Crop Profile for Honey Bees in New Jersey

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General Production Information

1. In 2002, there were approximately 2.5 million managed honey bee colonies in the United States. Of these, 10,000 bee colonies were located in New Jersey, ranking the State 32nd and accounting for 0.4% of the total number of registered colonies in the country.

2. Approximately 171.1 million pounds of honey were produced in the United States in 2002. National sales of honey totaled more than $221 million.

3. In 2002, New Jersey produced 350,000 pounds of honey, ranking the State 44th and accounting for 0.2% of the total honey produced in the United States. Based on the 2002 national average of $1.29 per pound, the market value of New Jersey honey was $451,500. New Jersey ranked 41st in total value of honey production in the country.

4. In 2000, the value of honey bee pollination to commercial crop production was estimated at $14.6 billion in the United States. The value of honey bee pollination to crop production in New Jersey was estimated at $83.6 million in 2002 (see Appendix I), where "value" refers to increased yield, seed set, and/or fruit quality.

5. The standing value of New Jersey's 10,000 managed bee colonies (as livestock and beehives) was estimated at $1.92 million, based on a 2002 establishment value of $192 per colony.

6. Production costs (colony maintenance) were estimated at $25 per colony per year in 2002. New Jersey beekeepers spend approximately $250,000 each year on colony maintenance, which is a reinvestment of 55% of their honey sales revenue back into bee management.

Production

Honey bees in New Jersey are managed for contract pollination services, honey production, secondary hive products (beeswax, pollen, royal jelly, propolis), and as a source of bee stock (the sale of queens, “package” bees, and nucleus colonies). Crop growers rent thousands of bee colonies each year to pollinate the many crops grown in New Jersey that depend on insect pollination. These crops include apples, blueberries, cantaloupes, cranberries, cucumbers, melons, squash, pumpkins, watermelons, and vegetables grown for seed. Honey is wholesaled in bulk to packagers, redistributors, bakeries, or other companies; or is retailed to individuals through roadside stands, farmers markets, or under contract to grocery stores and specialty product markets. Beeswax is generated as a byproduct of honey production, and is typically marketed in the form of candles or as solid blocks for the commercial cosmetics industry (lotion, lip balm, etc.). Pollen, royal jelly, and propolis (plant resins collected by bees to fortify and sanitize their comb and nest cavity) are collected by some beekeepers and are profitable items in the homeopathic and health food market (as tinctures, salves, dietary supplements, etc.). Pollen is also used by beekeepers to boost bee populations in early spring or other times in which few plants are in bloom. Queens, bee packages (small wood and wire boxes containing 2 to 5 pounds of worker bees and a queen), and nucleus colonies (small wood hives containing 2 to 5 frames of adult bees, wax comb, bee brood, and a queen) produced in New Jersey are typically sold to regional beekeepers to start, expand, or replace colonies of beekeeping operations within the State and region.

Hobbyists (50 colonies or less) comprise the majority of beekeepers in New Jersey. Sideliner (50-500 colonies) and commercial (more than 500 colonies) beekeepers are not as numerous as the hobbyists, yet they provide most of the State’s pollination contract services and produce most of the bulk wholesale honey.

New Jersey provides a reasonably good habitat for honey bees, and offers a diversity of natural and cultivated plant species that serve as nectar and pollen sources. Some areas (e.g., the Pine Barrens) are less conducive to year-round beekeeping due to the lack of food resources in the summer and fall seasons. Sideliner and commercial beekeeping operations in New Jersey are generally located in the central and southern portions of the State, while hobbyist beekeepers are found throughout the State, including the more heavily populated northern areas. Bee colonies used for contract pollination services are moved to farmland during the crop’s blooming period and are then removed one to several weeks later once pollination is completed.

Most hobbyist and sideliner beekeepers overwinter their bees within the State, having permanent or long-term apiaries, each containing 2 to 20 colonies per location. Commercial beekeepers tend to practice migratory beekeeping, and relocate their colonies to southern states (e.g., Florida) during the winter to reduce winter mortality, pollinate crops, or take advantage of seasonal nectar flows in the South.

Cultural Practices

Honey bees (*Apis mellifera*) are perennial, social insects native to Europe, Eurasia, the Middle East, and Africa. A typical bee colony is comprised of one queen (female), 15,000 to 60,000 worker bees (females), and zero to several hundred drones (males). The queen honey bee is the head of her colony, and may live up to several years. Under normal conditions, only the queen is capable of laying eggs that develop into adult worker and drone bees. Worker bees perform all of the non-reproductive activities for the colony, including brood care, comb construction, foraging, hygienic behavior, processing nectar into honey, hive ventilation, and colony defense. The population of worker bees varies by season, being smaller in winter and peaking in late spring to mid-summer. Bee population growth and decline closely parallels the blooming periods of the major nectar and pollen resource plants in a given area. Drones are also most abundant in late spring and mid-summer. Their only function is to mate with new queens from other bee colonies. The physical act of copulation kills the drone. If a drone does not mate during the season, it is forcibly removed from the hive in the fall by worker bees, and colonies are typically free of drones during the winter clustering period.

Settlers introduced honey bees into the New World in the 1600s. Through human migrations and natural bee dispersal, honey bees now are now distributed throughout North and South America. Feral honey bees typically live in hollow trees or similar enclosed cavities. In the 1800s, the moveable-frame hive was developed and has undergone very few changes. The basic design is still used today.

Standard bee management practices are common throughout the United States; however, the timing of specific activities varies by region. These activities include general management, disease and parasite control, swarm prevention, honey production, colony splits, requeening, and winterizing colonies. Honey production times are variable by location and based on the blooming periods of plants from which nectar is collected.

Worker Activities

Beekeepers use a variety of personal protection equipment to avoid bee stings. Hats and veils are used to protect the face, neck, and eyes, while long sleeve shirts and gloves may be used to protect the arms and hands. These protective clothing items are not intended as chemical protective gear, but may offer some protection from inadvertent exposure to materials used for bee disease and pest management.

Aside from year-round general management practices, beekeepers have concentrated periods of activity in spring (bee population build-up, parasite control, swarm prevention, and honey production), summer (honey extraction, queen replacement), and fall (parasite control, fall honey production, winterizing procedures). Beekeepers that provide contract pollination services have additional periods of activity, such as when they relocate their bee colonies from field to field and possibly state to state.

Population build-up occurs in early to mid spring, as beekeepers prepare for the nectar flows in late spring to early summer. It is generally recognized that a colony with 50,000 bees makes more honey than two colonies of 25,000 bees each. Very strong colonies may be split into two colonies, and two weak colonies may be combined into one strong colony. Most colonies are fed supplemental diets in early spring to accelerate brood production, as natural resource plants are limited in the early season. Sugar or corn syrup and pollen substitutes (e.g., a soy flour and brewer's yeast mixture) are the most widely used supplemental diets.

Chemical treatment for the parasitic mite, *Varroa destructo*r, typically occurs once (late summer or early fall) or twice (early spring and late summer) a year in New Jersey, depending on the population of mites. In early spring, standard chemical treatments are applied such that pesticide strips are removed from beehives at least four weeks before honey production begins in late spring to early summer. Varroa mite control is accomplished by placing single-use, acaricide-impregnated plastic strips (Apistan ®; tau-fluvalinate; or Checkmite+, coumaphos) inside the beehives. Fluvalinate- or coumpahos-impregnated plastic strips are hung in the brood chamber; hence there is minimal exposure to the piarist. Strips are easy to install and remain in place for 45-56 days before they are removed and disposed of in accordance with the label directions. Chemical-resistant gloves (e.g., waterproof) must be worn when handling either pesticide strip formulation.

Coumaphos is a pesticide used to control both varroa mites and small hive beetles (*Aethina tumida*) in honey bee colonies. It is currently available as CheckMite+® in New Jersey and other states under a Section 18 Emergency Exemption. It is notable that coumaphos is an organophosphate, and hence under close scrutiny as a pesticide.

Due to the application method for small hive beetles, there is essentially no risk to beekeeper or honey bees in the hive, or to honey or wax contamination. For varroa mite treatments, the potential risks of hive product contamination, and bee and beekeeper injury are alleviated when this pesticide is used in accordance with its label.

Currently, small hive beetles have only been found in several apiaries in southern New Jersey, and it is not yet known whether these beetle populations are truly established or are simply an impermanent result of interstate migratory beekeeping operations. Chemical control for small hive beetles is targeted at the adult stage of the pest, and treatments for beetles can occur at any time this pest is detected in beehives. The placement of CheckMite+® strips underneath plastic corrugated cardboard is the only in-hive treatment approved for small hive beetles in active bee colonies.

Soil drenching with GardStar® 40% EC (permethrin) is also used to kill small hive beetle larvae as they burrow into the ground to pupate. Beekeepers can adequately reduce the risk of pesticide exposure when applying this chemical by wearing chemically-resistant gloves, proper clothing (long-sleeved shirts and pants), and waterproof shoes.

Chemical alternatives to fluvalinate and coumaphos to control varroa mites are currently limited to two registered products. ApiLife VAR®, an essential oil product used to suppress varroa mites in bee colonies, is currently available in New Jersey and other states under a Section 18 Emergency Exemption. It is a mixture of botanical oils soaked into a foamed vermiculite pad, where oil components are, by percent pad weight: thymol (74.1%), eucalyptus oil (16.0%), L-menthol (3.7%), and other ingredients (6.2%). ApiLife VAR® is generally not as efficacious as fluvalinate or coumaphos in controlling varroa mites, is more expensive and more laborious to apply than the standard chemical treatments, and may negatively affect brood production; hence, many beekeepers are unwilling or unable to rely on ApiLife VAR® as the sole means of varroa mite control. The other alternative chemical is Sucrocide™, a formulation of 40% sucrose octanoate. Sucrocide™ was granted a Section 3 General Use status in 2004 nationwide. Preliminary studies show that Sucrocide™ can control varroa mites in late fall as effectively as fluvalinate or coumaphos, yet more research is needed for other times of the year when differing levels of bee brood are present in the hive. While relatively inexpensive, Sucrocide™ is more difficult to apply than the standard chemical strips, as beekeepers must spray each frame of bees individually with a garden-type sprayer. Because of this and the yet unknown degree(s) of varroa mite control when applied during heavy brood rearing seasons, many beekeepers are reluctant to try this alternative treatment. Researchers are attempting to develop more data on the year-round use of Sucrocide™ and more efficient means of applying the material inside the bee colony. While Sucrocide™ poses a low risk to the beekeeper, protective eyewear such as goggles or a face shield should be worn during application to avoid temporary eye injury. Although harmless to human skin, waterproof gloves can be worn to avoid contact with Sucrocide™ sprays during application.

In early spring and other non-honey production periods, beekeepers may chemically treat for different diseases and pests as needed. Included are the use of terramycin to combat European Foulbrood, a bacterial disease of larval honey bee caused by *Melissococcus pluton*; and fumagillin to combat Nosema Disease, a protozoan infection of adult honey bees caused by *Nosema apis*.

Swarming is the way honey bees reproduce at the colony-level. This behavior is triggered by various factors, the primary cause being colony overcrowding. If the bee population exceeds the available space within their nest cavity, the old queen is forced out of the hive by worker bees and is followed by roughly half of the worker bee population. They alight briefly (several hours to days) on a tree branch or similar structure, and eventually fly off to a new nesting site once a suitable cavity is found.

Because strong colonies are better honey producers than weak colonies, beekeepers actively manage their bees to prevent swarming. Swarm prevention procedures typically occur in mid spring. Various techniques are used, and include “colony reversal”, colony splits, swarm traps, removal of queen swarm cells, confinement of the queen, and clipping the queen’s wings.

Reversing the hive and splitting overpopulated colonies are most efficient means of swarm control. Hive reversal is the repositioning of hive bodies to allow more usable space for the colony. During winter, bees migrate upwards in the hive as they consume their honey stores to thermoregulate the nest cavity. By spring, the colony is concentrated in the uppermost chambers of the hive, while the lower portions are unoccupied. By switching the upper chambers with the lower ones, the colony now has more usable space and is less likely to swarm. Splitting very strong colonies into two colonies will also alleviate overcrowded conditions.

The placement of swarm traps (hollow boxes baited with bee lures) help beekeepers recover swarms that issued from their colonies, and the captured swarms can be added back to weak colonies or set up as new colonies in unused hives. Removal of queen swarm cells is not a reliable technique, as the odds of missing one swarm cell are high in a large colony. Although practiced by some beekeepers, confining the queen to prevent her from flying is not recommended because it results in the queen becoming egg-bound, a condition which can affect her future vitality as a queen. Clipping the queen's wing(s) will not prevent swarming, but does prevent the swarm from flying away. Instead, the queen and trailing swarm crawl on the ground, and can be collected and returned to the hive. Flightless queens and crawling bees are at high risk to injury and predation by birds and rodents.

Beekeeper prepare for honey production in mid spring by adding empty "supers" (hive boxes) to the tops of their hives. Many beekeepers use metal or plastic devices called queen excluders to prevent the queen from migrating into the honey supers and laying brood. Supers containing only honey are the easiest to extract and require less filtering of extraneous material during the extraction of liquid honey from the combs. Other forms of honey include "comb honey" (natural honeycomb built in market-ready containers), "cut comb honey" (the sectioning of natural honeycomb to fit containers), "chunk honey" (cut comb honey combined with liquid honey), and "creamed honey" (liquid honey which has been seeded with minute sugar crystals so that the honey as a whole eventually takes on a crystallized form, where the crystal size is undetectable by the human tongue, thereby imparting a creamy consistency). Most of the honey sold in the United States is in the liquid form.

The type (color, flavor, and other characteristics) of honey collected varies considerably by location and season. Beekeepers in New Jersey can often make surplus honey from spring or summer "nectar flow" plants such as basswood (*Tilia* spp.), black locust (*Robinia pseudoacacia*), wild and cultivated blueberry (*Vaccinium* spp.), clover (*Trifolium* spp.), dandelion (*Taraxacum officinale*), holly (*Ilex* spp.), pepperbush (*Clethra* spp.), Russian olive (*Elaeagnus angustifolia*), sumac (*Rhus* spp.), and tulip poplar (*Liriodendron tulipifera*). In some areas of New Jersey, beekeepers can make late summer or fall honey crops from aster (*Aster* spp.), buckwheat (*Fagopyrum esculentum*), goldenrod (*Solidago* spp.), heartsease and smartweed (*Polygonum* spp.), and "mallow" (various genera).

Bees are removed from the full honey supers with brushes, blowers, or approved bee repellents. Honey supers are then transported to a honey extraction site. The layer of wax covering the honey cells is removed with hot knives or machines, and the exposed honey frames are placed in an extractor, which can be manual or electric. The honey can be heated, filtered, or bottled immediately. Honey extraction and bottling usually takes place in summer or early fall. The empty supers are returned to the hive or stored for the next honey flow.

Most honey is labeled as "wildflower honey", although one floral source may dominate a honey crop. Labeling laws make it illegal to market "pure" source-specific honeys, as the beekeeper cannot guarantee that the bees did not visit any other plant species while making that particular honey crop. For example, "Pure Sumac Honey" is not an acceptable label, while "Sumac Honey" is allowable if 51% or more of the honey is presumed to have been collected from sumac flowers.

In late summer, many New Jersey beekeepers may introduce new queens into their colonies. This “requeening” assures that a young, viable queen will be in place for the following season. Studies have shown that colonies with young queens are generally more healthy and productive than colonies with older queens. Most beekeepers requeen every two years. Before a new queen is introduced, the old queen must be killed. Beekeepers must wait at least 6 hours, but no more than 2 days, to introduce the new queen, as the workers will likely kill a new queen if introduced too soon. If they wait too long, worker bees may start laying haploid eggs, leading to a loss of colony cohesion. Requeening yearly also helps beekeepers control the genetics of their colonies, which is of particular interest to those who are using specialty queen stock (mite- or disease-resistant genotypes, bred lines favored for their high honey production potential or gentle temperament, etc.).

Late summer and fall are additional times of disease and parasite management for New Jersey beekeepers. In many cases, another treatment for varroa mite control is needed, as reinfestation of colonies by this mite is common throughout the State and across the country. Varroa control is accomplished as described above, using Apistan® (tau-fluvalinate), Checkmite+® (coumaphos), or other means (see mite control section below).

New Jersey beekeepers must also treat for tracheal mites (*Acarapis woodi*) in the fall. These endoparasitic mites can cause massive winter die-offs if left untreated. Menthol is applied as crystals enclosed in screen packets placed on the top-most frames in the beehive; thus, there is limited chemical exposure to the apiarist. Beekeepers should wear gloves when handling menthol crystal packets. At temperatures of 70^{O}F or above, sublimation of the crystals occurs; menthol vapors permeate the hive and kill the tracheal mites.

In several states, ethylene oxide (ETO) is used to fumigate bee equipment that is contaminated with *Paenibacillus larvae*, the causal agent of American Foulbrood (AFB). The fumigation is done inside large pressurized containers and allows for the reuse of equipment that would otherwise be destroyed. ETO fumigation is not an option in New Jersey, as ETO has several physical and health hazards that outweigh its benefits for this use. ETO is flammable and highly reactive. Acute exposures to ETO gas may result in respiratory irritation and lung injury; while chronic exposure has been associated with the occurrence of cancer, mutagenic changes, neurotoxicity, and sensitization. In New Jersey, the only approved method for ridding an apiary of AFB is to destroy both the bees and bee equipment by burning in a ground pit. Some beekeepers depopulate the colony before burning with an over-the-counter general insecticide such as resmethrin (synthetic pyrethroid). Burning of the dead bees and bee equipment is done several days or weeks later, once the resmethrin has dissipated. Chemical-resistant gloves should be worn when spraying resmethrin into the beehive. Protective respirators are generally not needed since resmethrin application should only take place outdoors.

In late fall, New Jersey beekeepers must “winterize” their bee colonies. Various factors must be addressed to increase the survival rate of bee colonies during winter. Colonies must be checked for diseases and pests and treated immediately, if found. Each colony should have at least 45 pounds of honey stores, as this serves as their fuel to heat the hive and stay alive. The hive entrance should be reduced in size to limit the volume of cold air entering the hives, and also prevents invasion by mice or other opportunistic pests. The top cover should be raised slightly (ca. 1/16-1/8 inch) at the rear of the hive to create airflow. Slight ventilation is necessary to remove moisture-laden air from the hive, as cold moist air can severely stress clustering bees.

In winter, beekeepers generally prepare for the following season by building new equipment, repairing broken hives, purchasing pest control products they need to replace, or attending beekeeper meetings to catch up on the latest management techniques and pest control strategies.

Disease and parasite control is the single biggest challenge to successful beekeeping in New Jersey and across the United States.

Pests

Like all animals, honey bees are subject to many diseases, parasites, pests, predators, abiotic stresses, genetic abnormalities, and other ailments. Some diseases (e.g. American Foulbrood) and parasites (e.g. varroa mite) are considered serious problems throughout the United States, as they are ubiquitous and can cause considerable economic loss. Other pests, such as the tracheal mite, are also ubiquitous, but tend to be more problematic in the northern states than in the southern regions of the country. Various predators are common in some areas and lacking in others. For example, bears may cause considerable damage to beekeeping operations in areas where these animals are abundant. Some ailments are rarely detected or may be confused with other conditions.

The organisms and ailments affecting honey bees are described below. Categories are divided into organisms (bacteria, fungi, protozoa, viruses, parasitic mites, insect pests, birds and reptiles, and mammals), and non-infectious or physiological disorders (pesticide poisoning, plant poisoning, temperature stress, starvation, and genetic lethality). Summarized below is the biology of the organism or disorder, frequency of occurrence, damage caused to honey bees, symptoms and identification of the ailment, potential for economic loss (ranked as: None, Very Slight, Slight, Moderate, or Severe), and available control strategies (chemicals and alternatives).

BACTERIA

American Foulbrood
(Paenibacillus larvae)

Biology: American Foulbrood (AFB) is widespread and the most destructive of the honey bee brood diseases in the United States. Each year, there are scattered cases of AFB in New Jersey, but the occurrence of the disease does not follow any specific geographic or temporal pattern. AFB may persist in some individual beekeeping operations due to poor or inadequate management practices.

AFB is caused by the spore-forming bacterium, *Paenibacillus larvae*. Young bee larvae are susceptible, but older larvae and adults are not. Transmission occurs when spore-contaminated brood food is fed to young larvae by nurse bees. The spores germinate in the larval gut and multiply rapidly. Infected larvae typically die as prepupae; after their cell is capped, but before the cocoon-spinning stage is completed. New spores are formed while the larva dies. The infected larvae will eventually decompose into a “scale”, or the spore-laden remnants of the diseased individual. Infection may be slow to spread in the initial stages of an AFB outbreak, yet can result in the death of the colony during the same season or the following year.

The transmission of spores to house bees occurs when they attempt to clean out infected cells. The sticky nature of recently dead or dying larvae, or the tough, dry nature of the scales impedes their removal, and so completely contaminates the house bees and surrounding comb. Soon, spores are distributed throughout the hive and more larvae become infected.

The honey stores of infected colonies can easily become contaminated with AFB spores, and thus can also be a rapid source of transmission. Colonies weakened or killed by severe AFB infections will have their honey stores robbed out by bees from nearby, stronger colonies. If the honey is contaminated with spores, then the robbing colony will also likely succumb to AFB once infection spreads to its brood.

Bees drifting to and from infected colonies, and swarms from infected colonies can also spread AFB.

AFB is transmitted inadvertently by beekeepers using contaminated equipment (e.g., hive tools), reusing or exchanging contaminated combs between colonies, or exposing contaminated honey to other bees.

Signs of early and mid-infection are the presence of sunken, darkened brood cell caps, often with multiple perforations; a characteristics odor; discolored (brownish) brood; and decomposing larvae and/or pupae. The overall brood pattern will appear spotty due to the mixture of diseased and healthy brood cells.The presence of “scales”, or the dried down remains of infected individuals within brood cells, characterizes advanced infections. These scales adhere tightly to the bottom surface of the cell, and can only be removed with great difficulty.

Another diagnostic technique is called the “rope test”, whereby a toothpick or similar instrument is swirled inside the cell of a suspected diseased larva or pupa, and then slowly drawn outwards. If the diseased larval mass remains attached (“ropes out”) on the toothpick for a distance of about one inch or more, than it is likely that the larvae died from American Foulbrood (brood infected with European Foulbrood will also be discolored, but will not rope out as far). If death occurs at the pupal stage, the tongue of the pupa may protrude from the scale.

Potential for Economic Loss: Severe. AFB infections will eventually kill the colony, and can be spread rapidly between colonies and apiaries. The spores of *P.larvae* are not susceptible to antibiotics, and as such, contaminated hives must be destroyed. Advanced cases of AFB may lead to the destruction of an entire apiary. AFB spores remain viable for several decades or longer.

Cultural Control: In New Jersey, the only acceptable control tactic for an AFB-infected colony is the destruction of the bees and beehive by burning. If worker bees are still present, a pesticide can be applied inside the hive so that contaminated bees cannot escape and spread the disease to other colonies. The hive entrance can also be blocked, enclosing the bees inside. AFB colonies are typically burned in a ground pit, and covered with dirt once the equipment has finished burning.

Chemical Control: The vegetative cells of *P. larvae* can be killed with antibiotics (oxytetracycline), which will suppress the AFB infection. However, because of the spore contamination, antibiotics will not cure a colony of AFB and only serve to mask the infection for as long as the antibiotics are applied.

Treating AFB with antibiotics is illegal in New Jersey, since infections will re-manifest and/or spread to other colonies. Abuse of antibiotics also results in loss of efficacy against treatable bacterial diseases, like European Foulbrood, or in the contamination of hive products intended for human consumption.

Fumigation: Some states have fumigation chambers that can decontaminate AFB bee equipment. Ethylene oxide (ETO) is the most common fumigant for destroying AFB spores in beehives. Honeycomb cannot be fumigated, as ETO will not penetrate capped honey cells. Even when fumigated, empty comb with AFB scales should be cut out and destroyed before refitting the frames with new wax foundation. ETO fumigation of bee equipment is not allowed in New Jersey.

Sanitation: Sanitary practices and using common sense are the best ways for beekeepers to prevent the spread of AFB. If AFB is found, the hive should be closed off immediately, and any tools or clothing exposed to the AFB colony should be cleaned before opening another, AFB-free colony.

Some bee equipment can be reused if properly cleaned. Hive tools can be cleaned with a diluted Clorox solution (10%) and wire brush. Clothing should be also be cleaned, especially cloth or leather loves.

Honey from an AFB contaminated colony should not be exposed or fed to other bees. This honey can be bottled and consumed by people, as AFB presents no hazard to humans or other animals. Only honey bees are susceptible to infection by *P. larvae*.

European Foulbrood

(Melissococcus pluton)

Biology: European Foulbrood (EFB) is caused by the non-spore-forming bacterium, *Melissococcus* *pluton*. Like AFB, EFB only affects larval honey bees. Infection occurs shortly after bee eggs hatch as bacteria contaminated brood food is fed to young larvae by nurse bees. Larvae typically die before their cells are capped for pupation. These bacteria invade the larval gut and multiply rapidly, causing death of the individual larva typically within four days after egg hatch.

Transmission of EFB occurs through the contamination of house bees as they clean out dead and dying larvae from the comb, resulting in contamination of the entire beehive. Additional spread of EFB between bee colonies can occur through the beekeeper's action by the interchange of EFB-infected equipment among colonies, and by bees from other colonies as they rob contaminated honey stores from the EFB-infected colony.

Each year, there are scattered cases of EFB in New Jersey, but the occurrence of the disease does not follow any specific geographic pattern. EFB may persist in some individual beekeeping operations due to poor or inadequate management practices. EFB is most common in spring when brood rearing is at its height, particularly during the latter brood cycles in mid to late spring. EFB infections may appear suddenly and spread rapidly, resulting in the death of the colony; or can spread slowly and do little damage. EFB infections sometimes subside without treatment during summer, or can continue through summer and fall. Strong honey flows help bees naturally overcome mild EFB infection levels.

Combs containing bee larvae infected with EFB usually present a rather uniform appearance because the cells are not sealed. Larvae diseased by European foulbrood move restlessly within their cells and, therefore, when they die, are usually twisted in the cells or die while in the "C" stage at the bottom of the cell. However, some larvae may be stretched out lengthwise from the mouth to the base. In some cases, the larva collapses as though it had been melted, turns yellowish brown, and eventually dries to form a loosely attached brown scale. The consistency of recently dead larvae varies but it is not ropy. The odor of the larval remains also varies. The scale remains of larva dead from European foulbrood disease can be removed readily.

Combs containing larvae infected with EFB will not have the shrunken cell cap appearance common to AFB. Discolored larvae with silvery-looking tracheal tubes and a negative "rope-test" are means of distinguishing EFB from AFB.

Potential for Economic Loss: Slight to Moderate. Most FB cases can be treated successfully with antibiotics. Advanced and unchecked EFB infections can cause a serious reduction in the bee population or even death of the colony.

Control Practices: In New Jersey, the only approved treatment for EFB is the antibiotic, terramycin. Various formulations and means of applying treatments are available and discussed below. New antibiotics (e.g., tylosin) are being developed for control of EFB and as proactive suppressants for AFB.

Septicemia

[*Pseudomonas aeruginosa* (= *P. apiseptica*)]

Biology: Septicemia is caused by a Gram-negative, rod-shaped bacterium occurring singly, in pairs, or in short chains. Rods are 0.5-0.8 to 1.5-3.0 µm. Frequency of occurrence for this disease is unknown Infection is rarely reported and likely misdiagnosed as another ailment.

Infection results in disintegration of connective tissues of the antennae, legs, wings, and thorax. Affected bees will fall apart when handled. Dead or dying bees may have putrid odor.

Suspected cases of septicemia can be identified with a bacterial smear and Gram-stain by dipping a removed wing base in a water droplet on a microscope slide. Isolation of *P. aeruginosa* can be made using Difco *Pseudomonas* isolation agar and *Pseudomonas* Agar F.

Potential for Economic Loss: Very Slight. Septicemia is rarely encountered or correctly identified.

Control Practices: None.

Spiroplasmosis

(*Spiroplasma* spp.)

Biology: *Spiroplasma* ssp.are motile bacteria that lack cell walls. These tiny, coiled organisms can infect the hemolymph of infected adult bees. The organism is tiny and helical, measuring 2 to >10 µm long. Its body length increases with age and sometimes has branched filaments that are 0.7 to 1.2 µm in diameter.

Frequency of occurrence of this disease is unknown, and cases are likely misdiagnosed as another ailment. Little is known about the effects of spiroplasmosis of honey bees, as it is a rarely encountered condition. Information on the routes of infection and transmission between individual bees, and the damage caused to infected bees is lacking.

Spiroplasma can be found in the hemolymph of suspect infected bees using phase-contrast microscopy. Hemolymph samples are taken from adult bees by puncturing the intersegmental membranes directly behind the fort coxae with a fine capillary tube. Spiroplasma can be cultured in standard mycoplasma broth medium (GIBCO) and in Singh's mosquito tissue culture medium with 20% fetal calf serum.

Potential for Economic Loss: Very Slight. Spiroplasmosis is rarely encountered or correctly identified.

Control Practices: None.

FUNGI

Chalkbrood
(Ascosphaera apis)

Biology: Chalkbrood is a fungal disease of immature bees (larvae). Worker, drone, and queen larvae are all susceptible to the disease. Chalkbrood widespread in New Jersey and throughout the US. It is considered a minor disease that tends to occur mainly in spring or at other times of heavy rainfall. Stressed bee colonies are also more susceptible to Chalkbrood infections.

The affected worker bee larvae are usually found on the outer fringes of the brood area. Brood cells can either be sealed or unsealed. Diseased larvae are stretched out in their cells in an upright condition.

The spores of *A. apis* are ingested with the brood food provided by the nurse bees. The germination of the spores and proliferation of the fungus covers the larva with a white mycelium.

Typically, larvae dead from chalkbrood disease are chalk white, hence the name chalkbrood. Sometimes the diseased larvae can be mottled with brown or black spots, especially on the ventral sides. The color variation is from the brown to black color of the fruiting bodies (spore cysts).

Spores of *A. apis* remain viable for years. Consequently, the infection source could be present in the cells used to rear brood. Chalkbrood appears to be most prevalent in the spring when the brood area is increasing, yet normally does not destroy a colony.

Potential for Economic Loss: Very Slight to moderate. Chalkbrood is typically only a minor and temporary problem, and the colony usually recovers without noticeable losses during the height of the brood season (mid- to late-spring). Occasionally, chalkbrood infections can result in large die offs of bee brood in early spring, which may impact honey production in late spring to early summer by preventing normal bee population build-up.

Control Practices: None. The disease usually disappears or is reduced as the air temperature increases in the summer.

Stonebrood
(Aspergillus spp.)

Biology: Stonebrood is a disease caused by several *Aspergillus* species, including *A. flavus* and *A.*

fumigatus. *A. flavus* is the most important. The disease is transmitted by contaminated brood food supplied by nurse bees. Spores are ingested and terminate.

Frequency of occurrence is Occasional. Stonebrood is likely misdiagnosed as chalkbrood, despite differences in the color and consistency of mummies.

Both larvae and pupae are susceptible, and infection results in the mummification of infected brood. Stonebrood mummies resulting from infection with *A. flavus* are hard, solid, and covered with a powdery layer of green spores, especially around the head region. This is in contrast to the spongy consistency, and white or black color of chalkbrood mummies.

Potential for Economic Loss: Very Slight. Stonebrood is rarely encountered and detected, and as such, is considered of minor importance in beekeeping.

Control Practices: There are no recommended treatments, as diseased individuals are removed from the colony by worker bees. Strong colonies recover quickly.

PROTOZOA

Nosema Disease
(Nosema apis)

Biology: Nosema is a disease of adult honey bees caused by the single-celled microsporidian, *Nosema apis*. Nosema spores are inadvertently eaten and germinate in the adult bee midgut. The active phase of the organism multiplies rapidly, produces new spores, which ruptures the infected digestive cells. Spores accumulate in the fecal matter and are excreted. Under winter confinement, spore-laden excreta from infected bees may contaminate food reserves and combs, leading to additional transmission and infection. The spread of Nosema between colonies occurs from the use of contaminated equipment, robbing of infected hives, through infected package bees, infected queens, and her attendant workers.

Nosema disease is widespread in the United States. It generally occurs in the spring during cool wet weather or at other times of the year when similar conditions prevail.

Nosema infection causes extreme dysentery in advanced infections. Individual bees may exhibit the inability to fly. Heavy infections can result in slow bee population growth in the spring and/or an excessive number of dead or dying bees at the hive entrance.

No outward symptoms are particularly indicative of infection, although dysentery inside and on the outside of the hive is often a sign of infection. However, these signs may also be caused by other abnormal conditions or ailments. Latent infections may also occur without being noticed. Diagnosis is made by the removal and microscopic examination of the midgut. Healthy midguts appear tan-colored and convoluted, whereas infected midguts are white and appear bloated due to the presence of Nosema spores.

Potential for Economic Loss: Moderate to Severe. Substantial infections can cause extensive losses of adult bees and possibly lead to queen supersedure. Nosema disease is a particular concern for its effects on spring colony development following a long confining winter.

Control Practices: Treatment with Fumidil-B® (fumagillin) during infection or proactively in the previous fall. Fumidil-B® is mixed with sugar syrup and fed to the bees.

Amoeba Disease

(Malpighamoeba mellificae)

Amoebae Disease is caused by a protozoan that infects the Malpighian tubules of adult bees (the tubules are functionally analogous to the human (kidneys).

Infection often occurs as a co-infection with Nosema, but may persist individually. It is rarely detected or identified as the sole cause of bee mortality.

Amoebic infections may disrupt the normal water-balance physiology of infected bees.

Due to the nature of infection, diagnosis can be only made by the removal and dissection of the tubules under a microscope. Tubule examination of infected individual will show the presence of amoebae cysts, which measure 5-8 µm in diameter.

Potential for Economic Loss: Slight to Moderate. Co-infections with Nosema likely elevate the risk for economic loss of bees.

Control Practices: None specifically for amoeba. Treatment of Nosema with fumagillin may help alleviate the compound effects of co-infections.

Gregarines and Flagellates

Four gregarines *Monoica apis*, *Apigregarina stammeri*, *Acuta rousseaui*, and *Leidyana apis*) and some flagellates (*Crithidia* (= *Leptomonas*)) are associated with honey bees. These organisms can be sometimes found in the alimentary canal of adult bees, particularly around and attached to the midgut tissues. Detection and identification requires the use of compound microscopes.

These organisms are not associated with any economically important diseases of the honey bees, and as such, there are no recommendations for their control. However, it is important to recognize their potential presence in honey bee tissues, especially when bees that have died from unknown causes are dissected.

Viruses

Many viruses have been identified from honey bee brood and adults. Most are of academic interest only, as very few bee colonies will succumb to virus infections as the sole cause of mortality. However, some virus diseases (e.g. Sacbrood) are fairly common and should be recognized for their similarity in appearance to other diseases (e.g., foulbrood); likewise, infection with Bee Paralysis Virus can be mistaken for pesticide poisoning. Other viruses, such as Deformed Wing Virus (DWV), have become more prevalent and serious in recent years, as they are transmitted by varroa mites. There are no treatments for bee viruses.

Sacbrood Virus

Sacbrood is a widely distributed disease, but it rarely causes a detectable loss of the bee population in a colony. However, beekeepers should learn to recognize Sacbrood so it will not be mistaken for other, more serious diseases, such as American Foulbrood.

Sacbrood may appear at any time during the brood-rearing season, but it is most common during spring and summer. Usually it subsides after the main honey flow starts in late spring to early summer.

Scattered among the healthy brood are cells containing dead brood. Their cappings are dark and may be punctured or partly removed by the adult bees. About the time the cell is sealed, the larva dies. When it does, the head end turns up and remains in that position; also the pearly white color begins to darken, and the skin then becomes tough and separates from the rest of the body. At that stage, the larva, which resembles a liquid-filled sac, can be removed from the cell intact. The dead larva then continues to dry and harden until the dried-down scale is almost black. The head end is usually the darkest. Scales of larvae dead of Sacbrood can be removed from the cell easily by house bees.

The virus is probably fed to the young larva by the nurse bees in the brood food. It multiplies rapidly within the larva until it causes death. Then the house bees cleaning out the cells probably distribute the virus to other larvae within the hive. The disease is usually limited to one or a few colonies in an apiary.

Potential for Economic Loss: Slight.

Control Practices: None.

Bee Paralysis Viruses

Biology: Two different viruses, chronic bee paralysis virus (CBPV) and acute bee paralysis virus (ABPV), have been isolated from paralytic bees.

Bees affected by this disease tremble uncontrollably and are unable to fly. In addition, they lose the hair from their bodies and have a dark, shiny, or greasy appearance. Often mistaken for robber bees, paralytic bees are submissive to attack whereas robbing bees are not.

When paralysis is serious, large numbers of afflicted bees can be found at the colony entrance, crawling up the sides of the hive and blades of grass, and tumbling to the ground. Healthy bees often tug at infected bees in an effort to drive them away from the hive. Affected bees also may be found on top bars or frames next to the hive cover with wings extended.

A colony may recover from paralysis after a short time, or the condition may continue for a year or more without killing the colony. Usually only one or two colonies in an apiary will show signs of the disease.

Research has shown that susceptibility to the disease is often inherited. If paralysis persists, colonies should be requeened with a different strain of bees. Adding a frame or two of sealed brood from a healthy colony to build up the number of young bees in the diseased colony is also helpful

Potential for Economic Loss: Very Slight to Slight.

Control Practices: None.

Deformed Wing Virus (DWV)

Biology: Deformed Wing Virus (DWV) deserves special consideration, as the damage it causes is one of the primary means of identifying heavy varroa mite infestations in bee colonies.

Bee colonies with heavy varroa mite infestations tend to have high frequencies of adult bees emerging with deformed wings. These wing deformities were once thought simply to be the result of mechanical trauma from the feeding activities of varroa mites during the developmental stages of the bees. However, recent research has demonstrated that the deformities are induced by virus infections.

The transmission of DWV and other viruses by varroa mites has been demonstrated in laboratory and field research studies. The effect(s) of DWV and other varroa-transmitted viruses on bee colony dynamics and mortality rates is just now receiving considerable attention by scientists in the US, Europe, and elsewhere.

Bee viruses have also been detected in pollen and honey stores, on comb, and as persistent or latent infections in otherwise healthy-looking honey bees.

In comparison to healthy wings, bees with DWV have wings that are severely misshapen (appear as “tattered” remnants of healthy, normal wings), making them essentially useless for flying. Bees deformed in this way will typically die off or be actively removed from the colony by healthy bees.

Potential for Economic Loss: Moderate to Severe (if virus is present in varroa populations).

Control practices: None. There are no treatments available for DWV or any of the bee viruses. However, elimination or suppression of varroa mites is likely the key to controlling bee virus infections.

Other viruses identified from bees include: Arkansas Bee Virus, Bee Virus X, Black Queen Virus, Cloudy Wing Particle Virus, Egypt Bee Virus, Filamentous Virus, Iridescent Bee Virus, and Kashmir Bee Virus. See Bailey (1981) for more information on these and other honey bee viruses.

Parasitic Mites

Tracheal Mite

The honey bee tracheal mite, *Acarapis woodi*, or acariosis as the disease is known in Europe, afflicts only adult honey bees. The parasite was first described in 1921 in bees in Great Britain. This discovery and concern over the potential impact that this mite would have on beekeeping in the US led to the enactment of the Honeybee Act of 1922, which restricted the importation of honey bees from countries where this mite was known to exist. The tracheal mite has now been reported on every continent except Antarctica and Australia.

There are three *Acarapis* species associated with adult honey bees: *A. woodi*, *A. externus*, and *A. dorsalis*. These mites are difficult to detect and differentiate due to their small size and similarity; therefore, they are frequently identified by location on the bee instead of morphological characteristics. However, only *A. woodi* can be positively diagnosed solely on habitat; the position of other species on the host is useful, but not infallible. *Acarapis woodi* lives exclusively in the prothoracic tracheae; *A. externus*, being external, inhabits the membranous area between the posterior region of the head and thorax or the ventral neck region and the posterior tentorial pits; and *A. dorsalis* is usually found in the dorsal groove between the mesoscutum and mesocutellum and the wing bases.

The *A. woodi* female is 143-174 um in length and the male 125-136 um. The body is oval, widest between the second and third pair of legs, and is whitish or pearly white with shining, smooth cuticle; a few long hairs are present on the body and legs. It has an elongate, beak-like gnathosoma with long, blade-like styles (mouthparts) for feeding.

When over 30% of the bees in a colony become parasitized by *A.woodi*, honey production may be reduced and the likelihood of winter survival decreases with a corresponding increase in infestation. Individual bees are believed to die because of the disruption to respiration due to the mites clogging the tracheae, the damage caused by the mites to the integrity of the tracheae, microorganisms entering the hemolymph (blood) through the damaged tracheae, and from the loss of hemolymph.

The results of heavy infestation are many, and include respiratory congestion, reduction in worker bee life expectancy, injury to the hypopharyngeal (food) glands, destruction of flight muscle tissue, and impairment of thermoregulatory ability. Altogether, these stresses drastically reduce the overwintering success of honey bee colonies, particularly in the colder regions of North America.

The mites are transmitted bee to bee within a colony by queens, drones and workers. In addition, the movement of package bees and queens, as well as established colonies, has resulted in the dissemination of this mite throughout much of the US.

The population of *A. woodi* in a colony may vary seasonally. During the period of maximum bee population, the percentage of bees with mites is reduced. The likelihood of detecting tracheal mites is highest in the fall and winter.

No one symptom characterizes this disease; an affected bee could have disjointed wings and be unable to fly, or have a distended abdomen, or both. Absence of these symptoms does not necessarily imply freedom from mites. Positive diagnosis can only be made by microscopic examination of the tracheae; since only *A. woodi* is found in the bee tracheae, this is an important diagnostic feature.

In sampling for *A. woodi,* collect moribund bees that may be crawling near the hive entrance or bees at the entrance as they are leaving or returning to the hive. These bees should be placed in 70% ethyl alcohol as they are collected. Bees that have been dead for an indeterminate period are less than ideal for tracheal mite diagnosis.

Potential for Economic Loss: Slight (southern US) to Severe (northern US). Tracheal mites are a serious problem in New Jersey, and may cause annual winter mortalities of 50% or more.

Chemical Control: Menthol is the only material that is currently approved by the Environmental Protection Agency (EPA) for the control of these mites in the US. Colonies can be treated with menthol when there is no heavy nectar flow and daytime temperatures are expected to reach at least 60 F. The best time being in the spring when the weather is warm, and in the late summer or fall of the year immediately after removing the surplus honey. Most beekeepers in New Jersey treat for tracheal mites with menthol crystals. Beekeepers can minimize the impact of tracheal mites by intensive management practices to maintain populous colonies and by using menthol.

Genetic Control: The use of tracheal-mite resistant bee stock, such as the New World Carniolan, and Russian genotypes, provides reasonable protection from tracheal mites. However, the use of specialty bee stock may not provide adequate tracheal mite control in all areas in all years.

Varroa Mite

(Varroa destructor (= V. jacobsoni))

Biology: The parasitic bee mite, *Varroa destructor*, is one of the most serious honey bee pests in the US, including New Jersey. Without chemical intervention by the beekeeper, honey bee colonies will typically die within 6-18 months of varroa infestation. This fact is supported by the near total loss (> 95%) of feral honey bees that are not actively managed by beekeepers. Varroa mites have spread to all of the beekeeping continents.

The first Varroa species, *Varroa jacobsoni*, was described on *Apis indica* (= c*erana*) from Java in 1904. Recent studies show that *Varroa jacobsoni* is a species complex containing 18 different genetic variants that belong to 2-5 different species of *Varroa*.

The first report of Varroa attacking *Apis mellifera* (a new host) was in 1962 on a sample sent to the USDA in Beltsville from Hong Kong, and in 1963 in the Philippines. The mite spread through the commercial transport of bees and queens; the migratory activities of beekeepers; swarms that may fly long distances, or be carried by ships or aircraft; and drifting bees.

Adult female varroa mites are oval and flat, about 1.1 mm long and 1.5 mm wide, pale to reddish-brown in color, and can be seen easily with the unaided eye. Male mites are considerably smaller and are pale to light tan. Adult bees serve as intermediate hosts when little or no brood is available and as a means of transport. The females attach to the adult bee between the abdominal segments or between body regions (head-thorax-abdomen), making them difficult to detect. These are also places from which they can easily feed on the bees' hemolymph.

Low infestations result in decreased vitality of individual worker bees through loss of hemolymph (blood), which may impair the ability of bees to perform hive duties (e.g., brood rearing, comb construction, and nectar collection). High varroa infestations result in the outright death of pupating bees, the malformation (shortened or deformed abdomens, wings, and legs) of emerging bees, or a reduced life expectancy of adult bees; all of which have negative effects on the viable population and hive dynamics of the honey bee colony.

Varroa parasitism is further complicated by the ability of these mites to transmit bee viruses and their feeding activities can lead to microbial invasion, resulting in additional stress on individual bees and the colony as a whole.

The most severe parasitism occurs on the older larvae and pupae, drone brood being preferred to worker brood. The degree of damage depends on the number of mites parasitizing each bee larva. One or two mites will cause a decrease in vitality of the emerging bee. Higher numbers of Varroa per cell result in malformations like shortened abdomens, misshapen wings, deformed legs or even in the death of the pupa.

The adult female Varroa enter the brood cells shortly before capping and must feed on larval hemolymph before they can lay eggs. Each mite lays 2-6 eggs at approximately 30-hour intervals. The first egg usually develops into a male and the later ones into females. The development proceeds from egg to six-legged larvae, to eight-legged protonymphs, to deutonymphs, to sexually mature adult mites in 6 to 10 days. They mate in the capped cells with the males dying soon afterward. All immature mites will die after the emerging bee opens the cell, while the young adult female mites and the mature (gravid) females move on to passing bees. The mite enters another brood cell in 3 to more than 150 days depending on the season and availability of brood.

Potential for Economic Loss: Severe. Varroa mites are possibly the primary cause of bee colony death in New Jersey and the US.

Cultural Control: Various physical and cultural control options have been developed to suppress varroa mite populations. These include the passive culling of varroa mites with modified (screened) bottom boards and the active removal of varroa mites by trapping the mites in special drone comb (drone larvae are ca. 10 times more attractive to varroa searching for suitable cells to invade).

Chemical Control: Conventional pesticides such as Apistan® (pyrethriod; tau-fluvalinate) and Checkmite+® (organophosphate; coumaphos) are the standard means of varroa mite control in New

Jersey and the US. Other compounds evaluated for varroa control include an array of biopesticides (formic acid, oxalic acid, thymol, and sucrose octanoate). Some of these biopesticides provide reasonable control or suppression of varroa infestations, yet each has their own limitations and will likely not be adopted or accepted by all beekeepers due to the added labor and/or cost involved in treating with these alternative products or compounds. Some of these alternative chemical treatments (e. g., oxalic acid) are not yet registered in New Jersey or the US, and so cannot be used by beekeepers.

Biological Control: One or more species of entomopathogenic fungi (e.g., *Metarhizium anisopliae*) are being evaluated for their potential use as biocontrols for varroa mites. These research projects are in preliminary stages, and as such, no commercial formulations are yet available to US beekeepers.

Genetic Control: Recent bee breeding and importation programs have resulted in bee stocks that show medium to high tolerance or resistance to varroa mites. Such specialty bee stocks include: the *Suppression of Mite Reproduction* (SMR) and Russian Honey Bee projects of the USDA-ARS, and the Hygienic Bees developed at the University of Minnesota. While these bee stocks show great promise, beekeepers in New Jersey and the US must still rely on conventional pesticides to adequately suppress varroa infestations over time. In addition, these specialty bee stocks may not perform equally well in all regions of the US; an issue which is currently being addressed by the scientific community.

Insect Pests

Bee Louse
(*Braula coeca*)

Braula coeca, or the bee louse, is actually a wingless fly and an external parasite of adult bees. The adult lice are small (slightly smaller than the head of a straight pin), reddish brown, wingless flies. They first appeared in the US as "hitchhikers" on the bodies of imported queens. While several adult flies may live on a queen, usually only one lives on a worker.

Bee lice seem to prefer nurse bees; only rarely do they live on drones. *Braula* move rapidly over the body surface, settling on the dorsal surface at the junction of the bee's thorax and abdomen. They remain there until a hunger response causes them to crawl up to the bee's head near its mouthparts. This movement seems to irritate the bee, causing it to regurgitate a drop of nectar. *Braula* then inserts its mouthparts into those of its benefactor and takes its food. Bees actively try to remove the lice.

The louse lays its eggs on the cappings of honey storage cells during May through July. After oviposition, the adults die. Upon hatching, the young larvae burrow into the cappings. As the larvae grow, their tunnels lengthen and broaden; at this stage the infestation is easiest to observe. The larva pupates inside the tunnel after making a line of weakness in the wax to aid in its emergence as an adult. Soon after emergence, about twenty-one days later, the young adult crawls upon a bee. The diet of the larva appears to be wax and perhaps pollen grains incorporated into the wax by worker bees. In New Jersey, bee lice overwinter as adults and do not appear on queens until June.

Potential for Economic Loss: Very Slight (bees) to Moderate (comb honey appearance). *Braula's* damage to a colony of honey bees is limited. The amount of food taken by the larvae and adults is negligible. However, tunneling larvae can damage the appearance of comb honey. Honey production by strong colonies infested with bee lice appears to be little affected.

Control Practices: None. Little work has been done on control of *Braula*, and the measures that are suggested are antiquated.

Greater Wax Moth

(*Galleria mellonella*)

Larvae of the greater wax moth, *Galleria mellonella*, cause considerable damage to combs left unattended by bees. Combs in weak or dead colonies and in storage areas are subject to attack. Wax moths pose a continuous threat except when temperatures drop below 40 degrees F. Strong colonies keep these grayish white larvae under control.

Adult female moths fly at night and deposit masses of eggs on unprotected honeycombs and in the cracks between hive bodies. After a few days these larvae hatch, crawl onto the comb, and begin their feeding activity. They damage or destroy the combs by boring through the cells as they feed on cocoons, cast skins, and pollen. As they chew through the wax, they spin silken galleries for protection. Combs are often reduced to a mass of webs and debris. Wax moth larvae seldom attack new combs and foundation.

Larval developmental time depends on temperature. The larval stage may last from 38 days to 5 months, depending on nutrition and environmental conditions. During this period, larvae may vary from 1/25 inch to 1 inch in length.

When fully grown, the larva spins a rough silken cocoon, which is usually attached to the frame or inside of the hive. Frequently the larva cements the cocoon inside a cavity chewed in the wood. Chewed frames are weakened and easily broken. Within the cocoon, the larva changes to the pupa and overwinters in the pupal stage. Under warm conditions, adults may emerge at almost any time of year.

The larvae of the wax moth do considerable damage to comb honey. The eggs are probably laid on the comb or section boxes before the comb honey supers are removed from the hives, but the damage does not become evident until sometime after the honey has been placed in storage.

Potential for Economic Loss: Moderate to Severe. Wax moths can do serious damage to stored comb and comb containing honey. In addition, their pupating activities can damage wood bee equipment, which if severe, may have to be replaced.

Control Practices: At the present time, two approaches can be used to protect combs: paradichlorobenzene and cold temperatures. When placing combs in storage, beekeepers must kill any existing stages of wax moth and guard against later infestations. Freezing weather kills all stages of wax moth, so some beekeepers keep supers on the bees until after a killing frost. Supers are best stored outside in the cold or in a dry unheated building. Many beekeepers store a portion of their supers in stacks in each bee yard so that they are ready for use in the spring

Chemical Control: If supers must be stored in a warm room or basement, they may be protected by placing paradichlorobenzene (PDB) crystals on a small piece of paper on every fifth super in the stack, which should then be covered. The treatment must be continued at regular intervals all winter. PDB kills adult and immature wax moths, but not eggs. The continuous presence of crystals within the stack not only repels moths and prohibits egg laying, but also kills any young larvae that hatch after the combs are placed in storage. Untreated combs should be inspected regularly for signs of infestation, especially if temperatures rise above 60 ^{O}F and permit wax moth activity. Supers should be aired before using them in the spring. CAUTION: Moth balls and crystals (naphthalene) should not be used to control wax moth.

Cultural Control: PDB can be used to protect all combs in storage except those containing honey intended for human consumption. The odor of PDB is readily absorbed by honey, and, though the bees do not object to this odor, such honey is unfit for human consumption. The only approved method for preventing wax moth damage to comb honey is freezing. The USDA recommends a temperature of 0 degrees F for twenty-four hours to kill wax moth. Small amounts of comb honey can be stored in the freezer. This not only prevents wax moth damage but also retards crystallization.

Alternative Control: In the past, a B.t. (*Bacillus thurengiensis*)-containing product, Certan®, was available for use in protecting stored comb from wax moth damage. B.t. is a bacteria complex that produces toxins with activity against moths and other lepidopterans. Certan® is no longer available to beekeepers. One or more species of parasitic (braconid) wasp naturally parasitize wax moth larvae, but commercial rearing operations are considered economically impractical.

Small Hive Beetle
(*Aethina tumida*)

The small hive beetle (SHB), *Aethina tumida* Murray (Coleoptera: Nitidulidae), was first identified from honey bee colonies in Florida in June 1998. This was the first report of this insect in the Western Hemisphere; it was previously known only in sub-Saharan Africa.

Adult SHB are 5mm long, dark brown to black and can be found within honey bee colonies. Eggs are laid in concealed areas and empty cells and larvae seek out pollen, bee brood, and honey to feed upon. The feeding of larvae causes honey to drip from the cells and often ferment, leaving a repellent on combs that can cause adult bees to abandon the comb and leave the hive. Beetle larvae complete their feeding on bee combs and then migrate outside to pupate in the soil. Development from egg to adult beetle takes 30-80 days.

Reports from South Africa suggest that SHB is rarely a significant pest with African bees. However, since beekeepers in the US manage a different race of honey bee than in South Africa, the effects of this pest on US beekeeping are largely unknown.

As of 2003, SHB can be found in over 30 states, most of which are east of the Mississippi River. Migratory beekeepers transport bee colonies from beetle-infested areas and the probability that this pest is more widespread is very real due to the migratory pollination demands within the US.

SHB is considered a secondary pest in South Africa, attacking small or weak hives but rarely affecting strong hives. The honey bees in South Africa are primarily *Apis mellifera scuttelata*, an aggressive bee that has excellent housecleaning and defensive traits. In contrast, the bees kept in North America are predominately *A. m. ligustica* or *A. m. carnica* and differ in behavior from African bees. The difference between races of bees coupled with different climatic and colony management styles between South Africa and the US make it difficult to predict the impact of this new pest on the US bee industry. Reports from states with SHB have indicated occasional problems with beetles infesting and destroying hives in the apiary. However, more problems have been reported from damage by SHB to stored honey.

SHB larvae affect combs of stored honey and pollen and will also infest brood combs. During the feeding action by larvae an associated repellent sticky substance is laid down on the combs and this can result in bees abandoning the hive. When honeycombs are removed from colonies, bees then no longer protect the combs allowing the beetle larvae to feed uninhibited.

The management practice of removing honey and then storing it in warehouses prior to extraction will need to be changed with the introduction of this beetle. Additionally, the handling of wax cappings and honey in areas known to have the small hive beetle will require increased sanitation. Research has shown that reducing relative humidity below 50% where honey is stored will inhibit SHB eggs from hatching and thus reduce or eliminate larval damage in honey.

Potential for Economic Loss: Slight to Severe. There is no simple answer as to the potential damage SHB can cause to New Jersey beekeepers. There are many colonies in New Jersey that have active SHB populations, yet very few, if any, colony losses due to beetles have been reported. SHB is generally considered an opportunistic pest that will have the greatest negative impact in honey extraction facilities. However, it is important to note that beekeepers in the southern states can loose bee colonies to this pest, and similar events happening in New Jersey and elsewhere are possible.

Chemical Control: Chemical control for SHB is targeted at the adult stage of the pest. The placement of CheckMite+® strips underneath plastic corrugated cardboard is the only in-hive treatment approved for SHB in active bee colonies. Soil drenching with GardStar® 40% EC (permethrin) is also used to kill SHB larvae as they burrow into the ground to pupate.

Biological Control: Various entomopathogenic fungi and nematodes have been evaluated for their ability to kill SHB larvae. No commercial products are currently available and it is likely none of them will represent viable alternatives to conventional pesticides from controlling SHB.

Ants (various species)

Biology: Ants are not usually serious pests in honey bee colonies. Occasionally, however, certain species may enter colonies to search for food or establish nesting sites. The presence of ants may indicate a weak colony or a colony with problems.

Ants are typically found between the inner and outer covers of the hive and in pollen traps. Even though ants seldom disturb the bees, they can become a nuisance to the beekeeper. Once they are established in a colony, they are difficult to control.

Potential for Economic Loss: None to Slight: Ants are typically only a nuisance, but infestations will occasionally reach levels that require control.

Cultural Control: Maintain strong colonies and keep bottom boards raised off the ground. Remove brush, rotten wood, grass, and weeds from around the colonies. A fuel oil barrier applied to the soil under the colonies may be helpful. Single colonies can be placed on stands with oil or sticky barriers.

Chemical Control: When ants are a persistent problem, beekeepers may have to use approved insecticides. Extreme caution must be used when applying insecticides in the apiary. Insecticides that are effective in controlling ants are also highly toxic to bees. Application of insecticides should be done when the bees are inactive.

BIRDS, REPTILES AND AMPHIBIANS

Blue jays and other North American insectivorous birds are known to eat honey bees and can sometimes be found perched near the entrance of beehives waiting for bees to capture and consume. Bird predation of bees in the US is typically only a problem for queen rearing operations, and in these cases, birds can be serious economic pests. There are no approved techniques for eliminating bee-eating birds in the US.

Various frogs, toads, and lizards will also eat honey bees, and can be serious pests in some parts of the world. There are likely no confirmed reports of economic bee losses to reptiles or amphibians in the U.S.

MAMMALS

Mice

Biology: Mice (various species) are serious pests of stored combs and active honey bee colonies during the fall and winter months. These rodents chew combs and frames to make room for building their nests. Mouse urine on combs and frames makes bees reluctant to clean out these nests in the spring.

Adult mice move into bee colonies in the fall and usually nest in the corners of the lower hive body away from the winter cluster. Colonies located in fields or at the edges of woodlots are especially vulnerable. Mice can successfully build a nest even in a strong colony. They move in and out of the colony while the bees are inactive, and their nests furnish additional protection. Their activity may disturb the bees but the greatest damage is from the nests.

Potential for Economic Loss: Slight to Moderate. If mice get in a hive during winter, they can cause moderate destruction to combs.

Cultural Control: Early in the fall, hive entrances should be reduced with entrance cleats or hardware cloth (three mesh to the inch) to keep out the mice. Chase away any mice found inside a colony, then remove the nest and restrict reentry. If comb chewing is extensive, replace the frames. When bees repair damaged combs, they replace worker-sized cells with drone comb.

Combs in storage should be protected from mice by covering the top and bottom of each pile of supers with a queen excluder, wire screen, or outer telescoping lid.

The use of poisons and traps is not needed if cultural control tactics are practiced.

Skunks, Raccoons, and Opossums

Biology: In some areas, varmints (skunks, raccoons, and opossums) are serious threats to successful beekeeping, since they hamper the development of strong colonies. Being insectivorous (insect-eating), these varmints will raid the bee yards nightly, consuming large numbers of bees. While such attacks are most common in the spring, they also can occur throughout the summer and fall.

To capture their prey, varmints scratch at the hive entrance; when worker bees come out to investigate the disturbance, they are knocked down and eaten. A successful varmint will repeat the process several times and may feed at the hive entrance for an hour or more.

In addition to rapidly depleting the bee population, varmint predation makes a bee colony very defensive. Besides the front of the hive being scratched up and muddy, the grass in front of the hive will be packed down or torn up and there will be small piles of chewed up bee parts. The varmint chews the bees until all the juices are consumed, then spits out the remains. Strong colonies sometimes put up a good fight but weaker colonies usually fall victim.

Potential for Economic Loss: Moderate. Can result in loss of bee populations and reduce honey production.

Cultural Control: Maintaining strong colonies is a partial deterrent to varmint attacks. Predation by these animals may also be discouraged by screens or queen excluders attached to the front of the hive above the entrance. These devices hamper the varmint in scratching at the front entrance, and if it climbs up the screen over the entrance, its belly becomes vulnerable to stings.

Fencing the bee yard or placing the colonies on stands would be an effective technique but the cost may make it prohibitive.

Moving bees to a new location is another approach, but considered impractical to some beekeepers..

Chemical Control: Currently there are no chemical repellents or toxicants labeled for controlling skunks. Since the skunk is classed as a fur-bearing animal in many states, it is protected except during the annual trapping season (late autumn). However, the landowner has the right to kill wild animals engaged in the material destruction of cultivated crops, fruit trees, vegetables, livestock, poultry, or beehives. Opossums and raccoons sometimes attack apiaries in the same way skunks do. These animals are also protected by state game laws.

Bears

Bears are a serious threat to beekeeping operations, by doing a great deal of damage to hives and equipment in a short period of time. They normally visit the apiaries at night, smashing the hives to get to the brood and honey and scattering frames and equipment around the apiary. Once bears locate an apiary, they return repeatedly, and it becomes exceedingly difficult to control their marauding behavior.

Conflicts between bees and bears are not new, but in recent years the problem has escalated. Increases in urbanization, cultivated acreage, and the trend toward monocultural agriculture have rapidly reduced available bee pasture and suitable bear habitats.

Extensive use of herbicides has further reduced bee pasture and forced beekeepers to move their hive into remote areas to avoid pesticide kills. In addition, higher honey prices have led beekeepers to seek better locations for honey production. Bear populations and damage claims are on the increase. Coexistence of bees and bears in the same habitat has resulted in severe casualties to both animals.

Solutions to this complex problem are highly political, expensive, and have not been totally effective. Concessions need to be made by all sides. Beekeepers, game commission personnel, sportsmen, and environmentalists must work together to save bee/bear habitats and develop management schemes that will be favorable for both animals.

There are several precautions the beekeeper can take to reduce the chances of bear damage. Typically, bears move through their home ranges with preferred travel lanes or bear crossings that often follow along certain ridges, ravines, streambeds, or the forest edge. While these are not necessarily beaten paths, they may be. Beekeepers can help avoid damage from bears by careful selection of the apiary site. Placement of colonies on or near bear crossings or dumps will most likely result in problems. Spreading litter around an apiary site may also invite trouble. Research has shown that the farther bee yards are located from the forest edge and ravines, the less chance there is of bear visitation.

Potential for Economic Loss: Severe (in areas where bears occur).

Control Practices: Whenever possible, game commission personnel try to trap a nuisance bear and move it to an area where damage is less likely to occur and where it is desirable to increase population levels. They use baited culvert traps mounted on a small trailer, or special foot snares, to capture the problem bears.

An apiary can be protected from bears by a sturdy electric fence. Such a fence must be dependable, relatively cheap to construct, and capable of operating in the wilderness.

A relatively inexpensive and simple fence can be reasonably effective in deterring bears. The fence is constructed with steel concrete reinforcing rods cut to 4-foot lengths and driven 12 inches into the ground. Three strands of barbed wire are used. The top and bottom wires are strung using plastic insulators on each rod to avoid contact with the rod. The middle strand is wired to each rod with a small scrap of wire to ensure good contact with the metal. This middle wire serves as a ground. The bottom wire should be 6 inches above the ground with 12 inches separating the others. A stake and guy wire are used for extra support of each corner. Insulated gate handles can be used to open the fence for easy access by vehicles.

Sturdy electric fences with a wire mat around the outside perimeter to prevent bears from digging beneath appear to be the most effective way of protecting colonies from bear damage. Two other basic fence designs are used by the beekeeping industry. One design consists of three or four strands of barbed wire, 10 to 12 inches apart, with the lowest wire 6 inches from the ground. The other design is a 4-foot-high woven wire fence, with two strands of barbed wire 8 inches above the ground and above the woven wire fence. With both designs, either steel or wooden posts can be used.

For all fence designs, power is supplied with a 6-or 12-volt battery that often proves to be the weak link in the system. Both the battery and electric fence charger should be protected from the weather using a wooden enclosure. Because a good ground is essential, many recommend earthing the wire mat out-side the fence.

With the simpler fence designs, it is important to have some kind of bait (e.g., suet or pork rind) attached to the wires. The bait gives the bear a proper introduction to the electricity when it touches the tempting morsels with its moist tongue or nose. Without the bait, the bear is likely to crash right through the wire, as impervious to the electricity as it is to bee stings. During warm weather, bacon or pork rind does not last long, so the beekeeper must continue to replace old with new. Local butcher shops can be a cheap source of bacon and pork rind.

Fences are totally ineffective if not installed and managed properly. The location of the electric fence is important in protecting colonies of bees. Avoiding sites with overhanging trees is needed, because limbs falling across the wires may render the fence inoperable. It is also quite common for bears to climb trees and then drop down inside the fence. To ensure continued successful operation, one must control grass and weeds along the fence so that they will not contact the charged wires and short them out.

NON-INFECTIOUS and PHYSIOLOGICAL DISORDERS

Pesticide Poisoning

The application of pesticides to control crop pests and human health hazards (e.g., mosquitoes) can cause serious injury to honey bees. In most areas, exposure to pesticides is the greatest abiotic hazard to bee colonies and beekeeping operations.

Most herbicides and fungicides are relatively nontoxic to bees, but the widespread use of insecticides and miticides has killed several million honey bee colonies over the last 50 years.

Foraging bees exposed to pesticides may die in the field or back at the hive. The loss of foraging bees, while occasionally substantial, generally does not result in colony death, and the population usually recovers from the loss. Sometimes, the beehive itself is exposed to a pesticide spray which, depending on the product’s toxicity, may kill the entire colony.

Granular formulations are considered the least hazardous to bees, while wettable powders and emulsified sprays are moderately to highly hazardous. Dusts tend to be the most harmful due to their longer residual activity and potential to be picked up by the hairs on a bee's body. Microencapsulated pesticides, such as Penncap-M (methyl parathion), also pose serious hazards to honey bees, as foragers inadvertently pick up the pesticide particles and may store them in the beehive mixed in with the pollen stores. In these cases, pesticide-contaminated food reserves can poison adult and larval honey bees alike.

Signs and symptoms of pesticide-related bee kills include the sudden loss of older, foraging bees; moderate to massive bee mortality at the hive entrance; and individual bees exhibiting signs of poisoning, such as death, the inability to fly, erratic behavior, trembling, paralysis, and regurgitation. Poisoned bees often look wet as they have regurgitated the contents of the stomach onto their bodies.

Considerations for the applicator:

- Do not apply pesticides onto beehives.
- Do not apply pesticides when bees are actively foraging on the crop.
- Eliminate bee-attractive weeds that may be sprayed.
- Do not allow spray tank rinsate to puddle; bees may attempt to collect it as water.
- Choose the chemical and formulation least toxic to bees and has a short residual period (if there is a choice between equally effective pesticides for the pest).
- For highly toxic chemicals with long residual periods, consider spraying at night.
- When possible, notify the beekeepers in your area 48 hours prior to application.

Considerations for the beekeeper:

- Provide a clean water source for the bees.
- Choose apiary sites where pesticide use is uncommon or nonexistent.
- Relocate colonies if the area they reside in is near a field ready to be sprayed.
- For pollination hives, coordinate crop spray programs to avoid time when bees are flying.
- If moving beehives is not an option, cover the hives with wet burlap. This provides some protection, although the bees cannot tolerate the practice for more than several hours to 2 days, depending on temperature and wetness of the burlap.

Appendix II provides a list of common pesticides and their relative toxicity to honey bees.

Plant Poisioning

The nectar and/or pollen of certain plants may contain compounds that are toxic to honey bees. Poisonous plants are only a problem in specific areas and, if the toxin(s) are nectar-borne, only during the plant species' blooming period. However, if the pollen contains the toxic compounds, the duration of poisoning may linger as long as the culprit pollen remains in the combs. There are few telltale signs to distinguish between plant poisoning and pesticide poisoning, although pesticide poisoning tends to be more devastating and shorter in duration than plant poisoning. Areas with abundant poisonous plants should be avoided by beekeepers when the plants are in bloom.

Signs of possible plant poisoning are dead adult or larval bees, hairlessness, queen supersedure, trembling, failing queens, discoloration, and larval mummification. Examples of poisonous plants affecting honey bees include *Cyrilla racemiflora* (southern leatherwood), *Aesculus californica* (California buckeye), *Asciepias* spp. (milkweed pollinia), *Gelsemium sempervirens* (Yellow jessamine), *Astragalus* spp. (Loco plants), and *Veratrum californicum* (False hellebore). Few, if any, cases of plant poisonings have been reported in New Jersey.

Overheated Bees

Bees can overheat during hot weather when they are confined in their hives without adequate ventilation or access to water, as can happen during the transportation of beehives between locations. Possible signs of overheating are a large accumulation of dead bees on the bottom board of a flight-restricted hive and/or worker bees crawling rapidly while fanning their wings. Colonies confined during transportation should have the solid hive cover replaced with a screen cover to allow for adequate ventilation. When protecting colonies for short periods from overhead pesticide sprays, thoroughly wetting the burlap cover may reduce overheating stress.

Genetic Lethality

Genetic abnormalities during brood development can also kill bees, usually without exhibiting symptoms of known diseases. However, drone brood from laying workers and failing queens often die with symptoms similar to European Foulbrood but in the absence of known pathogens. Inbreeding of queen stock may also result in the laying of non-viable bee eggs; these eggs are usually consumed by worker bees.

Chilled Brood

If larvae are underfed, or if adult bees cannot adequate maintain the hive temperature, some of the brood may become chilled and die. Brood killed by chilling turns grey and may resemble other conditions, such as sacbrood. Chilled brood will be removed from the colony by worker bees once colony homeostasis has returned. Working bees during cold or cool weather is one way beekeepers can cause chilled brood themselves. Providing adequate food reserves and working bees only during warm weather (above 60^{O}F) are the best techniques to avoidance the occurrence of chilled brood.

Starved Brood

Under periods of prolonged nectar and/or pollen dearth, larvae may be removed and/or consumed by adult bees. However, if there is a sudden and substantial reduction in the adult bee population, there may not be enough workers available to feed the larvae. In these cases, larvae may simply starve. Larvae crawling from their cells in search of food are a striking feature of starved brood. Larvae are most often the stage affected, however emerging bees may also starve if they were stressed as pupae and are not fed soon after chewing through their cell caps. These bees may die with only their heads protruding from the cell and have often their tongues extended. Starved brood may occur sporadically in New Jersey, particularly when rapid and massive bee kills resulting from pesticide use occur.

Disease, Parasite, and Pest Controls

For varroa mites, monitoring thresholds are initiated to help beekeepers determine whether chemical treatment is actually necessary to prevent economic damage to bee colonies. In New Jersey, monthly sampling of bee colonies should be conducted throughout the active bee season (March to November).

Antibiotics, Insecticides, and Miticides for Beekeeping Use in New Jersey

Terramycin

Terramycin is an antibiotic used for the control of European Foulbrood (EFB) and as a prophylactic treatment for American Foulbrood (AFB).

Formulations: TM-50D, TM-100D, Terramycin Soluble Powder (TM-25), Tetra-B Mix.

Target pests: Bacteria: *Melissococcus pluton* (EFB) and *Paenibacillus larvae* (AFB).

Amount of active ingredient applied: Data not available for New Jersey.

Types of application: Sprinkled as a dust mixed with dry powered sugar over frames above brood chamber or mixed with vegetable shortening and sugar to make extender patties. Feeding terramycin in sugar syrup is not recommended.

Application rates: Terramycin formulations are the only registered medications for use against bacterial diseases of honey bees. Formulations have different grams of active ingredient per pound of product (i. e., TM-25 = 25 g a.i./lb product; TM-50D = 50 g a.i./lb, TM-100D = 100 g a.i./lb). Dusting (1 oz/colony applied 3 times at 5-day intervals). Extender patty (one 6.4 oz. packet of TM-25 + 4.6 lb vegetable shortening + 9.1 lb sugar = 14 lbs. One-pound patties will treat 14 bee colonies).

Number of applications: Dusting: 3 times at weekly intervals. Patties: one per colony.

Timing: Terramycin cannot be used within 4 weeks of a marketable honey flow. Honey stored during medication periods in combs for surplus honey should be removed after the final medication and must not be used for human food.

Re-entry and pre-harvest intervals: Not applicable. Do not use within 4 weeks of honey flow.

Use in resistance management programs: None.

Efficacy issues: There are numerous reports of AFB-resistance to terramycin. Alternative antibiotics such as tylosin are being developed for use in bee colonies, but not products are yet available.

Fluvalinate

Fluvalinate is a pyrethriod miticide used for the control of varroa mites

Formulations: Apistan®

Target pests: Varroa mites (*Varroa destructor*)

Amount of active ingredient applied: Data not available for New Jersey.

Type of application: Fluvalinate-impregnated plastic strips are hung in brood chamber.

Application rates: 10.25% a.i.-impregnated plastic strips are placed between frames near the brood nest inside bee colonies. Two strips are used per brood chamber (e.g., single brood chamber colonies receive 2 strips, and double-brood chamber or equivalent colonies receive 4 strips).

Number of applications: Apistan can be used twice per year (spring and fall).

Timing: Apistan cannot be used within 4 weeks of a marketable honeyflow. Remove honey supers before application of Apistan and do not replace supers until 14 days after the strips are removed. The treatment is most effective when brood rearing is lowest. Effective control may be achieved by treating hives in the spring before the first honeyflow and in the fall after the last honeyflow. For maximum efficacy leave the strips in the hive for at least 42 days, but not more than 56 days. Do not treat more than twice a year for varroa mites. Do not reuse strips. Honey stored during treatment periods in combs for surplus honey should be removed after the strips are removed and must not be used for human food.

Re-entry and pre-harvest intervals: Not applicable. Do not use within 4 weeks of honey flow.

Use in resistance management programs: Fluvalinate may be used to treat bee colonies hosting coumaphos-resistant varroa mites.

Efficacy issues: There are some reports of fluvalinate-resistant varroa mites in NJ and the US. Alternative treatments such as coumaphos (Checkmite+), thymol (ApiLfe VAR), and sucrose octanoate esters (Sucrocide) are available to treat fluvalinate-resistant varroa mites.

Coumaphos

Coumaphos is an organophophate used to control varroa mites and small hive beetles in honey bee colonies. It is currently available in New Jersey and other states under a Section 18 Emergency Exemption. The emergency registration of coumaphos is due to the development of varroa mite populations that are resistant to fluvalinate, coupled with the possible introduction of small hive beetles from other states known to have established beetle populations. Further, CheckMite+® is the only in-hive treatment approved for small hive beetles in active bee colonies. Thus, without the emergency use of coumaphos, beekeeping operations hosting luvalinate-resistant varroa mites could suffer drastic bee colony losses; and all beekeeping operations hosting small hive beetle infestations would not have a means to treat for beetles within the hive. It is critical for the New Jersey beekeeping industry that the Section 18 Emergency Exemptions for CheckMite+® (coumaphos) be renewed annually until the products are officially registered as Section 3 General Use under FIFRA.

Formulations: CheckMite+®

Target pests: Varroa mite (*Varroa destructor*) and small hive beetles (*Aethina tumida*).

Amount of active ingredient applied: 7000 g of coumaphos in New Jersey in 2003 (5000 strips).

Type of application: Coumaphos-impregnated plastic strips are hung in brood chamber. Each strip contains 1.4 g a.i.

Application rates: ***For varroa:*** Use one CheckMite+ Strip for each 5 combs of bees in each brood chamber (Langstroth deep frames or equivalent in other sizes). Hang the strips in separate spaces between the combs as near the center of the bee/brood cluster as possible. If two deep brood chambers are used for the brood nest, hang CheckMite+ Strips in both the top and bottom brood chambers. Treat all infested colonies within the yard. ***For small hive beetles:*** One strip is cut in-half, stapled to a piece of cardboard, and placed on the bottom board of beetle-infested colonies.

Number of applications: CheckMite+ used for varroa mites can be used twice per year (spring and fall), and up to 5 times for small hive beetles.

Timing: ***For varroa:*** Remove honey supers before application of CheckMite+ and do not replace supers until 14 days after the strips are removed. The treatment is most effective when brood rearing is lowest. Effective control may be achieved by treating hives in the spring before the first honeyflow and in the fall after the last honeyflow. For maximum efficacy leave the strips in the hive for at least 42 days (six weeks). Do not leave strips in hives for more than 45 days. Do not treat more than twice a year for varroa mites. Do not reuse strips. ***For small hive beetles***: Remove honey supers before application of CheckMite+ and do not replace until 14 days after the strips are removed. Prepare a piece of corrugated cardboard box approximately 4x4 inches by removing one side. Remove one CheckMite+. Cut the strip in half, crossways, and staple the two pieces to the corrugated side of the cardboard box. Tape over the smooth side of the cardboard (the side opposite the strips) with duct tape, shipping tape or similar tape to prevent the bees from chewing and removing the cardboard. Or use one-sided plastic corrugated sheets. Place cardboard as near to the center of the bottom board as possible with the strips down. Make sure the bottom board is clean and the strips lay flat on the bottom board. For maximum efficacy leave the strips in the hive for at least 42 days (six weeks). Do not leave strips in hive for more than 45 days. Do not treat more than four times per year for the small hive beetle. Do not reuse strips.

Re-entry and pre-harvest intervals: Not applicable. Do not use within 4 weeks of honey flow.

Use in resistance management programs: Coumaphos may be used to treat bee colonies hosting fluvalinate-resistant varroa mites.

Efficacy issues: There is one report of coumaphos-resistant varroa mites in NJ and several reports in the US. Alternative treatments such as fluvalinate (Apistan), thymol (ApiLfe VAR), and sucrose octanoate esters (Sucrocide) are available to treat coumaphos-resistant varroa mites.

Thymol

Thymol is the predominant essential oil in ApiLife VAR®, a product used to suppress varroa mites in bee colonies. It is currently available in New Jersey and other states under a Section 18 Emergency Exemption. The emergency registration of ApiLife VAR® is due to the development of varroa mite populations that are resistant to both fluvalinate and coumaphos; and as such, it is one of only two available products (the other being Sucrocide™) that have utility in a resistance management strategy for varroa mites. It is critical for the New Jersey beekeeping industry that the Section 18 Emergency Exemptions for ApiLife VAR® be renewed annually until the products are officially registered as Section 3 General Use under FIFRA.

Formulations: ApiLife VAR®

Target pests: varroa mites (*Varroa destructor*)

Amount of active ingredient applied: 30,954 g of this essential oil mixture in New Jersey in 2003 (1407 packets).

Type of application: Apilife VAR is a mixture of essential oils soaked into a foamed vermiculite pad. Oil components are, by percent oil weight: thymol (74.1%), eucalyptus oil (16.0%), L-menthol (3.7%), and other ingredients (6.2%). One tablet is broken into 4 equal pieces and placed on frames in the corners of the uppermost hive body. Do not place tablet pieces directly above brood nest. Leave tablet in beehive for 7-10 days and repeat treatment twice more at 7-10 day intervals.

Application rates: Each 22 g tablet contains ca. 16.3 g thymol, 3.5 g eucalyptus oil, and 0.8 g L-menthol. Three consecutive treatments per colony will potentially introduce (as vapors with low residual accumulation or activity) 48.9 g thymol, 10.5 g eucalyptus oil, and 2.4 g l-menthol.

Number of applications: ApiLife VAR can be used only in the fall (once a year). A full treatment with ApiLife Var uses 3 packages over a 21-30 day period.

Timing: Do not use when surplus honey supers are in place to prevent excessive residues in marketable honey or wax with unwanted residues. Remove treatments from bee colonies at least 30 days before the honeyflow. Use when daily temperature are between 59-69 ^{O}F. Do not use ApiLife VAR when temperatures are above 90 ^{O}F.

Re-entry and pre-harvest intervals: Not applicable. Do not use within 5 months of honey flow.

Use in resistance management programs: ApiLife VAR may be used to treat bee colonies hosting fluvalinate- and coumaphos-resistant varroa mites.

Efficacy issues: Efficacy may not be consistent because this product is temperature-dependent. Typical efficacy will range from 65-98% control of varroa.

Menthol

Menthol is a chemical fumigant used to control tracheal mites in bee colonies.

Formulations: Mite-A-Thol

Target pests: Tracheal mites (*Acarapis woodi*).

Amount of active ingredient applied: Data not available.

Type of application: Menthol is applied as crystals enclosed in screen packets placed on the top-most frames in the beehive.

Application rates: Fifty grams (1.8 ounce) of crystalline menthol should be enclosed in a 7"x7" plastic screen bag or equally porous material and placed inside a colony for 20-25 days. Menthol placed on the top bars is the preferred method of treatment provided the daytime temperature does not exceed 80 degrees F. During hot weather, the menthol should be placed on the bottom board of the colony.

Number of applications: Mite-A-Thol should only be used in fall (once a year).

Timing: No honey supers should be on the hive during the treatment, and the menthol should be taken out of a colony at least one month before any anticipated flow. Daily temperatures should average 70 ^{O}F or higher to ensure adequate sublimation of menthol crystals and subsequent tracheal mite control.

Re-entry and pre-harvest intervals: Not applicable. Do not during honey flow.

Use in resistance management programs: Menthol is the only medication registered for use to control tracheal mite infestations of honey bee colonies.

Efficacy issues: At temperature below 70 ^{O}F , menthol sublimation is reduced and may not provide adequate control of tracheal mites.

Sucrose octanoate

Sucrose octanoate is a sugar esters formulation that is registered to control varroa mites in bee colonies.

Formulations: Sucrocide™

Target pests: Varroa mites (*Varroa destructor*).

Amount of active ingredient applied: Data not yet available for New Jersey.

Type of application: Direct spraying of bees on comb in colony.

Application rates: 0.625% product (v/v) for application to honey bees (0.25% a.i.). Mix product with water and use garden sprayer or similar to apply to bees at 1.5 oz/frames of bees. Current label directs indicate good control of varroa will be obtained if colonies are sprayed 3 times at 7-10 day intervals. There are, as of yet, no restrictions as to the number of applications that can be made per season or year.

Number of applications: There are currently no restrictions on number of applications for this product.

Timing: There are currently no restrictions on timing of application for this product.

Re-entry and pre-harvest intervals: Not applicable.

Use in resistance management programs: Sucrose octanoate esters may be used to treat bee colonies hosting fluvalinate- and coumaphos-resistant varroa mites.

Efficacy issues: This is a new product and preliminary field tests have demonstrated good control of varroa in single- (68% varroa control) and multiple-spray applications (96% varroa control). However, more studies are needed to determine the product's efficacy with varying levels of brood production and under a range of environmental conditions.

Permethrin

Permethrin is an general-use insecticide that is approved for use to control small hive beetle larvae ***outside*** the beehive. This pesticide is toxic to honey bees and should never be used inside the beehive.

Formulations: GardStar® 40% EC

Target pests: Small hive beetle *(Aethina tumida*)

Amount of active ingredient applied: Data not available.

Type of application: Soil drench applied around beehive using sprinkle can or similar.

Application rates: 5 ml per gallon water (0.5% a.i.), for 6 hives; 12 inches around entire front of hives; Re-apply after 30 to 45 days, depending on rainfall. Move a hive to a site where GardStar 40% EC has been previously applied to reduce potential insecticide exposure to bees.

Number of applications: GardStar can be used whenever necessary, as long as the label is followed.

Timing: Soil drenching should not affect bees or honey production if applied using approved method.

Re-entry and pre-harvest intervals: Not applicable.

Use in resistance management programs: Permethrin is the only registered pesticide for the ground-treatment of small hive beetles. There are no reports of beetles that have become resistant to permethrin.

Efficacy issues: Permethrin is effective at killing small hive beetle larvae as they exit the beehive and enter the soil to pupate. Even small amounts of pesticide spilled or sprayed onto the hive can be dangerous to bees.

Paradichlorobenzene (PDB)

Parabichlorobenzene is used to repel wax moth adults and kill wax moth eggs and young larvae in stored stacks of honey supers.

Formulations: Para-moth®

Target pests: Greater wax moth (*Galleria mellonella*)

Amount of active ingredient applied: Data not available for New Jersey.

Type of application: PDB granules are placed on a piece of paper on the top bars of frames in stored honey super stacks. The cover should be put tightly in place.

Application rates: 100% PDB granules at a rate of 3 oz/stack of 5 hive bodies.

Number of applications: Sublimation of PDB crystals is temperature-dependent. Crystals are replaced when previous ones have evaporated in the equipment stacks.

Timing: Never use on live bee colonies or comb containing honey or wet from the honey extraction process. Stacks should be inspected every 2-3 weeks and more crystals added if needed.

Re-entry and pre-harvest intervals: Air out honey supers at least 2 weeks before placing on live bee colonies. Placing supers in an open-air environment will eliminate any remaining PDB odors.

Use in resistance management programs: PDB is the only registered fumigant for repelling and killing wax moths in stored bee equipment. There are no reports of wax moths that are resistant to PDB in New Jersey or elsewhere.

Efficacy issues: PDB is effective at repelling adult wax moths and killing wax moth eggs and larvae. There are no chemical substitutes. Freezing combs may serve as a non-chemical alternative to PDB.

Fumagillin

Fumagillin is an anti-protozoan medication used to treat for Nosema Disease caused by the internal microsporidian honey bee parasite, *Nosema apis*.

Formulations: Fumadil-B, Fumagillin-B.

Target pests: Microsporidian (*Nosema apis*)

Amount of active ingredient applied: Data not available for New Jersey.

Type of application: Fumagillin powder is mixed into sugar syrup and fed to bees.

Application rates: 0.1 grams per gallon of 2-to-1 sugar syrup, 2 gallons medicated syrup per colony.

Number of applications: Typically reserved for fall treatment only (once ea year).

Timing: Treat bee colonies in fall (2 gallons) or spring (1 gallon). Not less than 30 days before spring honeyflow and any time after fall honeyflow.

Re-entry and pre-harvest intervals: Not applicable. Do not use during honey flow.

Use in resistance management programs: Fumagillin is the only registered medication for control of Nosema disease.

Efficacy issues: When appliedcorrectly, fumagillin is an effective treatment to prevent or control *Nosema* infections in honey bees.

Resmethrin

Resmethrin is a synthetic pyrethroid used to kill honey bees colonies infected with American Foulbrood (AFB).

Formulations: Resmethrin®, and other trade names.

Target pests: Honey bee colony infected with American Foulbrood. This depopulation of bees is done prior to the burning of bees and bee equipment as an attempted means of eradicating AFB from an individual beekeeper's operation.

Amount of active ingredient applied: Data not available for New Jersey.

Type of application: Resmethrin is sprayed (aerosol canister) inside a beehive to kill adult bees.
Application rates: Use enough product to adequately kill off infected bee colony. Amount or volume will depend on colony and beehive size.

Number of applications: One spray will kill the bees in an AFB infected hive.

Timing: Whenever bee colonies are infected with AFB.

Re-entry and pre-harvest intervals: Dead bees and equipment should be burned 12 or more hours after application of resemethrin.

Use in resistance management programs: None.

Efficacy issues: When applied correctly, resmethrin kills off infected bees and stops them from drifting to non-infected, healthy bee colonies nearby.

Contacts

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Appendix I

Value of Honey Bee Pollination to New Jersey Crops

Acres harvested, production units, value of production, and the dependence on and value of honey bee pollination for the primary bee-pollinated crops in New Jersey.

The annual value attributable to honey bees ([x]) is the product of (value of production) x (dependence on insect pollination) x (proportion of pollinators that are honey bees) x (adapted and modified from Morse and Calderone 2000).

Crop	Acres Harvested	Production (lbs)	Value of Production ($)	Dependence on Insect Pollination	Proportion of pollinators that are honey bees	Annual value ($) attributable to honey bees[x]
Applles[z]	2,600	35,000,000	4,830,000	1.0	0.9	4,347,000
Blueberries[z]	7,400	42,000,000	46,790,000	1.0	0.9	42,111,000
Cranberries[z]	3,100	43,000,000	11,008,000	1.0	0.9	9,907,200
Cucumbers[z]	3,000	67,500,000	11,948,000	0.9	0.9	9,677,880
Peaches[z]	8,000	57,000,000	25,194,000	0.6	0.8	12,093,120
Pumpkins[y]	2,000	36,000,000	4,032,000	0.9	0.4	1,451,520
Squash[z]	3,500	45,500,000	11,057,000	0.9	0.4	3,980,520
Strawberries[y]	540	1,800,000	2,080,000	0.2	0.1	41,600
Other crops[w]	NA	NA	NA	NA	NA	NA
Total	30,050	327,800,000	116,939,000	-	-	83,609,840

[z] Values obtained from 2002 reports from the USDA National Agricultural Statistics Service (www.usda.gov/nass).

[y] Values obtained from 2000 reports from the USDA National Agricultural Statistics Service (www.usda.gov/nass).

[x] The annual value attributable to honey bees is the product of [value of production x dependence on insect pollination. x proportion of pollinators that are honey bees] (adapted and modified from Morse and Calderone 2000).

[w] Includes cantaloupes, honeydew melons, watermelons, and other bee-pollinated crops for which there are no available production data for New Jersey (NA = not available). Additional crops such as soybeans and snap beans are also not included, yet these crops do benefit from bee visitation in terms of increased pod set even though they are not generally dependent on bee pollination.

Appendix II

Relative Toxicity of Pesticides to Honey Bees

Most pesticides are at least somewhat toxic to honey bees; however, the degree of toxicity varies considerably from product to product. Insecticides are generally the most likely to cause a bee kill; herbicides, fungicides, and defoliants present minor danger to bees if used according to label directions. Pesticides are listed as active ingredients or common names, with examples of trade names in parentheses.

GROUP I: Highly Toxic. Severe bee losses may be expected **IF**the following pesticides are used when bees are present, or the product is applied near beehives, or within a day after application to foraging bees in the pesticide application area.

abamectin (AgriMek, Avid, Zephyr)	cypermethrin (Ammo, Cymbush)	flucythrinate (Pay-Off)	naled (Dibrom)
(Temik G)	*d*-phenothrin (Sumithrin)	heptachlor	parathion (Parathion)
arsenicals (Zotox)	decamethrin (Decis)	lindane (Lindane)	permethrin (Ambush, Pounce)
acephate (Orthene, Payload)	diazinon (Diazinon, Spectricide)	malathion (Cythion, Malathion D/ULV)	phosmet (Imidan)
azinphosmethyl (Guthion)	dichlorovos (DDVP, Vapona)	methamidophos (Monitor, Tamaron)	phosohamidon (Dimecron)
bifenthrin (Brigade, Talsar)	dicrotophos (Bidrin)	methidathion (Supracide)	prallethrin (ETOC)
bioethanomethrin	dieldrin (Octalox)	methiocarb (Mesurol)	propoxur (Baygon)
carbaryl (Sevin-WP, -4-oil, -XLR)	dimethoate (Cygon, De-fend, Rebelate)	methomyl (Lannate, Nudrin D)	pyrazophos (Afugan)
carbofuran (Furadan)	famphur (Famophos)	methroprene	resmethrin (Synthrin)
carbosulfan (Advantage)	fenitrothion (Sumithion)	methyl parathion (Penncap-M)	

chlorpyrifos (Dursban, Lorsban)	fenpropathrin (Danitol)	mevinphos (Phosdrin)	tetrachlorvinphos (Appex, Gardona)
cyfluthrin (Baythroid)	fensulfothion (Dadanit)	mexacarbate (Zectran)	tralomethrin (Scout)
cyhalothrin (Karate)	fenthion (Baytex)	monocrotophos (Azodrin)	zetacypermethrin (Fury, Mustang)

GROUP II: Moderately Toxic. These pesticides can be used in the vicinity of bees **IF** dosage, timing, and method of application are correct; but these products should never be applied directly on bees in the field or at the colony location.

aldicarb sulfone (Standak)	endosulfan (Thiodan)	phorate (Thimet)	sumithrin (Anvillollo)
aluminum phosphide (Phostoxin)	endothion	phosalone (Zolone)	tartar emetic
biothion	endrin	profenofos (Curacron)	temephos (Abate)
carbophenothion	ethoprop (Mocap)	propamocarb (Carbamult)	terbufos (Counter)
chlordane	fluvalinate (Mavrik)	propamocarb hydrochloride (Banol)	thiodicarb (Larvin)
coumaphos (Co-Ral)	fonofos (Dyfonate)	pyrethrum	zephyr
crotoxyphos (Ciodrin)	formetanate (Carzol)	ronnel	
demeton (Systox)	oxamyl (Vydate)	spinosad	
disulfoton (Di-syston)	oxydemeton-methyl (Metasystox-R)	sulprofos (Bolstar)	

GROUP III: Relatively Non-Toxic. These pesticides can be used around bees with minimum risk **IF** dosage, timing, and method of application are correct. Never apply pesticide directly to the beehive.

Acaricides, Biological Control Agents, Insect Growth Regulators, and Insecticides

allethrin	cymiazole (Apitol)	methoxychlor (Chemform, Prentox)	pyriproxyfen (Nylar)
amitraz (Mitac)	dibromochloropropane (Nemagone)	multimethylalkenols (Stirrup)	rotenone
azadirachtrin (Margosan-O)	dicofol (Kelthane)	nicotine	ryania
Bacillus thuringiensis (Biobit, Thuricide)	diflubenzuron (Dimilin)	*Nosema locustae* (Canning)	tetradifon (Tedion)
B. t. kurstaki (Dipel, Javelin)	dinobuton (Dessin)	oxythioquniox (Morestan)	tetraflubenzuron (CME)
chlordimeform (Fundal)	dioxathion (Desnav)	pheromones (traps, mating disruption)	trichlorfon (Dylox, Proxol)
chlorobenzilate (Acaraben, Folbex)	esfenvalerate (Asana)	pirimicarb (Pirimor)	toxaphene
clofentizine (Apollo)	ethion (Ethiol, Ethion Oil)	polynactins	z-11-hexadecanol (tipworm pheromone)
cryolite (Kyocide)	*Heliothis* virus	propargite (Comite, Omite, Ornamite)	

Fungicides			
anilazine (Dyrene, Kemate)	cuprous oxide	fenaminosulf (Lesan)	strobilurins
benomyl (Benlate)	dazomet (Mylone)	folpet (Phaltan)	sulfur
bordeaux mixture	dichlone	glyodin (Glyoxide)	thiram
captafol (Difolatan)	diniconazole (Spotless)	maneb (Manzate)	thiramlmethoxychlor (Atasan)
copper 8-quinolinate	dinocap (Karathane)	metiram (Polyram)	triforine (Funginex)

copper oxychloride sulfate	dithianon (Thynon)	nabam (Parzate)	triphenyltin hydroxide (Du-Ter)
copper sulfate-monohydrate	dodine (Cyprex)	prochloraz (Sportac)	ziram (Zerlate)

Herbicides, Defoliants, Desiccants, and Plant Growth Regulators			
2,3,6-TBA (Trysben)	cyanazine (Bladex)	imadagylin (Arsenal)	pronamide (Kerb)
2,4-D (2,4-D)	dalapon	linuron (Lorox)	propanil (Stam F-34)
2,4-DB (Butoxon, Butyrac)	dicamba (Banvel)	MCPA (Mapica)	propham (Ban-Hoe, IPC)
alachlor (Lasso)	dichlobenil (Casoron)	metaldehyde propazine (Miloguard)	quinchlorac (Facet)
amitrole	diquat	methazole (Probe)	simazine (Princep)
ammonium sulfate	diuron (Karmex)	metribuzin (Lexone, Sencor)	sodium chlorate (Drop-Leaf)
atrazine (Aatrex, Weedex)	EPTC (Eptam)	monuron	terbacil (Sinbar)
benomyl (Benlate)	etephon (Ethrel)	naptalam (Alanap)	terbutryn(e) (Igran)
bentazon (Basagran)	ethalfluralin (Sonalan)	nitrofen (TOK)	thiadiazuron (Dropp)
bromacil (Hyvar)	EXD (Herbisan)	norflurazon (Zorial)	tribufos (DEF, 6EC)
butifos (DEF)	fluometuron (Cotoran)	paraquat (Gramoxone)	tributyl phosphorotrithioite (Folex)
chlorbromuron (Maloran)	fluridone (Brake, Sonar)	phenmedipham (Betanal)	
chloroxuron (Tenoran)	gylphosate (Roundup)	picloram (Tordon)	
cloproxydim (Select)	hydrogen cyanamide (Dormex)	prometryn (caparol)	