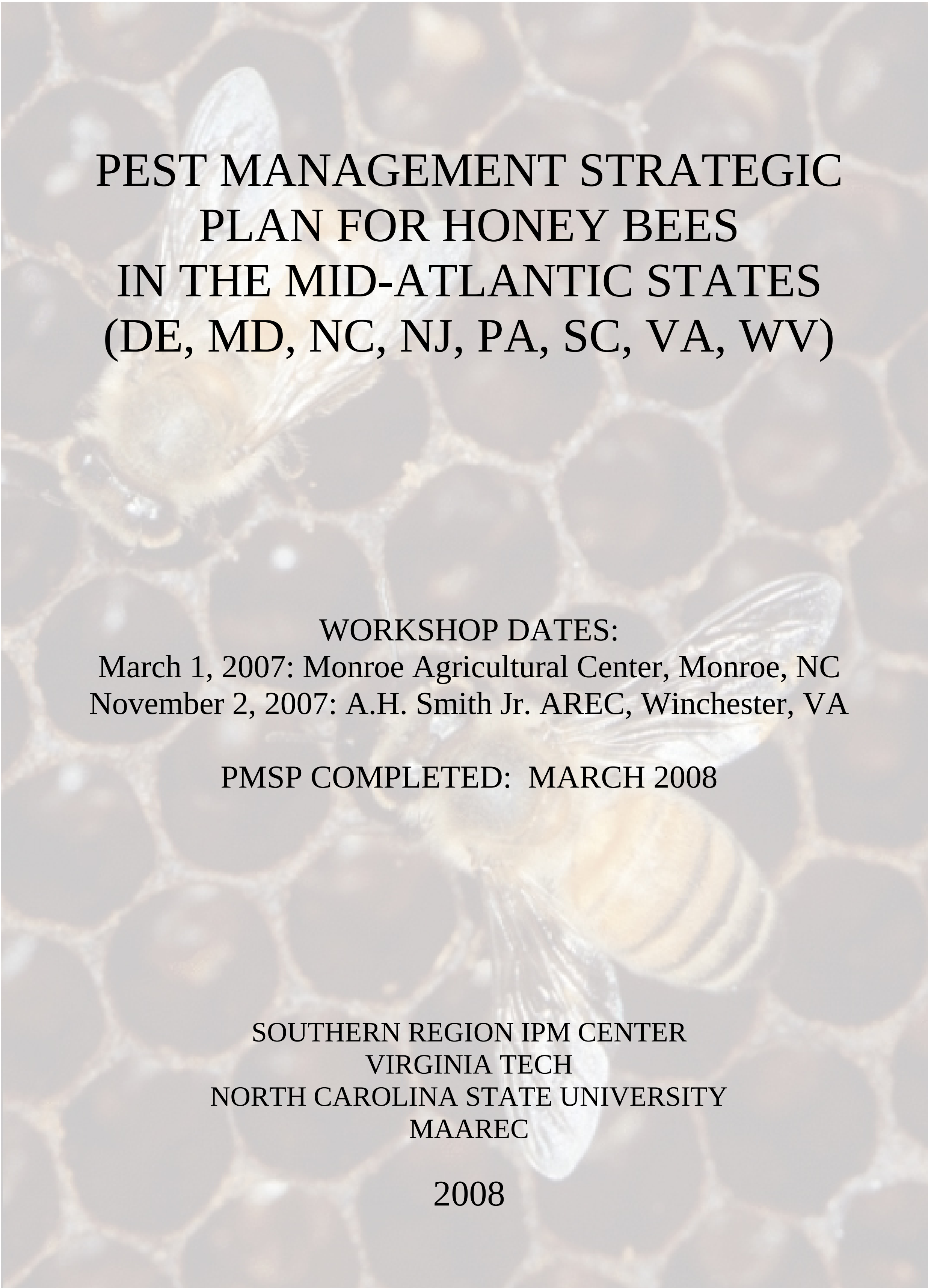

# PEST MANAGEMENT STRATEGIC PLAN FOR HONEY BEES IN THE MID-ATLANTIC STATES (DE, MD, NC, NJ, PA, SC, VA, WV)

WORKSHOP DATES:
March 1, 2007: Monroe Agricultural Center, Monroe, NC
November 2, 2007: A.H. Smith Jr. AREC, Winchester, VA

PMSP COMPLETED: MARCH 2008

SOUTHERN REGION IPM CENTER
VIRGINIA TECH
NORTH CAROLINA STATE UNIVERSITY
MAAREC

2008

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# EXECUTIVE SUMMARY

With the passage of the Food Quality Protection Act, an urgent need has developed to address current pest management issues and embrace alternative or "reduced risk" pest control options for various commodities. The USDA Office of Pest Management Policy (OPMP) is funding the production of Pest Management Strategic Plans (PMSPs), which identify pest management needs and priorities for specific crops in particular regions. These documents are developed through the collaboration of growers, commodity associations, specialists, food processors, crop consultants, and the U.S. Environmental Protection Agency. Two workshops were held: one before the Joint North and South Carolina State Beekeepers Conference on March 1, 2007 (Monroe, NC), and one during the Mid-Atlantic Apiculture Research and Extension Consortium (MAAREC) meeting on November 2, 2007 (Winchester, VA). The purpose was to gather input from beekeepers, state apiarists, apiary inspectors, researchers, and other specialists representing various organizations within Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, South Carolina, Virginia, and West Virginia in order to identify critical pest management needs for honey bees. The following PMSP outlines the management practices used in beekeeping along with the pests and diseases that are most troubling to the apiculture community and industry. Honey bee specialists have assembled data tables to demonstrate the efficacy of currently available chemical and nonchemical control methods. The priorities listed on the following page must be addressed in order to ensure the success of future honey bee production in the mid-Atlantic states.

NOTE: Please refer to "Abbreviations" at the end of this report for a list of abbreviations and acronyms used for organizations and other terms discussed below.

# SUMMARY OF PRIORITIES FOR HONEY BEES IN THE MID-ATLANTIC STATES*

| RESEARCH PRIORITIES | EDUCATIONAL PRIORITIES | REGULATORY PRIORITIES |
|---|---|---|
| • Determine ways to improve overall colony health & productivity; identify factors leading to decline in honey bee health, such as nutrition, stress, & pests; focus on new or current major issues (e.g., mites, CCD, & genetic disorders)<br>• Design best management practices (BMPs) related to point above<br>• Study mites & develop new control methods<br>• Study selective breeding, stock improvement, & means to increase genetic diversity<br>• Reduce dependence on chemical control methods<br>• Create & disseminate surveys of honey bee diseases & pests to apiarists throughout the mid-Atlantic region<br>• Search for & study beneficial or symbiotic organisms within honey bees<br>• Develop better diagnostics for AHB<br>• Improve understanding of changing bee forage<br>• Examine the nutritional quality of GMOs & the impact on honey bees; also, whether modified genetic material is being transferred to bees & possible effects | • Educate public on honey bee best management practices & address misconceptions<br>• Share BMPs with beekeepers<br>• Work to improve viability of beekeeping industry; encourage & educate new or potential beekeepers<br>• Improve information transfer techniques (e.g., eXtension)<br>• Educate apiarists on changing bee forage<br>• Advise public and local agencies on AHB facts, along with appropriate preparations & action plans<br>• Promote local & small-scale queen & bee production, as well as local pollination services<br>• Provide information on alternative pollinators<br>• Inform crop growers of beneficial farming practices that protect pollinators (e.g., timing & planting nectar-bearing plants)<br>• Develop & maintain interstate collaborations, such as MAAREC, because working groups may find it easier to get new control methods in the pipeline or registered for beekeeper use<br><br>***Priorities were summarized from those identified at both Honey Bee PMSP Workshops.** | • Explore the possibility of reclassifying honey bees as livestock in order to protect beekeepers from economic losses during natural disasters, but only where doing so will not trigger ordinances prohibiting livestock<br>• Reduce liability of beekeepers for hive activities<br>• Produce lists of certified queen breeders<br>• Develop & implement regionally valid hive inspections<br>• Train beekeepers in pesticide safety & encourage them to get private applicator licenses |

# PRODUCTION AND CULTURAL PRACTICES

## Honey Bee Biology

Honey bees are social insects native to Europe and Asia that were first brought to the Americas in the 1600s. The typical honey bee colony has one queen, 20,000 to 80,000 adult female workers, and up to 5,000 male drones. A queen's primary responsibility is reproduction; her eggs will develop into workers, drones, or new queens depending on the time of year, the colony's strength, and the nutrition given the developing larvae. The honey bee population is lowest in winter and peaks in late spring or early summer. Workers perform many different tasks during their lifetimes, including brood rearing, queen care, comb building, nest construction, foraging, nest maintenance, honey production and storage, hive thermoregulation, and colony defense. Drones perform no labor for the colony and serve only to mate with foreign queens, after which they die. Those that fail to mate are evicted from the nest in preparation for winter.

## Cultural Practices

Honey bees are managed for their honey, secondary hive products (e.g., beeswax and propolis, the latter being a dark, waxy substance also known as "bee glue" that is collected from trees by bees), genetic stock, and crop-pollination services. Beekeepers typically sell their honey to manufacturers in bulk or to individuals in smaller quantities. Honey is sold in four forms: extracted (liquid), comb honey, chunk honey (a combination of comb and liquid honey), and crystallized (creamed) honey. Beeswax may be used in candles or, most frequently, sold as solid blocks to the cosmetic industry. Pollen, royal jelly, and propolis can be found in various health-food products. Queens, packaged bees, and nucleus colonies ("nucs") are sold to supplement or start honey bee colonies. Bee pollination of agricultural crops is valued at $14.6 billion per year and is 30 to 40 times greater than the value of honey and beeswax alone. Approximately 30% to 35% of food in the United States is directly or indirectly dependent on insect pollination. Strawberries, cucumbers, squash, pumpkins, watermelons, muskmelons, beans, blueberries, peas, and peppers all require bee pollination to produce larger, more attractive fruits and vegetables. Successful pollination also results in a higher crop yield, where development is more synchronized; conversely, inadequate pollination leads to smaller yields of inferior fruit over an extended period. Annually, about two million colonies are contracted for pollination services in the United States. For example, in Virginia, 12,000 to 15,000 colonies are used each year to pollinate crops, particularly apples, cucumbers, and melons. Rental fees are usually $35 to $50 per hive, with approximately one to three colonies needed per acre, depending on the crop.

The ideal apiary location is protected from the wind, sloped so that water drains away from the hives, exposed to sun all day, accessible throughout the year, and is relatively hidden so that it is left undisturbed. Also, it is very important to have a clean water source within a quarter mile of the bee yard. This allows bees to adequately thermoregulate and cool the colony during the hot summer months. The hives should face south or southeast to encourage flight and be slightly elevated off the ground with a clear front entrance. The typical beehive is constructed of wood and consists of a bottom board, two hive bodies (brood chambers), honey supers (or boxes) of various depths (full, medium, shallow, and comb honey), and a cover. Each box in a hive contains wooden frames that hold the wax combs, which serve as the nest substrate for the colony. Other hive components include an outer telescoping cover, inner cover, queen excluder, entrance reducer, and a hive stand. Personal beekeeping equipment consists of light-colored, smooth clothing along with a veil, gloves, a smoker (to pacify the bees), and a hive tool.

Beekeepers fall into four categories based on the number of hives they keep: hobbyists (one to five), small scale (five to 50), sideliners (50 to 300), and commercial beekeepers (300 or more).[1] General management activities occur at different times of year depending on location and colony requirements. They typically include disease and parasite control, swarm prevention, adding additional honey supers for surplus honey storage, honey collection and processing, colony splits, requeening, and colony winterization. In late winter and early spring, the apiarist's chief concern is ensuring colony survival. It is vital that the colony grows rapidly in the spring but does not swarm. In early to mid-summer, supers should be added to encourage surplus honey production. Finally, in the late summer and early autumn, beekeepers should replace the queen (if necessary), treat for mites and diseases, and help the colony prepare for winter.

Bee colonies should be checked three to five times during the spring. The first exam is made in early spring and focuses on evaluating food stores, the queen's condition, and the colony's strength. The precise timing of the exam depends on local climate and weather conditions. The colony should be examined a second time in late spring to inspect the brood, assess the queen, identify disease, and implement swarm-prevention measures. Starved brood may appear when there are not enough nurse bees to feed the developing young. Larvae may be observed crawling out of their cells, or adult bees will be found in their cells with their tongues extruded. Swarming is prevented either by repeatedly reversing hive bodies or by using the Demaree method, which involves segregating the queen at the bottom of the hive in a brood chamber with empty comb. If the bees are preparing to swarm, queen cells should be removed or destroyed, and the colony should be split or the Demaree method used. Bee colonies should not be disturbed during major nectar flows, except for quick inspections and to add honey supers. A queen excluder may be added to keep the queen from laying eggs in honey storage areas.

During the summer, one or two inspections should be made to assess honey production and prevent or control diseases and parasites. Summer is also a good time to evaluate the colony's overall performance, such as honey production, tendency to rear brood and adjust rearing to nectar flows, and gentleness. Honey supers can be removed and cleared of bees by shaking and brushing workers from the frames or by using a bee repellent, bee escape, or bee-blower. Only frames on which at least three-quarters of the cells are capped with wax should be removed to ensure the honey is "ripe" (< 18.6% moisture) and ready for extraction. Honey supers are initially placed in a warm room (≈90°F) for one or two days to make the honey less viscous. Cell cappings are removed with an electric knife or an uncapping machine, and the honey is extracted via centrifugal force using a manual or electric radial extractor. The honey is then strained, allowed to settle, and bottled for sale or personal use. Tracheal and varroa mites should be treated in late summer after honey stores have been removed (see below).

[1] Overlapping ranges incorporate differences in goals, invested effort, derived income, etc.

At least two inspections should be made in the fall to monitor and assist the bees in their preparation for winter. In order to successfully overwinter, a colony needs at least 30,000 bees to maintain warm cluster temperatures within the hive. Weaker, smaller colonies should be combined (unless an effort is being made to prevent the spread of certain diseases described below). To survive through the winter months, a typical colony requires 35 to 60 pounds of honey (depending on the location and severity of the winter dearth) and three to five frames of pollen. The colony may be provided with supplemental sugar if food stores are inadequate. During the fall, it is also important to make sure the queen is healthy and the colony is free of diseases and parasites. Colonies should be requeened at least every two years, and annual requeening is increasingly recommended to maintain colony health. Signs of a good queen are a solid brood pattern, similar-aged brood, and no symptoms of disease. Autumn is also the period during which most disease-management strategies are implemented by the beekeeper. Other management practices that help bees overwinter include reducing the lower hive entrance, adding an upper entrance, and placing a layer of absorbent material (such as newspaper) over the inner cover. If bees cannot maintain the high temperatures necessary for development, the brood will die. For this reason, hives should not be opened or inspected at any time during the year when the ambient temperature is below 60°F, particularly during wet or rainy periods. However, a late-winter check (mid-January) of colony conditions is advisable. Stimulatory feeding with pollen supplementation in late January can help survival and encourage colony buildup.

## Worker Activities

Beekeepers typically wear a veil, long-sleeved shirt, shoes, gloves, and a protective suit to minimize bee stings. These items are not worn to prevent pesticide exposure, but they may help minimize dermal contact. Pesticides are usually administered to treat honey bee diseases or parasites in early spring, late summer, or early fall. Most pest control measures are centered around mitigating *Varroa destructor*, the exotic ectoparasitic mite of bee brood and adults. Varroa mites are typically controlled in the late summer or early fall using pesticide strips (e.g., Apistan or Checkmite+), which are hung in the brood chamber and pose little risk of pesticide exposure. However, strips must be removed after approximately 50 days and at least four weeks before honey production. Chemical-resistant gloves should be worn when handling the plastic strips. Two other pesticides, ApiLife VAR and Sucrocide, are used to control varroa mites with variable success. Although Sucrocide is harmless to humans, goggles and waterproof gloves should be worn when applying ApiLife VAR. Small hive beetle adults may be controlled at any time during the year by placing Checkmite+ strips under a piece of plastic cardboard on the bottom board of the hive. In addition, the soil surrounding the hives may be treated using Gardstar 40EC to control pupating hive beetles. Apiarists should follow label directions and wear chemical-resistant gloves, a long-sleeved shirt, pants, and waterproof shoes to avoid pesticide exposure. In the early spring or late fall, colonies may be treated with the antibiotics oxytetracycline and fumagillin to control foulbrood diseases (both American and European foulbrood) and nosema disease, respectively. Potential hazards to antibiotic-sensitive workers should be recognized and may be reduced by wearing personal protective equipment. Tracheal mites are controlled in the late summer or early fall using menthol crystals contained in screen packets on frames at the top of the hive. There is little risk from exposure to menthol, but gloves should be worn as a precaution. Currently, tracheal mite treatments are recommended only if analyses indicate a mite problem.

Ethylene oxide can be used to fumigate equipment contaminated with American foulbrood (AFB) disease. However, soon this product may no longer be registered because it poses a high risk of health hazards. Presently, when AFB is detected in a colony, a state bee inspector should be notified. The current practice for AFB-infected beehives is to remove and destroy any comb with AFB symptoms (by burning or burying them) and to treat the colony with terramycin. Samples of diseased larvae are tested for AFB resistance to tetracycline, and, if found, tylosin (Tylan) can be used to treat the colony. Colonies are usually destroyed and burned only in cases of heavy infestation and low bee populations.

# ARTHROPOD PESTS

Currently, the most serious arthropod pests of honey bees in the mid-Atlantic states are varroa mites and small hive beetles, although the latter have not been as prevalent in recent years. Minor pests include tracheal and external mites, bee lice, wax moths, and other nuisance pests, such as ants, other bees, dragonflies, earwigs, hornets, roaches, termites, and wasps.

## INSECTS

### **<u>Ants</u>, <u>European Hornets</u>, and <u>Yellow Jackets</u>**, Formicidae and Vespidae spp.

Although ants and yellow jackets are not usually serious pests of beehives, their presence may indicate colony weakness. Ants are very hard to control once they become established. However, they tend to bother apiarists more than they bother the honey bees themselves.

**MONITORING:** No specific monitoring protocol is recommended.
**CHEMICAL CONTROL:** Pesticides should not be applied directly to the colony or hive equipment. If pesticides are necessary, apply them only when the bees are inactive since general insecticides will also kill honey bees.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** Maintain colony strength, keep bottom boards raised off the ground, remove debris from around the bottom of the hive, use ant barriers around colonies, or place single colonies on stands surrounded by oil or sticky traps. For wasps, use traps baited with meat or other attractants.
**TO DO:**

- Provide the public with more information on the most effective types of traps and bait.

### **<u>Bee Louse</u>**, *Braula coeca*

The bee louse is a wingless, ectoparasitic fly pest of adult bees. It is reddish brown and smaller than the head of a pin. Bee lice entered the United States by hitchhiking on imported queen bees. Worker bees usually harbor only one bee louse while queens can be found with several of these parasites attached. Bee lice feed by stealing nectar directly from the mouths of bees, particularly nurse bees, but they rarely parasitize drones. Female bee lice lay their eggs on honeycomb cappings from May through July. The fly larvae then hatch and tunnel through the comb while eating wax and pollen. This activity makes comb honey unsightly for sale to the public.

**MONITORING:** No specific monitoring protocol is recommended because the bee louse is rarely found in the mid-Atlantic region.
**CHEMICAL CONTROL:** No chemical controls are currently recommended.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** No cultural controls are currently recommended.
**TO DO:**

- None.


The bee louse

**Small Hive Beetle**, *Aethina tumida*

The small hive beetle (SHB) is native to southern Africa. Both adults and larvae can be serious pests of weakened honey bee colonies or honey supers. Adults are reddish brown or black, less than ¼ inch long, and live up to six months. Female beetles lay their eggs, which are smaller than those laid by queen bees, in crevices within a hive. Larvae damage the wax comb while feeding on honey and pollen. They also ruin honey by defecating within the food cells, causing the honey to ferment and smell like rotten oranges. Furthermore, the honey becomes thin and runs out of the combs. This, compounded by the repugnant smell, may cause bees to abandon the hive. Small hive beetles spend five to seven weeks pupating in the soil before emerging as adults.


Small hive beetle larvae

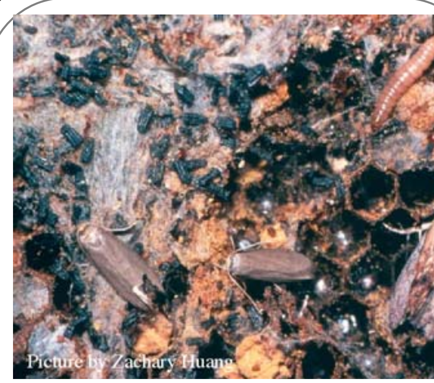
**MONITORING:** Look for the symptoms noted above.
**CHEMICAL CONTROL:** Coumaphos (Checkmite+) and permethrin (Gardstar) are used to control SHB. See the Chemical Arthropod Control section for more information.
**BIOLOGICAL CONTROL:** Fungi and nematodes have been evaluated but are not available for commercial use.
**CULTURAL CONTROL:** Do not store honey for any length of time before extraction. Keep the comb in a location with less than 50% relative humidity to keep SHB eggs from hatching. Use traps (corrugated plastic or pit traps), freeze honey, or install hot lights in honey houses to burn grubs.
**TO DO:**

- Develop a better trap using pheromones or lures.
- Look at hive traps vs. honey house traps.
- Determine treatment thresholds.
- Evaluate SHB's potential for damage.
- Educate beekeepers on traps and best control options currently available.

- Register paradichlorobenzene for control of SHB in stored products.
- Research nematodes as biological control agents of SHB.
- Research and develop alternatives to coumaphos.
- Research and develop alternatives, especially nonchemical options (e.g., black plastic), to Gardstar soil treatment.
- Conduct research to determine the efficacy and longevity of Gardstar along with potential resistance issues resulting from its use.

**Wax Moth**, *Galleria mellonella*
**Lesser Wax Moth**, *Achroia grisella*

Wax moths are serious pests of wax comb and cause over $5 million in damage within the United States annually. The lesser wax moth is not as important, although it does occur. These moths lay 300 to 600 eggs on or near wax combs each day. Caterpillars hatch three to five days later and tunnel through the wax combs, leaving webbing and debris behind. Immature wax moths feed on pollen, cast skins, and cocoons, but they do not usually attack new wax combs or foundation (man-made wax sheets upon which bees construct comb cells). Wax moths pupate outside of the comb and take from one to several months to complete development. These Lepidopteran pests typically do not directly destroy bee colonies, but they can infest stored equipment and weaken colonies by forcing them to spend more time on comb maintenance. Strong bee colonies are better able to keep wax moths under control by themselves.



Wax moths

**MONITORING:** Signs of wax moth infestations include webbing, frass and debris, pupal cocoons, and tunnels in the combs. Stored equipment that contains comb is most susceptible to wax moth infestations.
**CHEMICAL CONTROL:** Paradichlorobenzene (PDB) crystals will protect stored comb without honey. However, this treatment only works on five or fewer stacked supers. If any honey is present, it will be unsuitable for human consumption. Aluminum phosphide may also be used to fumigate hives and equipment. See the Chemical Arthropod Control section for more information.
**BIOLOGICAL CONTROL:** *Bacillus thuringiensis* (*Bt*) (Certan) is available in Europe, but it is no longer available in the United States. Natural enemies include parasitic wasps, but they are rather ineffective.
**CULTURAL CONTROL:** Freezing temperatures kill all stages of wax moths, so comb honey should be stored in the freezer while equipment is left in a dry, un-insulated room during the winter. Storing equipment in well-lit areas with good air circulation is also effective. Beekeepers are advised not to store units together and to keep brood comb away from honey supers.
**TO DO:**
- Educate beekeepers on various cultural control methods.
- Research efficacy of parasitic wasps for wax moth control.

- For small beekeepers, seek to re-register *Bt* products. This may be appropriate for an IR-4 minor-use project.

**Other Insect Pests**
**Beetles, Dragonflies, Roaches, Robber Flies, and Termites**

These insects may be occasional minor pests of honey bees, either preying on them, infiltrating their hive, stealing their honey, or colonizing their equipment.

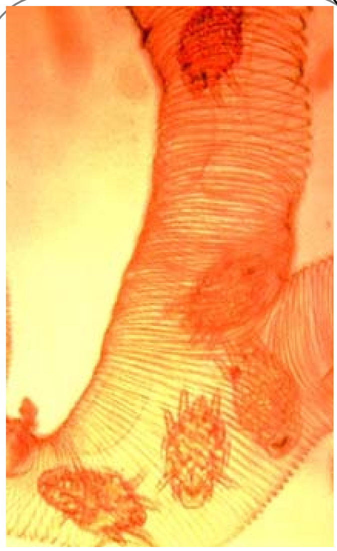
**TO DO:**
- None.

## MITES

**Tracheal Mites**, *Acarapis woodi*
**External Mites**, *A. externus* and *A. dorsalis*

Tracheal mites are parasites of the respiratory system of adult bees. They were first discovered in the mid-1980s. These mites can be more severe in areas with colder winters. They usually infest the respiratory tubes of the first thoracic segment, although they may invade the air sacs as well. Tracheal mites are transmitted by bee-to-bee contact and may also be introduced into colonies from package bees (a quantity of adult bees, with or without a queen, shipped in a wire cage along with a food source) or new queens. Female mites lay their eggs in the tracheal tubes of honey bees where they complete development in as rapidly as two weeks. Mites feed by puncturing tracheal walls and ingesting the host’s hemolymph (blood). Infested bees become physiologically stressed and have damaged flight muscles. Mite populations are highest and most destructive during the winter when heavy infestations can kill an entire bee colony. Honey production and winter survival are impacted when as few as one-third of the colony workers are parasitized. External mites (*A. externus* and *A. dorsalis*) are not considered an economic problem.

**MONITORING:** These mites are easier to detect during the fall and late winter. Sick bees can be collected from the hive entrance and stored in 70% ethanol until the tracheae can be examined under a microscope. Tracheal tubes infested with mites will usually have brown staining. Recent studies in the mid-Atlantic region indicate tracheal mites are not as significant a problem as they were during their initial introduction. Colonies do not need treatment unless sampling indicates otherwise.



Tracheal mites

**CHEMICAL CONTROL:** If treatment is necessary, it is best to apply controls such as formic acid or menthol in August or early September when winter bees are being reared. See the Chemical Arthropod Control section for more information.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** Use resistant honey bee stocks (e.g., New World Carniolan, Russian, Buckfast, and Ontario). Vegetable oil grease patties can also be used for year-round control of tracheal mites.
**TO DO:**

- Research the interaction of tracheal mite infestations with viruses and other diseases.

**Varroa Mites**, *Varroa destructor* (formerly *Varroa jacobsoni*)

Varroa mites are the most serious pests of honey bees globally. They can kill a colony in two to four years if preventive measures are not taken. Varroa mites first appeared in the mid-Atlantic region in the mid- to late 1980s, and they are now extremely widespread. These ectoparasites feed on the hemolymph of immature bees (preferentially drone brood), but they will also feed on adults. Developing drones are ten times more attractive to varroa mites than are the worker brood. Female mites infiltrate cells before they are capped and feed on their hosts. They lay eggs a day and a half after cells are capped and continue to produce new eggs approximately every 30 hours. Immature mites develop on bee pupae and take about a week to mature. This intense parasitism leads to shortened life span of the host bee due to tissue damage, diminished productivity, pupal death, and malformed wings, legs, and abdomens. Varroa mites also vector numerous viral diseases, such as deformed wing virus (DWV), Kashmir bee virus (KBV), chronic bee paralysis virus (CBPV), and acute bee paralysis virus (ABPV).

**MONITORING:** Identify mites on adults by using the shaking/washing method or the ether/sugar roll method. Capped pupae, especially drones, can be examined directly by opening the cells with an uncapping tool such as a cappings scratcher. A screenboard with white sticky paper on the bottom board can also be used for quantitative measurements. Spotty brood patterns may indicate a varroa mite infestation, particularly if associated with DWV.
**CHEMICAL CONTROL:** Coumaphos, fluvalinate, formic acid, sucrose octanoate, ApiLife VAR, and Apiguard are all used to treat varroa mites. See the Chemical Arthropod Control section for more information.
**BIOLOGICAL CONTROL:** Entomopathogenic fungi (e.g., *Metarhizium anisopliae*) are being studied but are not yet commercially available. Research has also been conducted on the use of pseudoscorpions (*Ellingsenius* spp.), which naturally coexist in hives with honey bees in Africa and Asia, but there are no current recommendations for their use.
**CULTURAL CONTROL:** Cull mites with screened-bottom boards and trap mites in drone combs. Tolerant stocks (bee varieties) have been developed, including Russian, varroa-sensitive

hygienic (VSH), and other hygienic strains. Other control options include requeening, using a caged queen, or applying a powdered sugar treatment (Dowda method).

**TO DO:**

- Research the interactions of varroa mites with other diseases and stressors; determine their impact on the honey bee immune system.
- Register oxalic acid and determine its efficacy; also examine the proper timing of applications with regard to regional differences.
- Conduct further research to determine if treating hives with the smoke from plants and plant parts, such as creosote bush and grapefruit leaves, may be effective in controlling varroa mites.
- Research and register new materials for control, both chemical and nonchemical.
- Determine damage and treatment thresholds; take into account interactions of mites, viruses, SHB, etc.
- Attempt to breed gentler mites that will be less stressful to the honey bees.
- Develop effective IPM programs.
- Identify pest management options that avoid breeding more resistant mites.
- Look at IPM economics on both small and large scales.
- Evaluate Hivastan and seek to expand its registration, if beneficial.
- Expand label of formic acid to include other application methods.
- Determine how/if powdered sugar treatment actually works.
- Investigate sublethal effects of miticides.

The varroa mite

## SUMMARY – CHEMICAL ARTHROPOD CONTROL

- **aluminum phosphide & other metal phosphides** (*Phosfume*, *Gastoxin*) – Fumigants. For fumigation of diseased beehives and beekeeping equipment. Kills bees and greater wax moths. RESTRICTED USE PESTICIDE.
- **coumaphos** (*Checkmite+*) – Organophosphate. For control of fluvalinate-resistant varroa mites, use one strip per five combs placed close to the bee cluster. Apply in spring two months before adding honey supers or in the fall after removing the honey supers. DO NOT use during surplus honey flow, and remove honey supers before treating. Supers can be replaced after a 14-day withholding period. For SHB, cut a strip in half, staple it to a piece of plastic-corrugated cardboard, and place on the bottom board of the hive. Leave strips in place for 42 – 45 days. SECTION 18 EXEMPTION.
- **fluvalinate** (*Apistan*) – Pyrethroid. For control of varroa mites in beehives, hang two strips in the brood chamber during the spring or fall for 42 – 56 days. DO NOT use within four weeks of marketable honey flow. Remove honey before treatment and allow two weeks to pass after strip removal before replacing the supers.

- **formic acid** (*Mite Away II*) – Carboxylic Acid. For control of tracheal and varroa mites, use one treatment pad for 21 days when temperatures are 50°F – 79°F. Remove all honey supers before treatment and do not use during nectar flow.
- **menthol** (*Mite-A-Thol*) – Essential Oil. Treat tracheal mites in overwintering hives during the early spring or fall when there is no surplus honey flow and daytime temperatures are at least 60°F – 80°F. Put 1.8 oz. of product in a 7-inch-square plastic screen on the top frames or on the bottom board. Replace packs as necessary, but remove packets 10 – 12 weeks after initial treatment. Remove packs at least one month before surplus honey flow.
- **paradichlorobenzene** (*Para-Moth*) – Fumigant. For empty, stored combs, use at a rate of 3 oz. per five stacked hive bodies. Hive bodies with combs are stacked on a closed bottom board and a cover is placed on top. Place product on a piece of paper or cardboard at the top of the frames to control adult and immature greater wax moths. Does not kill eggs. Reapply after two to three weeks if crystals are gone. Air out honey supers for at least two weeks before introducing live bees. Do not use on stored frames of honey.
- **permethrin** (*Gardstar* 40EC) – Pyrethroid. For control of SHB outside of hive ONLY. Highly toxic to bees if applied incorrectly. Use at a rate of 5 mL per gallon of water for six hives. Use a sprinkler can to drench the soil 18 – 24 inches in front of each beehive once bees are inactive during the late evening. Reapply after 30 – 45 days.
- **sucrose octanoate** (*Sucrocide*) – Sucrose Ester. For control of varroa mites, spray bees on comb directly with a Sucrocide solution at a rate of 1.5 oz. per frame of bees. Administer three applications (one every 7 – 10 days). Sucrocide can be as effective as Checkmite+ and Apistan in controlling varroa mites in late fall. More research is needed to assess its effectiveness at other times when the brood population is higher. Although inexpensive, Sucrocide is harder to apply because each frame must be sprayed individually. It is harmless to human skin, but goggles and waterproof gloves are necessary when applying.
- **thymol (***Apiguard*) – Essential Oil. Gives 90% – 95% control of varroa mites. When applied, temperature must be warm enough to volatilize the gel and accessible to bees so they can distribute it throughout the hive. Do not treat during honey flow. Do not use when the maximum temperature is less than 60°F or when colony is very inactive. Do not use when the daily maximum temperature is above 105°F. Leave product in the colony until trays are empty. Remove product when installing supers on colony. Combine weak colonies before treatment. When ready to use, open hive, remove lid of tray (leaving one corner attached), and place tray centrally on top of the brood frames gel side up. Keep free space of at least ¼ inch between top of tray and cover board. Close hive. Replace first tray with new one after two weeks. Most effective when used in late summer after honey harvest, but may be used in spring as long as temperatures are above 60°F.
- **thymol + eucalyptus oil + menthol** (*Api-Life VAR*) – Essential Oils. For control of varroa and tracheal mites, break one tablet into quarters, enclose them in pieces of 8-mesh screen, and place on the top corners of the hive body. Reapply two additional times (after removing the old tablet pieces) at 7- to 10-day intervals. Leave the last tablet on for 12 days, and then remove all material. Remove honey supers 30 days before treating, and do not use within five months of surplus honey flow. Do not use when temperatures are above 90°F. SECTION 3 PESTICIDE.

# VERTEBRATE PESTS

Bears pose the greatest threat to honey bee colonies since they can destroy an entire bee yard in their quest for honey and brood. Generally, mice, skunks, raccoons, opossums, birds, amphibians, and reptiles are considered only minor pests of honey bees.

## Mice

Mice make nests in hives and destroy combs during the fall and winter months. Rodents build their nests in corners away from the bee cluster so they do not get stung. Mouse urine is partially repellent and will not be cleaned out by the bees in the spring. Mouse problems in beehives are most likely to occur in apiaries located near woodlots or in fields.

**MONITORING:** No specific monitoring protocols are recommended.
**CHEMICAL CONTROL:** Chemical control is unnecessary if cultural controls are followed.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** For beehives in use: reduce the lower hive entrance in early fall, chase away mice already in the hive, destroy nests, and replace chewed frames because bees will replace destroyed worker cells with drone cells. For beehives in storage: cover the top and bottom of combs with a pile of supers and a queen excluder, wire screen, or telescoping lid.
**TO DO:**

- Develop better ways to control mice.
- Educate beekeepers on various cultural control methods.
- Research rodents as possible honey bee disease vectors.

## Skunks, Raccoons, and Opossums

Skunks, raccoons, and opossums feed at beehive entrances at night (when bees are less likely to sting) primarily during the spring, but also during summer and fall. They scratch at the entrance, and when bees come to defend the colony, the invaders eat the bees. These mammals have been known to feed for an hour or more. This feeding activity causes bee colonies to become more defensive and aggressive.

**MONITORING:** Bee parts and animal scat will be visible on the ground near the entrance. Also, the grass and hive will appear disturbed.
**CHEMICAL CONTROL:** No chemical controls are currently recommended.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** A piece of chicken wire can be stapled to the bottom board and stretched in front of the hive to discourage skunks and other animals. Add an upper entrance, install a fence around the bee yard, keep colonies on stands more than 18 inches high, or move bees to a new location.
**TO DO:**

- Develop better repellents.

**Bears**

Bears eat bees, brood, and honey. They destroy hives and are very hard to control.

**MONITORING:** Install one strand of barbwire along with an electric fence. When bears come in contact with the wire, they will likely leave some hairs behind, thus making their identification easier.
**CHEMICAL CONTROL:** No chemical controls are currently recommended.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** Select the apiary site carefully to avoid the home ranges of bears and their pathways, as well as forest edges and ravines. Game wardens will capture nuisance bears and release them elsewhere, when possible. Install a baited, electric fence (at least 2,000 V) around the bee yard. If wires are more than 7 inches apart, the fence may not deter bears. Establish the apiary away from trees, which will prevent bears from climbing and dropping inside the fence.
**TO DO:**

- Develop better repellents.

**Birds, Amphibians, and Reptiles**

Insectivorous birds, blue jays in particular, eat honey bees as they are entering or leaving the hive. They can be a severe problem in queen-rearing operations. Amphibians and reptiles will also eat honey bees, but they are not serious pests.

**MONITORING:** No specific monitoring protocol is recommended.
**CHEMICAL CONTROL:** No chemical controls are currently recommended.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** Birds can be repelled by hanging video tape and used CDs around the hives.
**TO DO:**

- Research damage and treatment thresholds.

# DISEASE PESTS

Major diseases or disorders afflicting U.S. honey bees today include American foulbrood, European foulbrood, nosema, chalkbrood, assorted viruses, and Colony Collapse Disorder (CCD). Minor diseases that are occasionally found in stressed honey bee colonies include stonebrood and sacbrood.

## BACTERIAL DISEASES

**American Foulbrood**, *Paenibacillus larvae*

American foulbrood disease is the most serious honey bee brood disease in America. AFB spores are spread to young larvae (less than two days old) while being fed by nurse bees.

Immature bees die from this bacterial disease in the late larval or pupal stage and decay in their cells. AFB is also spread by housekeeper bees and by apiarists using contaminated equipment. Honey can become contaminated as well. Once a colony grows weak from AFB, robber bees may infiltrate the hive, steal infected honey, and bring it back to their own brood, thus spreading the disease. AFB spores remain viable almost indefinitely. However, honey from diseased hives is generally considered safe for human consumption.


American foulbrood

**MONITORING:** Dead bees change color from tan to dark brown and become "ropy" (stretch out 1 inch or more when pulled out of the cell with a toothpick). Prepupae form "scales" in their cells that are hard to remove. Pupae may be found with extruded tongues. Cell cappings may appear sunken and dark in color, with multiple perforations and a characteristic odor similar to animal-based glue. There may also be a spotty brood pattern of infected and uninfected cells. Positive identification of AFB can be made with the VITA diagnostic kit, which uses AFB-specific antibodies. Although not widely used, another method for AFB detection is the Holst milk test, which involves taking a scale or toothpick smear and swirling it into a tube with 3 to 4 mL of 1% powdered skim milk. The tube is then incubated at body temperature. If AFB is present, the turbid fluid will turn clear in 10 to 20 minutes. This does not happen with European Fouldbrood (EFB) and sacbrood infections.

**CHEMICAL CONTROL:** Terramycin is sometimes used to prevent or control the disease in colonies, although no antibiotics can completely eradicate AFB spores. Tylosin may control AFB infections in colonies if dealing with terramycin-resistant bacteria. See the Chemical Disease Control section for more information.

**BIOLOGICAL CONTROL:** No biological controls are currently recommended.

**CULTURAL CONTROL:** First and foremost, follow state regulations. All cases of AFB should (and in certain states, such as Virginia, must) be reported to the state apiarist or one of the state bee inspectors. To prevent AFB, maintain good management and sanitation practices. If AFB is identified in a colony, all infected combs with scale should be removed and destroyed by burning. The bees in an infected colony can be shaken into clean equipment with frames of foundation and treated with terramycin. Very heavily diseased colonies with small bee populations are best destroyed and burned. After killing the bees, seal off infected hives if they cannot be destroyed immediately. Healthy bees should not be exposed to AFB-infected honey or allowed to rob diseased colonies. After working with an infected colony, hive tools should be cleaned with a 10% bleach solution and a wire brush. Hive bodies, covers, and bottom boards from infected hives should be disinfected by scorching before reuse. Clean any contaminated clothing or gloves. It is also recommended to requeen with hygienic stock.

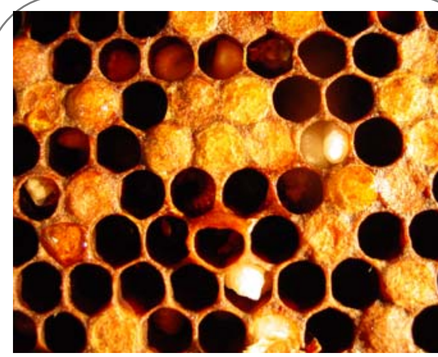
**TO DO:**

- Evaluate different treatment strategies since there is little evidence for current assumptions.
- Research AFB interactions with other diseases, stress factors, and pest products.
- Research and develop more consistently resistant genetic lines.
- Educate beekeepers on identification methods and treatment options, especially through hands-on activities.

- Explain ramifications of treatment methods to beekeepers.
- Look at nontarget effects of antibiotic use on bees, along with possible in-hive residues.

**European Foulbrood**, *Melissococcus pluton*

Along with sacbrood, nosema, and chalkbrood, European foulbrood is a stress disease of honey bees aggravated by conditions such as cool temperatures, moisture, and food shortages. It is caused by a nonspore-forming bacterium that is transferred throughout the colony via housekeeper bees as they remove dead larvae. It is also spread by beekeepers using contaminated equipment and robber bees. Young larvae ingest EFB bacteria and die within four days of egg hatch. EFB is most common with increased brood rearing in the spring. The severity of the disease may vary from one hive to the next. EFB can seriously retard colony growth, although the infection usually goes away on its own, especially as summer begins. Strong honey flows help honey bees overcome EFB.

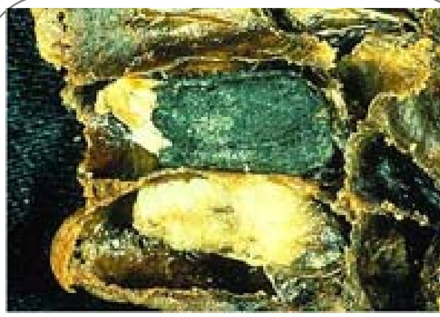

European foulbrood

**MONITORING:** Unlike with AFB, larvae killed by EFB usually die in the coiled stage and do not become "ropy." Also, the larvae change from yellow to brown, with a silvery cross pattern caused by tracheal discoloration. Decomposed larvae form a rubbery scale that is easily detached. Positive identification of EFB can be made with a VITA diagnostic kit, which uses EFB-specific antibodies.
**CHEMICAL CONTROL:** Treat with the antibiotic terramycin. See the Chemical Disease Control section for more information.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** To treat light infections, reduce stress; with moderate cases, reduce stress and possibly requeen; for severe infections, treat with terramycin and requeen. Honey bees vary in resistance to EFB; thus, requeening helps by changing stock.
**TO DO:**
- Research EFB/mite interactions and effects on honey bee health.
- Look at nontarget effects of antibiotic use on bees.
- Research associated bacteria and interactions with EFB.
- Research prevalence in various geographic regions.

## FUNGAL DISEASES

**Chalkbrood**, *Ascosphaera apis*

Chalkbrood is a fungal disease that infects three- to four-day-old larvae in stressed bee colonies. It is most common in the spring or any time there is heavy precipitation during cool weather. Nurse bees spread the fungal spores while feeding immature bees. The spores germinate in the gut of the larva and mycelia grow, causing the larva to appear white, chalky, and mummified. Larvae usually die in an upright, stretched-out position. Worker bees may then uncap the dead bee larvae. Chalkbrood does not usually destroy a colony, but it may result in fewer bees or less honey at peak times. Spores can persist for years in infected beehives.



Chalkbrood

**MONITORING:** Look for symptoms described above.
**CHEMICAL CONTROL:** No chemical controls are currently recommended.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** Treat by reducing stress, moving hives to areas that are sunny with low moisture, and requeen. Honey bee lines show differences in susceptibility to chalkbrood. No other effective treatments are available.
**TO DO:**

- Research different strains of chalkbrood.
- Conduct research on and develop chemical control options.
- Investigate interactions between various bee lines and different strains of chalkbrood.
- Breed genetic resistance.
- Educate beekeepers about chalkbrood control methods, especially requeening.
- Examine potential interactions with other disease organisms.

**Stonebrood**, *Aspergillus flavus* and *A. fumigatus*

Stonebrood is caused by two types of fungi. It may be misidentified as chalkbrood, although the mummies differ in appearance. As with other brood diseases, stonebrood is thought to be transmitted via infected food from nurse bees. Stonebrood affects larvae, pupae, and adult bees, causing them to become hard and covered with powdery greenish spores, especially around the head.

**MONITORING:** Stonebrood is extremely rare. Mummies are yellowish green or grayish green.
**CHEMICAL CONTROL:** No chemical controls are currently recommended.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** None. Bees remove diseased brood and recover quickly on their own.
**TO DO:**

- None.

**Nosema**, *Nosema apis* and *N. ceranae*

Nosema is a very common honey bee disease; for example, in Virginia, as many as 70% of the colonies may be infected. Although *Nosema apis* has been a problem in the United States for many years, no one thought to investigate whether other strains of this dysentery-like illness were also present until recently. Researchers have now determined that *N. ceranae*, once thought to be associated only with the Asian honey bee (*Apis ceranae*) is present in U.S. honey bee colonies, and may in fact be more common than *N. apis*. Some researchers are now wondering what role, if any, *N. ceranae* may play in bees succumbing to Colony Collapse Disorder.

*Nosema apis* typically becomes problematic in late winter, early spring, or during cool, wet weather, while *N. ceranae* may tend to be more prevalent in spring and summer. Adult bees consume infective spores, which then germinate in the midgut and invade the epithelial cells. The digestive system is disturbed, leading to malnutrition and a shortened life span. Other symptoms may include severe dysentery (defecation within the hive); weak, crawling bees; and poor buildup in the spring. Occasionally, many dead and dying bees are visible near the hive entrance. Nosema is spread in contaminated feces, honey, and combs. It also spreads via hive robbing, contaminated equipment, and infected package bees. In severe cases, nosema disease may lead to queen supersedure (queen replacement).


Nosema-infected bees defecating in the hive

**MONITORING:** Nosema disease is identified by analyzing abdominal contents; spores will be apparent during the microscopic examination of homogenized gut tissue. Bees infected with *N. apis* typically have swollen, opaque midguts, which are not apparent in bees infected with *N. ceranae*. Another possible symptom is the appearance of feces on the hive.
**CHEMICAL CONTROL:** Use fumagillin (Fumidil-B) during an active infection or preventively during the fall. *Nosema ceranae* may require treatment during the spring and summer. See the Chemical Disease Control section for more information.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** Keep bees healthy and use good management techniques to reduce stress. Use clean equipment to avoid spreading nosema among colonies.
**TO DO:**
- Develop alternatives to fumagillin, which is relatively costly.
- Research *N. ceranae*, its treatment/damage thresholds, and its interaction with other diseases and pests.
- Treatment plans for fumagillin – different application methods?
- Develop new methods to detect *N. ceranae*.

## SUMMARY – CHEMICAL DISEASE CONTROL

- **fumagillin** (*Fumadil-B, Fumagillin-B*) – Antibiotic. For control of nosema, mix 1 tsp. per gallon of syrup and feed at a rate of 2 gallons of syrup per colony during the fall or spring. Use at least 30 days before spring honey flow and any time after fall honey flow is finished.
- **resmethrin** – Pyrethroid. To kill colonies with heavy AFB infestations, apply inside the hive. Burn dead bees and infected equipment at least 12 hours after pesticide application. No longer in general use.

- **terramycin** (*TM-50D*, *TM-100D*, *TM-25*, *Tetra-B Mix*) – Antibiotic. For control of EFB and to prevent AFB, sprinkle dust mixed with powdered sugar over frames. DO NOT use within four weeks of marketable honey flow. AFB resistance to terramycin has been reported.
- **tylosin** (*Tylan*) – Antibiotic. Apply as a dust at a rate of 200 mg in 20 g of confectioner's sugar three times (once per week) to the top bars of frames. Do not use before or during honey flows.

## VIRAL DISEASES

### Sacbrood Virus

Sacbrood is a stress disease caused by a virus. The disease is most likely to occur in spring and early summer during stressful conditions such as cool temperatures, excess moisture, and malnutrition. Sacbrood tends to disappear after conditions improve and especially after the main nectar flow. It has been identified in healthy larvae and adults as well as in sick bees. However, two-day-old larvae are more susceptible to this disease. Immature bees turn from yellow-gray to black, with the head blackening first. The dark cappings of the brood cells appear punctured or partially removed. Larvae die in an upright position after their cells have been sealed. Dead larvae resemble fluid-filled sacs and can be removed from the cell intact. Like EFB, the decomposed larval scale is easily removed from the cell.

**MONITORING:** Look for the symptoms described above.
**CHEMICAL CONTROL:** No chemical controls are currently recommended.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** The only treatments for sacbrood are reducing stress and improving living conditions.


Sacbrood

**TO DO:**
- Research disease and virus interactions.
- Investigate virus prevalence, basic information, transmission (horizontal or vertical).
- Determine whether it impacts other bees besides queens.
- Examine interactions between virus and mite control practices – preliminary data suggest chemicals increase the prevalence of the virus.

### Bee Paralysis Viruses

Chronic bee paralysis virus (CBPV), Acute bee paralysis virus (ABPV), and Israeli acute paralysis virus (IAPV) are spread by varroa mites. These diseases may also be passed on contagiously in the hive. Paralysis viruses render bees unable to fly and cause them to shake uncontrollably. Afflicted individuals lose their hair and become dark and shiny like robber bees. Sick bees are usually seen crawling up and falling down from the front of the hive. Israeli acute paralysis virus was only recently discovered in U.S. bee colonies. Research suggests it may be a significant marker for identifying the presence of CCD in hives.

**MONITORING:** Look for the symptoms mentioned above.
**CHEMICAL CONTROL:** No chemical controls are currently recommended.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** Requeen using a different honey bee strain. Add a frame of sealed brood from a healthy colony. Control varroa mites, which vector these viruses.
**TO DO:**

- Research IAPV prevalence, distribution, transmission, etc.
- Develop good monitoring techniques and look at symptomology.
- Examine the potential involvement of viruses in CCD.
- Investigate subacute effects such as reduced longevity.

## Deformed Wing Virus

Deformed wing virus (DWV) is associated with heavy varroa mite infestations. DWV was once thought to be caused directly by mite feeding. However, varroa mites actually carry viruses that cause wing deformities. Viruses have also been isolated from pollen, honey stores, comb, and healthy-looking bees. DWV causes bees to grow ragged wings that are incapable of flight. Deformed bees either die off naturally or are actively removed from the colony.

**MONITORING:** Look for the symptoms mentioned above.
**CHEMICAL CONTROL:** No chemical controls are currently recommended.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** Control varroa mites to minimize the spread of DWV.
**TO DO:**

- Research DWV prevalence, distribution, transmission, etc.
- Investigate subacute effects such as reduced longevity.
- Examine the potential involvement of viruses in CCD.
- Develop good monitoring techniques and look at symptomology.

## Kashmir Bee Virus

Kashmir bee virus (KBV) is an RNA virus in the family Dicistroviridae and was first associated with the eastern honey bee, *Apis cerana*. It can now be found in the western honey bee, *Apis mellifera* L. This virus is highly contagious and virulent when found associated with varroa mites, which carry the disease both internally and externally. This virus is likely endemic in hives throughout the United States, although a precise range has not been established. Symptoms are the same as those of other viruses: colonies that appear weak for no discernible reason, the presence of many dead or dying bees in front of the hive, and sick bees that tremble and appear uncoordinated. Bees may also exhibit hair loss and appear oily (if older) or opaque (if younger).

**MONITORING:** Look for the symptoms mentioned above. KBV can be identified by submitting freshly killed live bees to the appropriate laboratory for analysis.

**CHEMICAL CONTROL:** No chemical controls are currently recommended.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** Implement good sanitation practices. Reduce bee stress by providing supplementary food stores and controlling mites.
**TO DO:**

- Research KBV prevalence, distribution, transmission, etc.
- Investigate subacute effects such as reduced longevity.
- Examine the potential involvement of viruses in CCD.
- Develop good monitoring techniques and look at symptomology.

### Black Queen Cell Virus

Black queen cell virus (BQCV) has been identified in North America, Great Britain, and Australia. Developing queens, and occasionally developing workers, are infected by BQCV after their cells have already been capped. Diseased pupae die and turn dark within their cells, which also turn black. This virus tends to be associated with nosema infections.

**MONITORING:** Look for the symptoms mentioned above.
**CHEMICAL CONTROL:** No chemical controls are currently recommended, although treating nosema infections with Fumadil-B may help curtail this virus.
**BIOLOGICAL CONTROL:** No biological controls are currently recommended.
**CULTURAL CONTROL:** Implement good sanitation practices. Comb replacement and requeening may also help.
**TO DO:**

- Research BQCV prevalence, distribution, transmission, etc.
- Investigate subacute effects such as reduced longevity.
- Examine the potential involvement of viruses in CCD.
- Develop good monitoring techniques and look at symptomology.

## COLONY COLLAPSE DISORDER

### Colony Collapse Disorder

Colony Collapse Disorder (CCD) was first reported in 2006 by a Pennsylvania beekeeper overwintering his hives in Florida. This disorder causes honey bees to die suddenly, within a few days to a few weeks. Unlike other diseases, their bodies are not found around their hives. Thus, the bees appear to mysteriously vanish. Some commercial migratory and nonmigratory beekeepers have experienced the loss of 50% to 90% of their colonies. The remaining colonies are weak and unable to pollinate crops or produce surplus honey.

Currently, activities that are NOT believed to directly cause, but may contribute to the development of, CCD are feeding, chemical pest treatment within the hive, bee usage (e.g., commercial pollination or honey production), and queen source. The following are being researched as potential causes of CCD: chemical residue within wax, food stores, and bees; bee pathogens and parasites; nutritional fitness of adult bees; stress levels in adult bees; and a possible lack of genetic diversity in American colonies. New research has shown that colonies with CCD also harbor IAPV, while healthy colonies do not. Although it is still unknown what role IAPV plays in the development of CCD, it may be a good indicator for identifying colonies afflicted with the disorder. *Nosema ceranae* is commonly found in colonies with CCD as well. GMO crops and radiation from cell phone towers are NOT believed to cause CCD, although these possibilities have not been entirely dismissed.

**MONITORING:** Early symptoms of CCD are a reduced workforce that appears to be almost entirely young bees, which cannot sufficiently care for the brood; a healthy, egg-laying queen; bees that are reluctant to feed on supplements provided by the beekeeper; and few or no foraging worker bees. After the collapse has taken place, look for the complete absence of live, adult bees in the hive (the queen and a few survivors may be present) and few or no dead bees present in and around the hive. Capped brood is often present, along with honey and/or bee bread, which is a mixture of collected pollen and nectar stored in cells for later consumption. When infected equipment is left in the field, there will be a delay in robbing by other bees, as well as colonization by hive pests (e.g., wax moths and small hive beetles).

**CHEMICAL CONTROL:** Feed colonies fumagillin in spring to prevent extra stress from nosema infections. If treating EFB, use terramycin—not tylosin (Tylan). Terramycin is known to work well, while tylosin has not been proven to control EFB. When treating varroa mites, use "soft" chemicals such as Apiguard, Apilife VAR, or MiteAway II. Do not use oxalic acid or other "hard" chemicals, such as fluvalinate, coumaphos, or amitraz, which may further stress the bees.

**BIOLOGICAL CONTROL:** No biological controls are currently recommended.

**CULTURAL CONTROL:** Practice good colony management and maintain a healthy, strong hive. Wear a protective mask when working with unhealthy hives. Move dead colonies away from healthy colonies within two weeks of collapse to avoid hive robbing. Do not combine weak colonies with strong ones. Replace old comb with new foundation regularly. Do not reuse equipment from colonies that appear to have had CCD. Currently, burning infected equipment is not recommended; putting the items in storage should be sufficient.

**TO DO:**

- Research IAPV's possible involvement in CCD.
- Investigate all areas of research – nosema, nutrition factors, stress, genetics, travel, etc.

See the MAAREC website for more information: http://maarec.cas.psu.edu/index.html

# ACKNOWLEDGMENTS

Workshop sponsors: North Carolina State University (NCSU), the Southern Region IPM Center (SRIPMC), Virginia Tech Pesticide Programs (VTPP), and the Mid-Atlantic Apiculture Research & Extension Consortium (MAAREC).

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# ABBREVIATIONS

ABPV – acute bee paralysis virus
AFB – American foulbrood
AHB – Africanized honey bee
BMP – Best management practice
BQCV – black queen cell virus
CBPV – chronic bee paralysis virus
CCD – Colony Collapse Disorder
DWV – deformed wing virus
EFB – European foulbrood
EHB – European honey bee
GMO – genetically modified organism (and/or crop)
IAPV – Israeli acute paralysis virus
IPM – integrated pest management
KBV – Kashmir bee virus
MAAREC – Mid-Atlantic Apiculture Research & Extension Consortium
PDB - paradichlorobenzene
PMSP – Pest Management Strategic Plan(s)
SHB – small hive beetle
VSH – varroa-sensitive hygiene

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*Attended Meeting

# PRIORITIES FOR HONEY BEES IN NC, VA, & SC*

| RESEARCH PRIORITIES | EDUCATIONAL PRIORITIES | REGULATORY PRIORITIES |
|---|---|---|
| • Secondary effects of internal/external chemicals on bee viability (e.g., do they increase susceptibility to other pathogens?)<br>• Improved genetics of bees as a solution to disease, disorders, & pests<br>• Alternative in-hive control method for SHB<br>• Integration of existing & new control methods for varroa<br>• SHB as a vector for bacterial diseases<br>• Alternatives to PDB<br>• Survey of *Nosema ceranae* & potential consequences of its introduction/infection<br>• New pest-bee control chemical<br>• Biocontrol methods & efficacy (e.g., nematodes for SHB, fungi for mites)<br>• Temporal efficacy of permethrin for SHB control<br>• Final distribution of AHB & survival rates across geographical regions<br>• New AHB diagnostics for field & lab use<br>• New ways to detect varroa<br>• Causal agent of CCD<br>• Improve hive designs for colony health & protection<br>• Genetic basis of resistance mechanisms of parasites & pathogens to chemical control methods<br>• Invasive species biology & potential host shifts of parasites & pathogens | • Strengthen regulatory activities & programs for apiculture & apiary inspection<br>• Do national survey of diseases & pests as a means of bolstering international trade barriers, policies, & activities<br>• Facilitate analysis of adulterated & contaminated honey, comb, & hive products<br>• Reassess current label language, requirements, & efficacy<br>• Maintain support for Section 24(c) & 18 labeling where appropriate & encourage movement toward Section 3 registration<br>• Facilitate IR-4 process for obtaining minor use labels<br>• Establish lines of communication & cooperation between regulatory agencies for wildlife & managed honey bees<br>• Promote research & understanding of potential (overseas) threats to develop proactive regulatory policies if they are introduced<br><br>***Priorities were merged with those listed for the mid-Atlantic states on p. 4 of this document.** | • Field diagnosis of brood diseases<br>• Importance of bees to greater agricultural economy<br>• Public awareness of Africanized honey bees & the realistic impact that they will have on public health, beekeeping, & agriculture<br>• First-responder training & incident management for AHB & stinging insects<br>• Hands-on demonstration apiaries for training & best management practices<br>• Promoting local & small-scale queen production<br>• Establishing effective linkages with government agencies & elected officials to be proactive in apiculture-related issues<br>• Educate beekeepers concerning mammalian threats to beehives (e.g., bears) to be proactive in their management practices<br>• Beekeeper recruitment & retention |

# EFFICACY TABLES FOR NC, VA, & SC

(Developed at March 2007 Workshop)

Table 1. Efficacy ratings for various pest management tools for arthropod pests of honey bees. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed or no experience with this tool; NU = not used; * = used, but not a stand alone tool.

| Pest Management Tools | Arthropod Pests | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ants | Yellow jackets European hornets | Bee Lice | Small hive beetles | Wax moths | Lesser wax moths | Tracheal mites | External mites | Varroa mites | Africanized honey bees | | |
| **Registered Insecticides and Miticides** | | | | | | | | | | | | |
| aluminum phosphide (Phosfume, Gastoxin) | | | | | | | | | | | | |
| coumaphos (CheckMite+ Strips) | | | | P-F | | | | | F-E | | | |
| fluvalinate (Apistan Strips) | | | | | | | | | F-E | | | |
| formic acid (Mite Away II) | | | | | | | E* | | F-G | | | |
| menthol (Mite-A-Thol) | | | | | | | E | | | | | |
| paradichlorobenzene (Para-Moth) | | | | G? | E | E | | | | | | |
| permethrin (Gardstar 40 EC) | E | | | ? | | | | | | | | |
| sucrose octanoate (Sucrocide) | | | | | | | | | P | | | |
| thymol + eucalyptus + L-menthol (Api-Life VAR) | | | | | | | E* | | G-E | | | |
| Other | E | | | | | | | | | ? | | |
| **Unregistered/Experimental Insecticides and Miticides** | | | | | | | | | | | | |
| Diazonol | E | | | | | | | | | | | |
| Certan (Bt product in Europe) | | | | | | ? | ? | | | | | |
| Mineral oil fogging | | | | | | | | | P | | | |
| Honey bee healthy (thymol) | | | | | | | | | ? | | | |
| Amitraz | | | | | | | | | ? | | | |
| Other | | | | | | | | | | | | |
| **Cultural Pest Management Practices** | | | | | | | | | | | | |
| Monitoring hives for pests | | | | | | | | | G | | | |
| Maintain colony strength | E | E | | E | E | E | | | | | | |
| Keep bottom boards off of the ground | E | | | | | | | | | | | |
| Remove debris from around bottom boards | E | | | | | | | | | | | |
| Use barriers and/or traps | E | E | | E | | | | | | | | |
| Culling mites with modified (screened) bottom boards | | | | | | | | | F | | | |
| Do not store honey for any time before extraction | | | | | | | | | | | | |
| Keep comb in location with < 50% relative humidity | | | | G | E | E | | | | | | |
| Store comb honey in freezer and leave equipment in dry, uninsulated room during winter | | | | | | | | | | | | |
| Use resistant varieties or stocks of honey bees | | | | | | | E | | F-G* | | | |
| Grease patties | | | | | | | G | | | | | |
| Dowda method (powdered sugar) | | | | | | | G | | F? | | | |
| Other | | | | | | | | | | | | |
| **Biological Controls** | | | | | | | | | | | | |
| Entomopathogenic fungi | | | | | | | | | P? | | | |
| Natural enemies (i.e., parasitic wasps) | ? | | | | | ? | ? | | | | | |
| Nematodes | | | | ? | | | | | | | | |
| Other | | | | | | | | | | | | |

Table 2. Efficacy ratings for various pest management tools for disease pests of honey bees. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed or no experience with this tool; NU = not used; * = used, but not a stand alone tool.

| Pest Management Tools | Disease Pests | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | American Foulbrood (bacteria) | European foulbrood (bacteria) | Septicemia (bacteria) | Spiroplasmosis (bacteria) | Chalkbrood (fungi) | Stonebrood (fungi) | Nosema (protozoan) | Sacbrood virus | Deformed wing virus | Other viruses (BQCV, KBV, IAPV, CBPV) | *Malpighamoeba mellificae* (amoeba) | Gregarines and flagellates |
| **Registered Bacteriacides and Fungicides** | | | | | | | | | | | | |
| ethylene oxide (ETO) | E | E | E | E | E | E | E | E | E | E | E | E |
| fumagillin (Fumadil-B, Fumagillin-B) | | | | | | | G-E | | | | | |
| terramycin (TM-50D, TM-100D, TM-25, Tetra-B Mix) | E | E | | | | | | | | | | |
| tylosin (Tylan) | ? | | | | | | | | | | | |
| Other | | | | | | | | | | | | |
| **Unregistered/Experimental Bacteriacides and Fungicides** | | | | | | | | | | | | |
| Gamma radiation | E | E | E | E | E | E | E | E | E | E | E | E |
| Apple cider vinegar | | | | | | | G? | | | | | |
| Other | | | | | | | | | | | | |
| **Cultural Pest Management Practices** | | | | | | | | | | | | |
| Good management and sanitation practices | | | | | | | | E | | | | |
| All infected combs removed and burned | E | | | | | | | | | | | |
| Heavily-diseased colonies with small bee populations destroyed and burned | E | | | | | | | | | | | |
| Use resmethrin to kill disease-infected honey bees | | | | | | | | | | | | |
| Close off infected hives after killing bees | | | | | | | | | | | | |
| Clean hive tools with 10% bleach solution and wire brush | G | | | | | | | | | | | |
| Hive bodies, covers and bottom boards from infected hives disinfected by scorching before reuse | F | | | | | | | | | | | |
| Reduce stress and improve living conditions of bees | | | | | | | | E | G | G | | |
| Requeening | | F-G | | | G | ? | | G | | | | |
| Use clean equipment | | | | | | | | | | | | |
| Other | | | | | | | | | | | | |
| **Biological Controls** | | | | | | | | | | | | |
| Other | | | | | | | | | | | | |

Table 3. Efficacy ratings for various pest management tools for vertebrate pests of honey bees. Rating scale: E = excellent; G = good; F = fair; P = poor; ? = research needed or no experience with this tool; NU = not used; * = used, but not a stand alone tool.

| Pest Management Tools | Vertebrate Pests | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bears | Birds | Mice | Opossums | Raccoons | Skunks | Amphibians | Reptiles | | | | |
| **Registered Pesticides** | | | | | | | | | | | | |
| Other | | | | | | | | | | | | |
| **Unregistered/Experimental Pesticides** | | | | | | | | | | | | |
| Other | | | | | | | | | | | | |
| **Cultural Pest Management Practices** | | | | | | | | | | | | |
| Fencing around the bee yard | E | | | | | | | | | | | |
| Wire screens on the hives | | | | | | | | | | | | |
| Selection of apiary sites to avoid animal ranges, pathways, forest ranges, trees, etc. | | | | | | E | | | | | | |
| Keep colonies on stands | | | | | | E | | | | | | |
| Other | | | | | | | | | | | | |
| **Biological Controls** | | | | | | | | | | | | |
| Legislation for compensation | ? | | | | | | | | | | | |
| Other | | | | | | | | | | | | |

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# EFFICACY TABLES AND HONEY BEE ACTIVITIES TIMELINE FOR THE MID-ATLANTIC STATES

(Developed at November 2007 Workshop)

Table 1a. Efficacy ratings for various pest management tools used against honey bee insect and mite pests. Rating scale: E = excellent; G = good; F = fair; P = poor; N = no control; ? = research needed; NU = not used; * = used, but not a stand alone tool.

| Pest Management Tools | Arthropod Pests of Honey Bees | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bee Louse, *Braula coeca* | Hymenopterans (Ants, Bees, Wasps) | Small Hive Beetle, *Aethina tumida* | Tracheal & External Mites, *Acarapis* spp. | Varroa Mites, *Varroa destructor* | Wax Moths, *Galleria mellonella* & *Achroia grisella* | Dragonflies | Roaches & Earwigs | Termites | Africanized Honey Bees |
| | Registered Insecticides & Miticides | | | | | | | | | |
| Alum./Magn. phosphide (*Phosfume, Gastoxin*) - RUP | NU | NU | NU | NU | NU | E | NU | NU | NU | NU |
| [1,2]Coumaphos (*Checkmite+ Strips*) - Sec. 18 | NU | NU | F | NU | G | NU | NU | NU | NU | NU |
| [2]Fluvalinate (*Apistan Strips, Apistan Queen Tabs*) | NU | NU | NU | NU | E | NU | NU | NU | NU | NU |
| [3,4]Formic Acid (*Mite Away II*) | NU | NU | NU | G | G | NU | NU | NU | NU | NU |
| [4]Menthol (*Mite-A-Thol*) | NU | NU | NU | G | NU | NU | NU | NU | NU | NU |
| [5]Paradichlorobenzene (*Para-moth, Fumigator*) | NU | NU | NU | NU | NU | E | NU | NU | NU | NU |
| Permethrin (*Gardstar* 40EC) | NU | NU | G | NU | NU | NU | NU | NU | NU | NU |
| Sucrose Octanoate (*Sucrocide*) | NU | NU | NU | NU | F | NU | NU | NU | NU | NU |
| [6]Thymol (*Apiguard*) | NU | NU | NU | NU | G | NU | NU | NU | NU | NU |
| [6]Thymol + Euc. Oil + L-menthol (*ApiLife VAR*) | NU | NU | NU | NU | G | NU | NU | NU | NU | NU |
| [7]Copper Napthalate | NU | NU | NU | NU | NU | NU | NU | NU | ? | NU |
| Boric Acid | NU | ? | NU | NU | NU | NU | NU | ? | NU | NU |
| Powdered sugar | NU | NU | NU | NU | F-P | NU | NU | NU | NU | NU |
| | Unregistered/New Insecticides & Miticides | | | | | | | | | |
| Amitraz (*Miticur*) - no longer registered | NU | NU | NU | E | E | NU | NU | NU | NU | NU |
| Oxalic Acid | NU | NU | NU | NU | F | NU | NU | NU | NU | NU |
| Acetic Acid | | | | | | ? | | | | |

[1]Use on small hive beetle is discouraged.
[2]Resistance issues have emerged with the use of these chemicals.
[3]Provides excellent control, but only when applied at the correct time.
[4]Not for use in hot weather.
[5]For stored equipment use only.
[6]Nontarget effects may include decreased sperm production/quality in drones.
[7]For wood treatment, not equipment.

Table 1b. Efficacy ratings for various pest management tools used against honey bee insect and mite pests. Rating scale: E = excellent; G = good; F = fair; P = poor; N = no control; ? = research needed; NU = not used; * = used, but not a stand alone tool.

| **Pest Management Tools** | Arthropod Pests of Honey Bees | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bee Louse, *Braula coeca* | Hymenopterans (Ants, Bees, Wasps) | Small Hive Beetle, *Aethina tumida* | Tracheal & External Mites, *Acarapis* spp. | Varroa Mites, *Varroa destructor* | Wax Moths, *Galleria mellonella* & *Achroia grisella* | Dragonflies | Roaches & Earwigs | Termites | Africanized Honey Bees |
| | Cultural/Non-Chemical Pest Management Practices | | | | | | | | | |
| Extract honey quickly & avoid long-term storage | NU | G | G | NU | NU | NU | NU | NU | NU | NU |
| Store comb and hive bodies in facilities with low humidity and freezing temperatures | NU | E | E | NU | NU | E | NU | NU | NU | NU |
| Practice good colony management - maintain colony strength, keep bottom boards off ground, remove debris | NU | E-G | ? | NU | NU | E | NU | G | G | NU |
| Requeen colonies, get acceptance | NU | NU | NU | ? | ? | NU | NU | NU | NU | G |
| Install pest barriers or traps | NU | E | NU | NU | NU | NU | NU | G | NU | NU |
| Store comb honey in freezers or use carbon dioxide to fumigate | E-G | NU | E-G | NU | NU | E | NU | G | NU | NU |
| Use resistant honey bee varieties (e.g., New World Carnolian & Russian genotypes, hygienic) | NU | NU | NU | G-F | G-F | NU | NU | NU | NU | NU |
| [1]Cull pests w/ screened sticky bottom boards, or trap pests in drone combs | NU | NU | NU | NU | G-F | NU | NU | NU | NU | NU |
| Relocate hives | NU | F | F | NU | NU | NU | F | F | F | NU |
| Install hive entrance reducer | NU | G | NU | NU | NU | NU | NU | NU | NU | NU |
| Use grease patties | NU | NU | NU | G | NU | NU | NU | NU | NU | NU |
| Store empty combs in well lit areas with good air flow | NU | NU | NU | NU | NU | G | NU | NU | NU | NU |
| Allow bees full access to all areas of the hive and let them fight pests | NU | G-F | F | NU | NU | E | NU | G | NU | NU |
| | Biological Controls | | | | | | | | | |
| Conservation of beneficial insects (e.g., parasitic wasps) | NU | NU | NU | NU | NU | F-P? | NU | ? | NU | NU |
| Entomopathogenic Fungi (*Metarhizium*) | NU | NU | ? | NU | ? | NU | NU | NU | NU | NU |
| Nematodes | NU | NU | ? | NU | NU | NU | NU | NU | NU | NU |
| *Bacillus thuringiensis* (Certan) - no longer registered | NU | NU | NU | NU | NU | E | NU | NU | NU | NU |
| Sterile male release | NU | NU | NU | NU | NU | ? | NU | NU | NU | NU |

[1]Sticky bottom boards do not usually work well for varroa mite control.

Table 2a. Efficacy ratings for various pest management tools against honey bee disease pests. Rating scale: E = excellent; G = good; F = fair; P = poor; N = no control; ? = research needed; NU = not used; * = used, but not a stand alone tool.

| Pest Management Tools | Disease Pests of Honey Bees | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | American Foulbrood, *Paenibacillus larvae* | European Foulbrood, *Melissococcus pluton* | Chalkbrood, *Ascospaera apis* | Stonebrood, *Aspergillus* spp. | Nosema, *Nosema apis* | Sacbrood Virus | Bee Paralysis Viruses | Deformed Wing Virus | Colony Collapse Disorder |
| | Registered Fungicides, Bactericides, Protozoicides, & Viricides | | | | | | | | |
| Fumagillin (*Fumidil-B, Fumagillin-B*) | NU | NU | NU | NU | E | NU | NU | NU | *? |
| [1]Oxytetracycline (*Terramycin, TM-50D, TM-100D, TM-25, Tetra-B Mix*) | G | E | NU | NU | NU | NU | NU | NU | NU |
| [2]Tylosin tartrate (*Tylan*) | G | NU | NU | NU | NU | NU | NU | NU | NU |
| | Unregistered/New Fungicides & Bactericides | | | | | | | | |
| ethylene oxide - being re-evaluated, but unlikely to be used again | E-G | NU | NU | NU | NU | NU | NU | NU | NU |
| Resmethrin - no longer generally used for killing infected hives | E | NU | NU | NU | NU | NU | NU | NU | NU |
| Lincomycin | ? | NU | NU | NU | NU | NU | NU | NU | NU |
| Acetic Acid | | | | | ? | | | | |

[1]Resistance issues have emerged with antibiotic use.

[2] Tylosin works well for controlling mild to moderate infections, but is poor when used on serious cases of AFB.

Table 2b. Efficacy ratings for various pest management tools against honey bee disease pests. Rating scale: E = excellent; G = good; F = fair; P = poor; N = no control; ? = research needed; NU = not used; * = used, but not a stand alone tool.

| Pest Management Tools | Disease Pests of Honey Bees | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | Cultural/Non-Chemical Pest Management Practices | | | | | | | | |
| Maintain colony strength and reduce stress by using good management & sanitation practices, improve feeding conditions | G-F | G | G | NU | G | G | NU | NU | ? |
| Isolate affected colonies to prevent hive robbing | E-G | NU | NU | NU | NU | NU | ? | ? | ? |
| Use clean equipment and tools, or transfer bees to clean equipment with new frames & foundation | E-G | NU | NU | NU | NU | ? | ? | ? | ? |
| Requeen w/ a different and/or hygienic honey bee strain | G-F | E-G | E-G | ? | G-F | G-F | ? | ? | ? |
| Control other pests (e.g., varroa mite or nosema) | NU | NU | NU | NU | NU | NU | ? | ? | ? |
| Burn bees, infected combs, and nonreusable equipment; scorch/heat treat reusable equipment | G | NU | NU | NU | NU | NU | NU | NU | ? |
| Sterilize equipment using a steam autoclave | E | E | E | E | E | E | E | E | ? |
| Sterilize equipment using ozone | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| Sterilize equipment using lye baths | G-F | NU | G-F | NU | NU | NU | NU | NU | ? |
| Replace old comb regularly | NU | NU | G | G | G | NU | NU | NU | ? |
| Sterilize equipment using gamma radiation | E? | NU | NU | NU | ? | NU | NU | NU | ? |
| | Biological Controls | | | | | | | | |
| | | | | | | | | | |

Table 3a. Efficacy ratings for various pest management tools against vertebrate pests of honey bees. Rating scale: E = excellent; G = good; F = fair; P = poor; N = no control; ? = research needed; NU = not used; * = used, but not a stand alone tool.

| **Pest Management Tools** | Vertebrate Pests of Honey Bees | | | | |
|---|---|---|---|---|---|
| | Mice | Skunks, Raccoons, Opossums | Bears | Frogs & Toads | Birds |
| | Registered Pesticides | | | | |
| Various mouse poisons used in honey bee buildings | E-G | NU | NU | NU | NU |
| | Unregistered/New Pesticides | | | | |
| | | | | | |

Table 3b. Efficacy ratings for various pest management tools against vertebrate pests of honey bees. Rating scale: E = excellent; G = good; F = fair; P = poor; N = no control; ? = research needed; NU = not used; * = used, but not a stand alone tool.

| **Pest Management Tools** | Vertebrate Pests of Honey Bees | | | | |
|---|---|---|---|---|---|
| | Mice, Moles, & Shrews | Skunks, Raccoons, Opossums | Bears | Frogs & Toads | Birds |
| | Cultural/Non-Chemical Pest Management Practices | | | | |
| Install hive entrance reducer in early fall | E-G | F | NU | NU | NU |
| Chase away or shoot pests; call Game Warden for bears | P | P | * | NU | P |
| Destroy nests & replace damaged frames | G | NU | NU | NU | NU |
| Cover stored hivebodies/supers to prevent pest entry | G | NU | NU | NU | NU |
| Use chicken wire in front of hive | N | E-G | NU | NU | NU |
| Install fence (baited & electrified) with lower wire around beeyard | NU | G | G | NU | NU |
| Keep colonies on stands (tall ones for bears) | N | N | G | E | NU |
| Select apiary site carefully; move bees to new location away from trees and pest home ranges/pathways | NU | ? | ? | NU | ? |
| Use baits or traps (snap, glue, or live catch) | E | G | NU | NU | NU |
| Employ harassment techniques or scare tactics (loud noises, bright lights) | NU | P | P | NU | P |
| Aversive conditioning (Lithium chloride) | NU | NU | P | NU | NU |
| Repellents (e.g., Critter Ridder - Capsaicin) | ? | ? | ? | NU | NU |
| | Biological Controls | | | | |
| | | | | | |

Table 4. Timeline of hive management activities in the mid-Atlantic states.

| WORKER ACTIVITIES | JAN. | FEB. | MAR. | APR. | MAY | JUN. | JUL. | AUG. | SEP. | OCT. | NOV. | DEC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Early Spring Management & Survival | ■ | ■ | ■ | | | | | | | | | |
| Initial Spring Inspection | | | ■ | | | | | | | | | |
| Initiate Swarm Prevention and/or Colony Splitting | | | ■ | ■ | ■ | | | | | | | |
| Supering | | | | ■ | ■ | ■ | ■ | ■ | | | | |
| Evaluate Colony Condition (Brood Rearing, Gentleness, etc.) | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| Honey Removal & Processing | | | | | | ■ | ■ | ■ | ■ | | | |
| Requeening | | | | ■ | ■ | | | ■ | ■ | | | |
| Disease & Parasite Control | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Fall & Winter Management | | | | | | | | | ■ | ■ | ■ | |
| IPM ACTIVITIES | | | | | | | | | | | | |
| Disease Monitoring | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Terramycin Application | | | ■ | ■ | | | | ■ | ■ | ■ | | |
| Mite Monitoring | | | ■ | ■ | | | | ■ | ■ | | | |
| Miticide Application | | | | | | | | ■ | ■ | ■ | | |
| Nosema Treatment | | | | | | | | | ■ | ■ | | |

Table 5. Timeline depicting when honey bee pests and diseases are problematic in the mid-Atlantic states. Lesser pests, or times when serious pests are less troublesome, are represented by a lighter gray.

| **Insects / Mites** | JAN. | FEB. | MAR. | APR. | MAY | JUN. | JUL. | AUG. | SEP. | OCT. | NOV. | DEC. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ants, Bees, Wasps | | | | | | | | | | | | |
| Bee Lice | | | | | | | | | | | | |
| Small Hive Beetle | | | | | | | | | | | | |
| Wax Moths | | | | | | | | | | | | |
| Tracheal/External Mites | | | | | | | | | | | | |
| Varroa Mites | | | | | | | | | | | | |
| Dragonflies, Beetles, Spiders, Bugs | | | | | | | | | | | | |
| Roaches & Earwigs | | | | | | | | | | | | |
| Termites | | | | | | | | | | | | |
| **Diseases** | | | | | | | | | | | | |
| American Foulbrood | | | | | | | | | | | | |
| European Foulbrood | | | | | | | | | | | | |
| Chalkbrood | | | | | | | | | | | | |
| Stonebrood | | | | | | | | | | | | |
| Nosema | | | | | | | | | | | | |
| Sacbrood Virus | | | | | | | | | | | | |
| Bee Paralysis Virus | | | | | | | | | | | | |
| Deformed Wing Virus | | | | | | | | | | | | |
| Colony Collapse Disorder | ? | ? | ? | ? | | | | | | | ? | ? |
| **Vertebrates** | | | | | | | | | | | | |
| Rodents (Mice, Moles, & Shrews) | | | | | | | | | | | | |
| Bears | | | | | | | | | | | | |
| Birds | | | | | | | | | | | | |
| Amphibians (Toads & Frogs) | | | | | | | | | | | | |
| Skunks, Raccoons, Opossums | | | | | | | | | | | | |