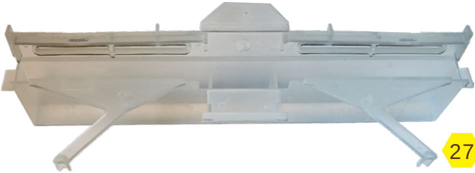
Many traps take advantage of the beetles' instinct to hide from bees inside the hive, causing them to drown in oil or soapy water. Vegetable oil must be changed periodically, or it becomes rancid; mineral oil lasts longer, but is more costly. Soap is added to water to break the surface tension and ensure that SHB drown.



Oil trays beneath hives can be effective traps when used properly. If allowed to accumulate pollen and debris, they become breeding sites for more beetles.

Adult beetles can fit through the standard 1/8" mesh in a screen bottom board. Placing a tray below this screen, filled with oil or soapy water, can trap and kill SHB. These trays will collect dropped pollen and other debris from the hive, as well as dead beetles, and should be cleaned out regularly. If soapy water is used, it can evaporate quickly in hot weather, and if not replaced, the debris in the dry tray can quickly become a source of food and a breeding ground for additional beetle larvae.

Numerous traps fit between frames and have openings that permit SHB, but are too small to for bees (AJ's Beetle Eater®, Beetle Blaster®, Beetle Jail Baitable®). Adult hive beetles enter these traps to hide from bees, and drown. Some designs also have a compartment to hold a bait, such as apple cider vinegar, which mimics the attractive odor of fermenting honey.



If a hive has been overrun by SHB larvae, beekeepers can treat the soil beneath and around their bee hives with permethrin (GuardStar®) to prevent pupating SHB from emerging to infest additional hives. Mow ground cover and remove water sources around hives if necessary. Mix product according to label instructions and apply in late evening when few bees are active. Thoroughly drench soil 18-24" in front of hives with a sprinkler can. Never use a pressurized sprayer, and avoid contact with bee hive equipment.

Some species of **entomopathogenic nematodes**, such as *Heterorhabditis indica* and *Steinernema carpocapsae*, are commercially available and may help suppress SHB population by killing pupae before they emerge from the soil. Mix the nematode substrate with water and apply directly to soil beneath and around hives. Success depends on soil type and moisture, as well as a consistent supply of beetle pupae to support the living nematode population. In general, soils that best support SHB development will likely support nematodes. While conclusive research is lacking on how well nematodes persist through extremely dry or cold periods in different climates, and how often they should be reapplied to soil, they can be used as a component of an overall IPM approach.

Wax Moths & Wax Worms

Two pests, the **Greater Wax Moth** (*Galleria mellonella*) and the **Lesser Wax Moth** (*Achroia grisella*) are ubiquitous, opportunistic pests. They may be found infesting weak or dwindling bee hives, and can be particular problems in stored combs. Both of these species have similar habits, and management recommendations are the same for both.

Female moths deposit clusters of eggs within crevices in the hive. Eggs can hatch within in a few days, depending on temperature conditions. The larval stage, known as a **wax worm** or **web worm**, is the actively destructive form. Larvae burrow through comb, consuming and destroying beeswax, and spinning silk webbing, which is thought to protect the larvae from honey bees. Dark, older comb, containing multiple layers of discarded bee cocoons, is most attractive to the wax worms. Comb that has only been used for honey storage is much less attractive to wax worms, but it may still be consumed when wax worm infestations are large.

Larvae feed for 6-7 weeks, molting 7 times as they grow up to 1" long. In the final stage they chew out a niche into the wooden wall of the hive or a frame, and spin a cocoon for pupation. Cocoons are often found in dense clusters. Pupation time varies with season and temperature, from 6 days to several weeks. Moths do not feed in the adult stage, and live a few days to several weeks. Mating occurs soon after adult emergence, with a single female capable of producing up to 2,000 eggs in her lifetime.

The best defense against wax moths is to keep bee colonies strong, healthy and queenright. Well-maintained hives, without cracks or holes, and full of bees, will best keep out pests such as wax moths.


Greater Wax Moth (left) and Lesser Wax Moth (right).
Photos by Ben Sale (flickr.com/photos/33398884@N03)

Damage to comb caused by wax worms.
Photo by Rob Snyder (beeinformed.org)

A strong colony will actively kill and remove individual *Galleria* adults and larvae. A symptom known as **bald brood** is sometimes observed, when a wax worm has been detected tunneling through the sealed brood cells, and worker bees uncap cells in a straight line, seeking to remove the caterpillar. These cells are typically not re-capped, but pupae inside should continue to develop and emerge normally.

If found in a weak colony, the supers containing moths and caterpillars can be frozen 48-72 hours to kill them. If damage is not severe, the hive body can be placed onto a strong, active colony for the bees to clean and repair combs. If damage is severe, use a hive tool to scrape and clean all damaged frames and hive bodies, and replace with new foundation. Caterpillars will rarely damage plastic foundation, which can be cleaned and coated with fresh beeswax and reused. Damage to frames or woodenware can be so extensive that it cannot be reused.

Drawn combs that have been removed from hives for storage are particularly vulnerable to wax moth damage. If undetected, the progeny from a single female moth can destroy countless boxes of comb. Moths usually avoid comb stored in areas with plenty of sunlight and air circulation, however, this is not always practical for the beekeeper. Boxes of combs can also be preserved by freezing or fumigation.

If space is available, entire boxes of drawn combs can be frozen indefinitely. Boxes can be placed in plastic trash bags to capture debris, but should not remain sealed in plastic if removed from the freezer because trapped moisture will promote the growth of mold. Combs containing pollen or honey should be kept frozen or placed into an active colony.

Because brood combs are far more attractive to wax worms, beekeepers should make efforts to prevent the queen from laying eggs in honey supers. This will reduce the amount of pollen stored there, and prevent a build-up of cast skins and cocoons that attract the adult moths. Newly drawn comb that has only been used for honey storage is not nearly as attractive.

Chemical **fumigation** can be used to kill both moths and larvae, and to protect stored combs, but cannot be used on colonies with live bees, nor should it be used with combs full of honey. Stack up to 5 "deep" or 10 "medium" supers vertically, on a thick pad of newspapers, and seal cracks between boxes with masking tape. Place a piece of paper or cardboard above the frames of the topmost super, sprinkle 3 ounces (4 tablespoons) of paradichlorobenzene (PDB), (Para-Moth® or Enoz Moth Ice Crystals®) onto the paper, and close with a standard bee hive lid.

This material is not the same as moth balls, which should never be used in beekeeping! PDB fumes are heavier than air, and will fill the entire stack, killing all stages of caterpillars, and will repel adult moths from entering stored equipment. Use only in a well-ventilated area. Apply to clean, dry supers after honey has been extracted. Never apply to combs containing honey. In warm weather, inspect the stack every 2-3 weeks to ensure that some crystals remain, adding more product if necessary. Wax moths are generally only active during warmer months, and are rarely a problem after the first hard freeze, as long as temperatures remain low. In the spring, moth activity is usually negligible. Unstack all equipment and allow it to air out for 2 weeks prior to use on bee hives.

Another fumigant, aluminum phosphide (Phostoxin®) can also be used to protect stored products, including drawn combs. It is highly effective at killing pests, but also extremely hazardous to humans, and is therefore a restricted pesticide, available for purchase and use only by licensed applicators.

Ants

While ants can be a common nuisance to beekeepers, few species are destructive pests. They occasionally nest in hive equipment, and may feed on honey or in syrup feeders. Keep hives elevated from the ground, away from contact with the soil. If possible, place hives on a stand with legs, and keep the legs in pool of water or oil. Ants will be unable to cross this moat to enter the hive. Alternately, coat legs of hive stands with petroleum jelly, which will also prevent ants from climbing up. Keep vegetation trimmed down so that ants cannot climb onto hives from tall grass or weeds.

Mice

Rodents will shelter in empty hive equipment, and can destroy combs when they build a nest, as well as bring in debris and leave their droppings. Mice may also nest inside of an occupied hive when bees remain clustered in cool weather. Elevate bee hives from the ground and restrict the size of the opening to discourage mice from entering. Mouse guards are available commercially or can be crafted by beekeepers. Mouse guards should be installed before temperatures fall below 57° and bees begin to cluster, to avoid trapping a mouse inside the hive.

Photo courtesy Brett Kozma, B&K Bees.

Photo courtesy Chinook Honey Company.

Skunks

Skunks visit bee hives at night, where they repeatedly scratch at the entrance of the hive. The disturbance draws out a few guard bees at a time, which are eaten. Skunks learn to avoid strong hives, and may return nightly to feed. Some beekeepers construct wire barriers across the entrance of hives, to prevent skunks from reaching the entrance. A length of carpet tack strip across the end of the landing board should also keep unwanted paws away from the entrance. Raising hives off the ground also generally keep them out of easy reach of small mammals.

Bears

Photo by Terry Spivey, USDA Forest Service (bugwood.org)

The largest and most destructive pest of bee hives are bears. These large animals will feed on honey, but protein-rich brood is their preferred food. A curious bear will usually approach at night, knock hives over, and drag or carry frames of food away from the stinging bees to eat. Once they have successfully fed, they will often return to the same apiary again, causing additional damage.

While expensive to install, electric fences are the most effective method to prevent bears from destroying an apiary. Electric fences must be installed and maintained correctly to be effective. Wrapping an electrified wire with raw bacon will entice a curious bear to investigate it, rather than the bee hives inside, and a single shock may be enough to convince a bear to avoid the fenced area completely. State wildlife officials may be able to trap and relocate bears that have become accustomed to people or bee hives.

An apiary damaged by bears.
Photo courtesy Janet A. Katz.

Sacbrood

Caused by a common bee viruses, sacbrood disease affects honey bee species around the world. Infected nurse bees likely pass the virus to larvae in brood food. Infected larvae fail to pupate after cells are capped, and remain on their backs in a distinct "canoe" posture. Larvae observed in uncapped cells may appear to have an abnormally small head, curved up, and changing color from gray to light brown then dark brown. Adult bees will remove dead larvae, which may spread the disease. If not removed, larvae dry out and adhere to the cell. If pulled from the cell with forceps, the larva will often appear as a bag of liquid, with one end a dark color. Adult bees exhibit no overt symptoms, although high viral levels may contribute to shorter lifespans and overall colony weakening.

Sacbrood is usually observed in spring colonies with a poor brood pattern. Symptoms may disappear in time, but can recur. No practical cure exists to treat honey bee viruses. Caging the queen for 2 weeks can break the transmission cycle to young bees. However, requeening the colony will usually clear up the infection by breaking the brood cycle and introducing new genetic stock, which may be more resistant.

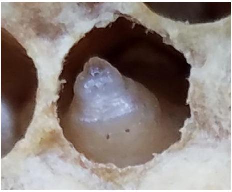


Photo by Jon Zawislak.

Photo by Michael E. Wilson.

Larvae with characteristic symptoms of sacbrood virus.

American Foulbrood

American Foulbrood is caused by the bacteria *Paenibacillus larvae*, and is perhaps the most serious and lethal condition that can infect a bee operation. Uncontrolled, it spreads easily to other hives, killing an entire apiary as weakened hives are robbed by stronger ones. The infection is caused by bacterial spores that are highly resistant to extremes of heat or cold, and can persist as dormant spores on old combs and woodenware for many decades. For this reason, it is unwise to use old beekeeping equipment with an unknown history. Only honey bee larvae are susceptible to AFB, while adult bees are immune. Nurse bees will contaminate larval food with bacteria, and infected larvae die soon after cells are capped.

AFB has distinct symptoms that can be recognized early. Capped brood cells may appear sunken, with perforated cappings. Also, the brood pattern appears spotty, rather than uniform. Dead larvae appear greasy and discolored at first, then darken as they decompose. These larval "scales" adhere to the bottoms of the cells, and are difficult for bees to remove. This disease is accompanied by a very unpleasant odor, for which it was named.

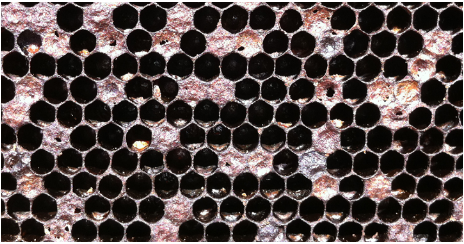


Photo by Jon Zawislak (uaex.edu/bees)

If American foulbrood is suspected, beekeepers can conduct a quick "ropiness" test in the field by inserting a toothpick into a cell with a dead larva and stirring the tissue. When the toothpick is withdrawn, if the mixture strings out up to 3/4" before snapping back into the cell, it is very likely infected with AFB. Beekeepers should immediately contact their state apiary inspector to report the suspected presence of this disease, and follow all recommendations. An inspector will be able to confirm the diagnosis before taking further action.

Photo by Virginia Williams, USDA-ARS.

There is no medical cure for American foulbrood, and most state laws require that infected colonies be destroyed and burned on site. While unfortunate, this is often the only practical way to prevent the disease from recurring. Other colonies in the apiary not showing symptoms should be placed under quarantine and re-inspected at a later date. Feeding colonies a preemptive dose of antibiotics does not cure or prevent the disease, but merely hides its symptoms.

Burning infected hives to prevent the spread of American foulbrood.

Photo courtesy Steve Repasky

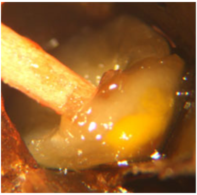
European Foulbrood

European Foulbrood is caused by the bacteria *Melissococcus plutonius*. While not as serious as AFB, EFB is still very contagious and can be a serious threat. This pathogen often exists in seemingly healthy hives at a latent level, but becomes apparent only when colonies are under stress. It is most common in the critical period after winter when colonies contain many older bees, and are building up their populations at a time when weather is unpredictable and forage is not yet abundant. European foulbrood affects only younger larvae, when nurse bees accidentally contaminate brood food with the bacteria.

Infected larvae die before cells are capped, so the disease can be detected by inspecting the brood nest. The most obvious symptom is a spotty brood pattern, although if the infection is at an early stage, this may not yet be apparent. Look carefully in individual open brood cells for discolored or deformed larvae. Infected larvae may appear off-white, yellow, brown or gray, with tracheal tubes visible beneath the skin. Larvae may appear twisted or curled, or even melted down. A sour odor may or may not be apparent, depending on the progress of the disease. Dead larvae form a rubbery scale which workers can remove, but may not be able to keep up with a heavily-infected colony.

Larvae exhibiting some visible symptoms of EFB.
Photos by Michael E. Wilson (beeinformed.org)

Brood infected with European foulbrood does not rope out when probed with a toothpick, as with AFB. It is important to recognize the difference in symptoms, because EFB-infected colonies **do not** need to be immediately destroyed.



Photos by Michael E. Wilson (beeinformed.org)

Because EFB does not form long-lasting resistant spores, it is possible for a colony to recover from a mild infection. Antibiotics were traditionally used to successfully treat and control EFB, but the over-use of antibiotics in the animal industry has resulted in a federal law that now requires a licensed veterinarian to prescribe their use, even for beekeepers. It can be difficult to find a veterinarian able to immediately examine colonies, confirm the diagnosis, and prescribe medication as soon as EFB is discovered. Beekeepers can often intervene to save their colony without the application of antibiotics.

Cage or remove the queen for 2 weeks to break the brood cycle and prevent transmission of the disease to a new generation of susceptible larvae. During this broodless period, shake all adult bees onto new foundation in a clean hive, discard all brood combs (which serve as bacterial reservoirs), and feed the colony heavily with syrup. The syrup provides the worker bees with food and resources to draw new comb on the foundation. When the queen begins laying again, the disease may not recur. Replacing the queen during this period may also be beneficial, because a young queen is typically more prolific, and the new genetic stock may be more resistant to EFB. The use of antibiotics with the "shook swarm" method described here may help to reduce the likelihood of a recurring infection. Applying antibiotics without discarding contaminated brood combs can rid the colony of symptoms, but the disease may recur later.

Chalkbrood

A condition known as chalkbrood disease is caused by a fungal pathogen, *Ascosphaera apis*, affecting larvae that have consumed spores. Infected larvae starve as the fungus grows within them and competes with the larva for food. Dead larvae swell to fill their cells, and are quickly overgrown with fluffy fungal mycelia. The fungus produces spores, giving the dead larva a characteristic "chalky" look. These larvae, called mummies, may be found in capped or open cells, or on the bottom board, but are usually first noticed on the landing board after they have been removed by housecleaning bees. Mummies may appear white, gray, green, black, or a mixture of colors, as multiple other fungi tend to quickly grow on dead brood. This disease should not be confused with common molds, which readily grow on stored pollen if a colony dies during winter and remains unnoticed for a while.

Photo by Rob Snyder (beeinformed.org)

Photo by Jeff Pettis, USDA-ARS.

Chalkbrood mummies may be observed in brood cells (left) but are often first noticed on the landing board after housecleaning bees have removed them (right).

There is no medication to treat for chalkbrood. It is most common in the early spring, and typically disappears when weather becomes warmer and drier, and as the queen increases spring brood production. Hygienic bees remove infected mummies, although this action may result in spreading spores throughout the brood area. A strong colony with abundant workers will be able to keep the brood nest cleaner. A well-ventilated hive, elevated above the ground and free of excess moisture, can help prevent fungal growth. If this condition persists or recurs each year, beekeepers should thoroughly scrape and clean woodenware, replace old brood combs with new foundation, and sterilize hive tools.

Stonebrood

Another brood disease, stonebrood, is caused by several species of *Aspergillus* fungi. These soil-dwelling microbes are common insect pathogens, but good nutrition and overall colony health reduce physiological stress on bees and reduce the chance of infection from this and other microbes. The infection can grow rapidly, with an early symptom being a yellowish ring near the head end of the infected larva. Mummified larvae become coated with a film of yellow, green or black spores (depending on the fungal species), and become very hard and difficult to crush. Mummies may be found on the bottom board or at the hive entrance, similar to chalkbrood.

This disease is fairly rare, and the treatment for it is similar to **chalkbrood**. However, these fungal spores can cause respiratory infections in mammals, including humans, and combs from severely infected colonies should be carefully destroyed by burning.

Black Queen Cell Virus

Photo by Rob Snyder (beeinformed.org)

This disease affects only developing queens, killing them after cells are sealed. Affected pupae appear similar to sacbrood-infected workers, initially turning yellow with a tough skin, then becoming significantly darker in color. After the pupa dies, the wall of the wax cell may appear dark and oily, indicating pupal mortality.

The condition is rarely seen outside of queen breeding operations that raise many queen cells from the same colonies. Workers and drones can carry infections, but do not develop clinical symptoms. The virus is likely transmitted via workers' brood food glands, and it may be that the accumulation of abundant royal jelly from multiple infected nurse bees concentrate virus particles in the food that queen larvae consume. BQCV has often been found in association with high levels of nosema, but a specific correlation is not clear. Viral incidence usually peaks in the early spring, when demand for queen production is high, and hives may also still contain a number of overwintered bees, which tend to harbor more nosema spores.

Traditionally, BQCV was successfully controlled by treating queen-producing colonies with antibiotics. Although antibiotics do not kill viruses, the treatment likely eliminated other pathogens, allowing the bees' immune systems to better cope with nosema and other viral infections.

Bald Brood

Bald brood is not a disease, but rather a symptom of wax moth infestation. As small larvae of *Galleria mellonella* tunnel through combs, worker bees uncap brood cells in order to catch and kill the caterpillars. Patterns of uncapped cells are typically observed in straight rows, extending for several cells. These pupal cells are usually not capped again, but the bees inside continue to develop normally and emerge as adults. Small patches of bald brood should not concern the beekeeper, but attention should be focused on maintaining strong colonies and keeping hives sealed tight, to prevent wax moths from entering.

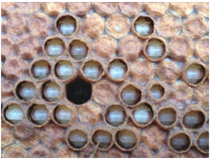


Photo by Ashley Mortensen, University of Florida.

Photo Jeffery Harris, Mississippi State University.

Bald brood (left) and hygienic brood removal (right).

Hygienic Behavior

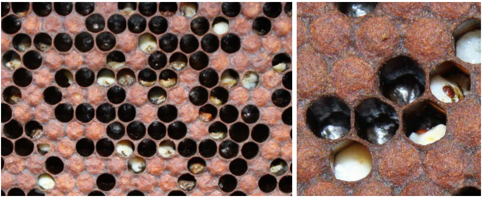
Adult bees will sometimes open capped brood cells and remove developing pupae. This hygienic behavior is thought to be a beneficial genetic trait that helps colonies resist diseases and mite infestations, and is being bred into queen stock to increase its expression in the managed bee population. Hygienic bees appear to uncap cells at random, likely in response to odor cues from the affected brood. Uncapped pupae are often observed to be "chewed down" and destroyed in the process of removing them. This differentiates the symptoms from **bald brood,** which are uncapped in straight rows and left to pupate untouched.

Parasitic Mite Syndrome (PMS)

This condition is not caused by a single specific pathogen, but is rather the result of a heavy parasitic mite infestation combined with a high load of one or more viruses. Together these factors can cause a colony's bee population to dwindle due to reduced brood survival.

Advanced cases will have such reduced adult bee populations that they cannot adequately feed a healthy queen or support substantial brood rearing, which leads to the colony's eventual collapse. Queen supersedure is not uncommon.

Colonies with this syndrome will exhibit a spotty brood pattern. Varroa mites may be visible on adult bees, may be seen crawling across sealed brood, or may even be observed feeding on larvae in open brood cells. Larvae in open cells may appear off-color and melting down. Symptoms can appear similar to those of European foulbrood, except that the brood in this case may be at all different stages of development. Colonies that exhibit hygienic behavior may open capped cells and chew down these pupae.



Colonies with PMS have a spotty brood pattern (left). Varroa may be seen feeding in open brood cells (right).
Photos by Michael E. Wilson (beeinformed.org)

Colonies with PMS often suffer from multiple viruses, usually transmitted by varroa mites. Bees infected with deformed wing virus (DWV) may or may not be observed crawling around at the hive entrance or on the ground, unable to fly. Many viral infections however, do not exhibit visible symptoms in adult bees. Because the overall health and immune response of the colony has been impacted by mites, other disease symptoms may also be observed, such as chalkbrood, sacbrood or European foulbrood.

Honey Bee Viruses

Of more than 20 known viruses affecting adult honey bees, some can be grouped based on clinical symptoms, although many others have no obvious visible characteristics. Many viruses are common, and exist at low levels in a colony without becoming pathogenic. These will generally weaken individual bees, shorten their lives, and result in smaller, less productive colonies without inducing overt signs of disease. However, other environmental stresses, such as poor nutrition or mite parasitism, can also exacerbate colony health.

Viruses may replicate in specific organs or tissues, and may be transmitted in numerous ways. Some are passed to larvae in brood food, or between adult bees through trophallaxis. Other viruses are vectored by parasitic mites, which physically weaken bees and impair immune response while transmitting the pathogens, and thus severely impacting colony health. The most accurate diagnostic tests for viruses rely on DNA testing, are performed only by specialized labs, and can be expensive. To reduce the prevalence of viral infection in a colony, keep mite levels low.

Deformed Wing Virus

One of the most recognizable viral infections is deformed wing virus (DWV). It is readily apparent as adult bees emerge from pupation with wrinkled, malformed wings, and may exhibit other deformities such as rounded, shortened abdomens. Severely infected bees may be expelled by guard bees, and are observed crawling in front of the hive entrance. This condition is most noticeable in summer, when bee and mite populations are both high. These bees cannot fly and cannot perform useful duties in the hive. Because they were fed as larvae, an abundance of DWV-infected bees can greatly impair productivity and overwintering success of a colony. Infected bees do not necessarily always display symptoms, but will have reduced life spans and impaired learning ability, and can still carry and spread the virus. DWV is transmitted between bees mainly by varroa mites, and is known to replicate within the mite between feeding on different bees. Continual management of varroa is essential in preventing outbreaks of DWV by reducing opportunities for mites to pass the virus to the next generation of developing brood.

Photo by Klaas de Gelder (flickr.com/photos/klaasdegelder)

Paralysis Viruses

A complex of viruses with similar effects can be grouped as the paralysis viruses. These include slow paralysis virus (SPV), acute bee paralysis virus (ABPV), Israeli acute paralysis virus (IAPV) and chronic bee paralysis virus (CBPV). Symptoms of infection include adult bees walking around, unable to fly. They may tremble as they walk, or shiver their wings, and may or may not have a dark, greasy, hairless appearance. Different viruses affect different tissues or parts of the bees, and symptoms will vary. They generally exhibit progressive paralysis until death, and usually do not live long. They may be expelled from the hive by other bees, and may be found crawling near the entrance.

Some of these viruses can infect bumble bees and other insects. All are thought to be common in honey bee populations at low levels, but can become highly virulent in association with varroa mites. Vigilant mite control remains the best defense against these viruses.

Photo courtesy The Animal and Plant Health Agency (APHA), Crown Copyright (UK).

Nosema

Nosema disease is caused by a microscopic fungus called a microsporidium, of which two species are known to affect honey bees. *Nosema apis* was the common European strain, with recognizable symptoms, typically seen during and at the end of winter, and was simple to treat. However, it has now largely been displaced by an Asian strain, *Nosema ceranae*, which is more virulent, can appear in summer and fall, and can be more difficult to detect or control.

Nosema is common at latent levels, and may not adversely affect an otherwise healthy bee colony. However, when a colony becomes stressed (by mites, poor nutrition or other pathogens) then the microbes can evade a bee's immune system, leading to a severe infection that impairs foraging behavior, reduces brood care, significantly shortens life span, and decreases winter survival.

These microbes are parasites of the midgut portion of the honey bee digestive tract. Bees consume spores, either when sharing food with infected bees or when cleaning the hive. In the bee's midgut, spores replicate as they destroy the epithelial cells that line the stomach. Reproduction takes 3-4 days, with resulting spores able to immediately infect more cells. As spores multiply, the midgut begins to swell, and bees become progressively weaker. Bees are increasingly unable to digest food, so waste accumulates in the hindgut and spores are passed with feces. When bees are confined for extended periods, as in overwintering hives or during shipment, the spores can spread readily though the bee population via fecal contamination of surfaces.

Streaking with fecal material on frames and near hive entrances is one obvious sign of nosema, but similar dysentery symptoms can also be caused by poor diet. Infected colonies may not always display overt symptoms during good weather, when bees are free to take cleansing flights away from the hive. A number of other symptoms are associated with nosema, but are not necessarily indicators of this disease. These including slow spring build-up, dwindling adult population despite abundant forage, bees crawling on the ground unable to fly, and bees displaying **K-wing**.

When young adult bees become infected, they may not digest food at all, and become incapable of producing brood food. These bees may skip nursing duties and prematurely begin foraging, which significantly shortens their lives and puts additional pressure on other bees to tend the brood. Queens that become infected are usually superseded. Severe infections result in weak colonies and high winter mortality even when overt symptoms are not obvious.

Visible streaking with fecal matter on the front of the hive can be a symptom of nosema infection, but can also simply indicate dysentery caused by a poor diet.

Photos by Michael E. Wilson (beeinformed.org)

Nosema infection cannot be positively diagnosed without a microscopic examination of the bees' midguts. A sample of 25 bees is recommended, viewed using 400x magnification. Older bees, crawling on the ground in front of the hive, are the most likely to have higher spore counts. However, the threshold for *N. cerana* spores is not yet clearly established, and the simple presence of spores does necessarily indicate a severe outbreak.

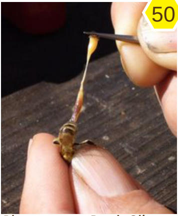


Photo courtesy Randy Oliver (scientificbeekeeping.com)

Traditionally nosemosis was treated with an antibiotic called fumagillin, but research suggests that resistant strains have developed, and medication may be insufficient to cure an infection of *N. ceranae*. The best way to prevent this condition is to ensure that bees have a continuous diet of good food, with access to the outside for cleansing flights. During periods of dearth, adding essential oil mixtures to syrup can stimulate feeding, which helps to flush the digestive tracts, and rid bees of excess spores. Spring and summer bees have short life spans, so spores may not have sufficient time to germinate to dangerous levels. Nosema disease is most prevalent in overwintering populations, and therefore is a more significant problem for beekeepers in climates with long colder winters. Feeding probiotoics may help, by allowing beneficial microbes to competitively exclude harmful microbes in the bees' digestive tract, but sufficient research in this area is currently lacking. Woodenware and combs that have been exposed to nosema can be sterilized by fumigating with 80% acetic acid or by freezing equipment for at least 4 days.

K-Wing

Honey bees have two pairs of wings, the forewings and hindwings. Bees can hook pairs together during flight, but then unhook and fold them back out of the way while at rest. Sometimes their wings become disjointed, and the hindwings will stick out somewhat perpendicular to the body in a position that resembles the letter *K*. These bees are unable to fly, and may be seen walking around on the ground in front of the hive.

This does not indicate a specific disease, but can be a symptom associated with several conditions, including nosema infection, severe tracheal mites, or even some viruses. A microscopic diagnosis of the bees is necessary to determine the exact cause, but the presence of numerous bees exhibiting this symptom should be cause to investigate further.

Photo courtesy James D. Ellis, University of Florida.

Starvation

A common cause of winter mortality is starvation, or rather the bees freeze to death because they have run out of honey stores to convert into heat energy. The bees are found in the spring with their heads in cells, as if searching for food. Usually a small cluster of dead bees is found on the comb, often with the queen, while many others are found in the bottom of the hive.

Occasionally a colony is found to have starved just a few inches from combs full of honey. This is usually after a period of extremely cold weather, causing the bees to tightly cluster and consume all the food within reach. Individual workers are unable to move away from the warm cluster for food, and the cluster itself is unable to move sideways around the edges of the empty comb and onto frames with honey. This can only be avoided if there is ample honey above the cluster, onto which they can easily move. If a wintering colony is discovered dead with food in it, place all frames of honey into another hive, and store all combs safely. If left unattended when weather warms, a dead-out may be robbed by other bees, or the hive may become infested with SHB or wax moths.

Photo courtesy Alex Wild (alexanderwild.com)

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USDA Agricultural Research Service

The USDA Honey Bee Research Laboratory offers a **Bee Disease Diagnosis Service** for beekeepers across the U.S. free of cost. Samples of adult bees or comb (with or without bee brood) can be examined for bacterial, fungal and microsporidian diseases, as well as for parasitic mites and other pests associated with honey bees. This laboratory *does not* analyze samples for the presence of viruses or pesticide residue, and does not differentiate between species of *Nosema*.

Samples are only accepted that originate in the U.S. or its territories, and must include the beekeeper's full contact information. All samples must be packaged and shipped according to the lab's requirements.

For complete information on submitting samples, call **(301) 504-8821** or e-mail **samuel.abban@usda.gov** or visit **www.ars.usda.gov/northeast-area/beltsville-md-barc/beltsville-agricultural-research-center/bee-research-laboratory/docs/bee-disease-diagnosis-service**.

Samples should be addressed to:

Bee Disease Diagnosis
Bee Research Laboratory
10300 Baltimore Ave. BARC-East
Bldg. 306 Room 316
Beltsville Agricultural Research Center – East
Beltsville, MD 20705

The **USDA National Science Laboratory** provides objective and timely testing services to detect and quantify chemical and pesticide contamination residues in honey bees, honey, and other bee hive products. For detailed information about their services and fees, call **(704) 833-1525** or email **NationalScienceLaboratories@ams.usda.gov** or visit **www.ams.usda.gov/services/lab-testing/nsl**.

The **Honey Bee Health Coalition** website has many useful resources for beekeepers, including an up to date list of treatments and instructions for their use, and management decision tools: **https://honeybeehealthcoalition.org/resources/varroa-management/**

The Apiculture Lab at North Carolina State University operates a **Honey Bee Queen & Disease Clinic**, offering a range of diagnostic services, including pathogen screening and queen genetic quality, as well as the ability to customize experimental evaluations. For more information about prices and services visit **entomology.ces.ncsu.edu/apiculture/queen-disease-clinic**.

The **EPA** uses incident report data to help inform pesticide regulatory decisions and identify patterns of bee kills associated with the use of specific pesticide ingredients. If you suspect pesticides are responsible for a bee colony death, contact **beekill@epa.gov**.

The Arkansas Department of Agriculture provides hive inspection services to Arkansas beekeepers. Contact the Apiary Section at **(501) 225-1598** to schedule an appointment or visit **agriculture.arkansas.gov/plant-industries/regulatory-section/apiary/** for more information. Beekeepers outside of Arkansas can find appropriate local agency contacts online at **apiaryinspectors.org/Inspection-Services**.

For the most current information on pest and disease treatment recommendations for bee colonies, consult ***Insecticide Recommendations for Arkansas - MP144***. This publication is updated each year, and is available at no cost from the University of Arkansas System Cooperative Extension Service. Ask for a copy at your local county office or view and download it online: **www.uaex.uada.edu/publications/mp-144.aspx**

The label is the law!

When using any pesticide product, read and follow all label directions and use all appropriate personal safety equipment. It is a violation of federal law to use any pesticide in a manner inconsistent with its labeling.

Pocket Guide to Honey Bee Health

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USDA United States Department of Agriculture

National Institute of Food and Agriculture