TEN

Dangers to Bees

Question 1: What dangers threaten bees in the environment?

Answer: Poor nutrition, disease, parasitic mites (see this chapter, question 3: What parasites and insects prey on bees?), pesticides, and pollution are some of the threats that stress colonies and cause them to fail. Honey bees are totally dependent on the weather for creating their food supply, and malnutrition is common when a lack of rain or extreme temperatures interfere with the normal bloom cycle of plants that are their nectar and pollen sources. A rainy period keeps the bees inside the colony, forcing them to use up food that had been stored for the winter, and if the weather has been poor, plants may not be robust and the pollen may not contain the usual proteins, vitamins, and other substances required by the bees. If bees are in poor health, they are more susceptible to disease, including about twenty known viruses to which bees are vulnerable (see this chapter, question 2: How do bees survive harsh weather?).

Insecticides are used as a seed treatment and in spray applications on plants. They become distributed throughout the tissues of the plants and can cause a toxic reaction when bees consume the nectar and pollen. Pollution also threatens habitat, as do housing developments and other large ground-clearing projects like airports, golf courses, and intensive agricultural projects that completely remove habitat.

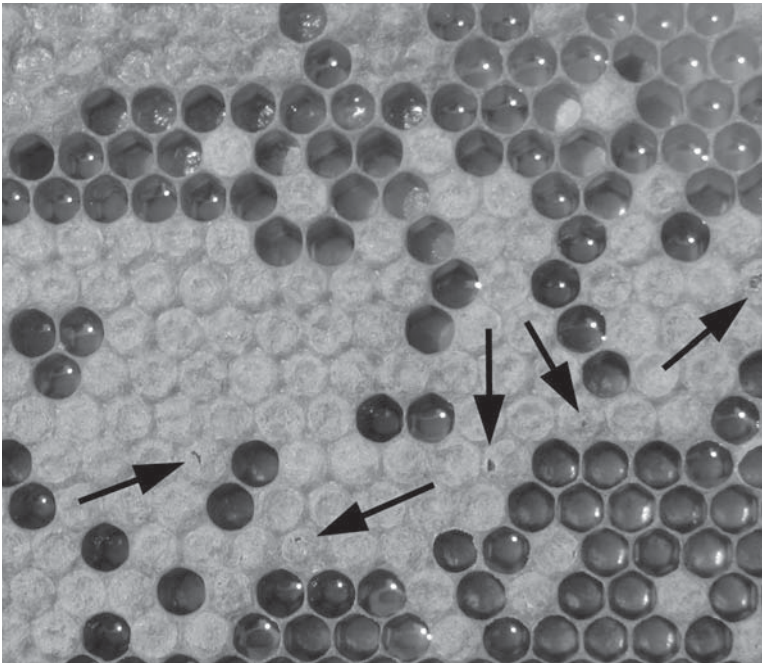

Fig. 30. The black arrows point to small perforations in the wax cappings over brood; these are signs of stress in an otherwise healthy colony. Some beekeepers believe that these imperfections signal future trouble within the colony, despite the absence of any current disease. *(Photo by Debra Cook-Balducci.)*

Question 2: How do bees survive harsh weather?

Answer: Rain provides a hazard for bees, including the danger of being knocked out of the sky by a big raindrop. When it rains, the bees stay in the colony and survive on stored food. An extended rainy period can deplete supplies stored for the winter, endangering the survival of the colony. If foragers are caught away from their colony by a sudden rainstorm or cold snap, they sometimes take shelter under flowers or vegetation until the weather conditions improve enough for them to head homeward.

In the warm weather, bees are very active, but in winter they become sluggish and their metabolism slows. So-called warm-blooded animals regulate their metabolism and maintain a relatively constant body temperature regardless of the temperature in the environment, and although cold-blooded creatures like bees and other insects are hot when their environment is hot and cold when their environment is cold, they do have some control over their body temperature through a process called thermoregulation.

Thermoregulation enables bees to adjust their body temperature by generating some heat when their environment is cool by, for example, shivering and crowding together. On cold winter days, bees keep warm by clumping together in large groups and beating their wings in order to produce heat, alternating positions on the colder perimeter of the cluster with their sisters who have warmer spots in the middle. The temperature in the center of the cluster averages 21 degrees Celsius (almost 70 degrees Fahrenheit), with a manageable range of approximately 12 to 34 degrees Celsius (54 to 94 degrees Fahrenheit). L. Fahrenholz and colleagues at the University of Berlin found that if the central temperature falls below about 15 degrees Celsius (59 degrees Fahrenheit) and the peripheral temperature is even lower, the bees are in danger.

The colony is more stable in the winter because the queen stops laying eggs and there are no fragile larvae requiring constant care and feeding. Honey bees can survive a normal winter sheltered in the hive, in a hollow tree, or in some other cavity, as long as they have enough stored honey to provide a source of energy. Most beekeepers only harvest the honey made during the spring and early summer for themselves, leaving the honey made from late summer and early fall flowering plants for the hive to consume during the cold weather. After the bees have eaten the honey in one part of the hive, they move in a cluster to another part where there is more honey. The bees tend to move from the lower honey storage areas of the hive (supers) to the upper supers during the winter. Some bees die when it gets too cold, and some species survive by migrating to warmer areas or by moving underground.

When external temperatures rise, bees increase the space between their bodies to help distribute the heat their bodies give off (metabolic heat), and they actively cool the hive in several ways. They may allow fluid droplets to evaporate from within their mouth to remove extra heat from the body, the bee's version of perspiration in mammals. When the colony is very hot, certain foragers will collect water, which they distribute in drops around the hive, and other bees will fan their wings to increase the air circulation and evaporate the water to remove some of the heat. When all else fails, the adult bees will hang as a group on the outside of the colony to totally remove their body heat from the brood area, a maneuver described by some beekeepers as a "beard." The hive would then be "bearded out," apparently wearing a beard made of bees.

The brood (the developing bees) needs to be kept at a stable temperature in order to grow normally, and during the summer season the temperature in the brood nest is maintained at 34.5 degrees Celsius (94 degrees Fahrenheit), with a range of plus or minus 1.5 degrees Celsius. Julia Jones and her colleagues, Madeline Beekman, Ryszard Maleszka, Ben Oldroyd, and Paul Helliwell, in Australia did experiments in which they transferred groups of brood cells into seven incubators that were kept at a different but constant temperatures, ranging from 31 to 37 degrees Celsius (87 to 99 degrees Fahrenheit). The brood cells were put into the incubators within one day of being capped, which indicates the beginning of the pupal phase. Seven days after the bees emerged from their brood cells, 378 bees were tested for long-term memory and 546 were tested for short-term memory.

To test the bees' memory, each bee was trained to associate a lemony scent with a reward of sucrose so that when the scent was detected, the bee would extend its proboscis in anticipation of the reward. Then they tested some of the bees after one hour and another group after twenty-four hours, to see if they extended the proboscis when they were exposed to the scent, which would indicate that the bees remembered the training experience. The study found that abnormal incubation temperatures had an effect on short-term learning and memory but that long-term learning and memory did not prove to be significantly affected by the temperature at which the pupae were reared. This suggests that there are some important neurological consequences of not maintaining the temperature within the desired range, and this could have some subtle impact on the development of optimal foraging ability.

Adult winter bees can live for several months, but when some die naturally, workers carry out their dead sisters and drop their bodies at a distance from the hive. On a warm day in the winter, bees will take cleansing flights. They do not defecate inside the hive, and indigestible material naturally found in honey and pollen accumulates in their intestines. If they cannot fly from time to time to eliminate waste from their bodies, they become ill and die. Some beekeepers remove the honey from small colonies during the winter, replacing it with high-fructose corn syrup, which is quite pure with no indigestible matter, allowing the bees to be kept for long periods without the need to void. In very cold areas in the northern United States and in Canada, some commercial beekeepers kill their bees at the end of each honey-gathering season and start the spring with a new package of bees purchased from a supplier. This strategy is not very common.

Question 3: What parasites and insects prey on bees?

Answer: Large dragonflies and hornets catch honey bees on the wing and feed on them, and many other bee predators are insects. The major insect pathogens and parasites are described below in some detail.

Varroa mites

Varroa destructor mites were introduced in the United States in 1987 from the Asian hive bee *Apis cerana*, and they spread across the country in five years, living up to their name by killing many American honey bees. They are eight-legged external parasites that can only reproduce in a honey bee colony, although they are sometimes found on other flower-feeding insects. *Varroa* mites feed on the hemolymph of bees in the larval and pupal stages. They are called *ectoparasites* because they stay on the outside of the bees as they feed, creating open wounds which make the weakened bees vulnerable to pathogens. Certain viruses can cause the pupal bees to develop deformities that include the possible absence of a leg, crumpled or vestigial wings, a shortened abdomen, or an overall reduction in size. If infested bees survive and are able to fly, their ability to forage normally does not seem to be impaired, but there may be non-lethal behavioral impacts about which we know very little. There are some chemicals

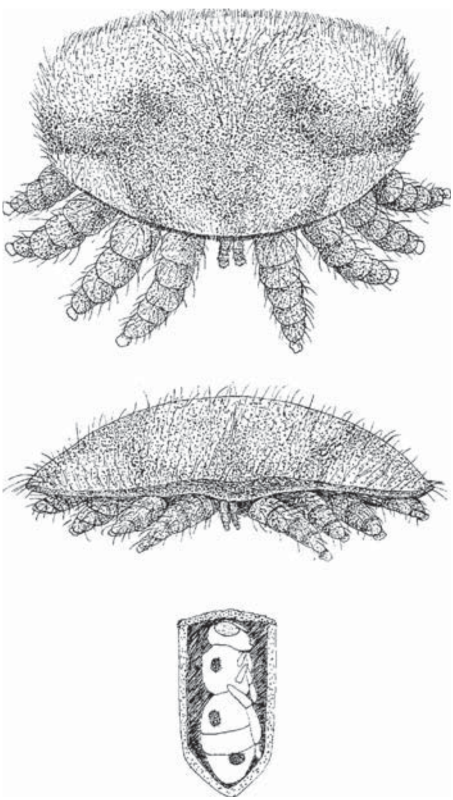

Fig. 31. These diagrams show the ectoparasite *Varroa destructor.* These mites cause physiological stress for bees and problems for beekeepers. The *top* image is a dorsal view, the *middle* is a side view, and the *bottom* illustrates mites on a honey bee pupa. *(Drawing by John F. Cullum.)*

that dissuade mite populations, but some mites have become immune to these drugs.

Tracheal mites

Tracheal mites, *Acarapis woodi,* are small, spider-like *endoparasites* that infest the breathing tubes, or trachea, of honey bees, feeding on a bee's hemolymph from inside the bee's body. Dense infestations of tracheal mites can result in colony death during the winter months because, with many mites in the trachea, the bees cannot breathe normally and aren't able to regulate the colony's temperature. Jon Harrison and his colleagues at Arizona State University studied the impact of mite infestation on the breathing of bees.

These mites are normally found on an Asian cousin of the European honey bee, and they were first identified in Mexico in 1980 and then found in Texas in 1984 and in southern Arizona in 1988. While it is unpleasant to think about it this way, tracheal mites exist like lice on people—the infection is present in low numbers, and they do not do much permanent damage to people suffering with them. Why tracheal mites jumped onto a new species is not understood, and, unfortunately, there is no clear treatment to prevent them except for keeping colonies strong and healthy.

Wax moths

There are two moth species that feed on the materials inside a beehive—both are generally called wax moths, but they are different creatures: the greater wax moth, *Galleria mellonella,* and the lesser wax moth, *Achroia grisella.* As adults, they are small, grayish-brown, and nocturnal, and they both have a keen ability to detect beeswax, in which they lay hundreds of tiny eggs. Wax moth larvae eat the larval skins that are shed when the adult bees emerge, and they also eat impurities in the wax of the bee brood combs, such as pollen and all sorts of debris carried on the thousands of bee feet that have walked across it. If a bee colony is healthy and strong, meaning it has a full complement of workers, the bees can detect and remove the moth larvae be-

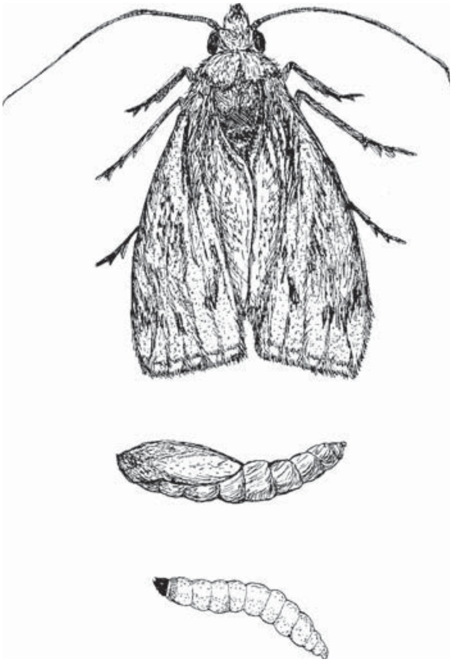

Fig. 32. A wax moth adult, pupa, and larva. These animals lay hundreds of eggs in weak or abandoned beehives. The eggs grow into larvae that damage the honeycombs. *(Drawing by John F. Cullum.)*

fore too much damage is done to the colony, but as the larvae grow, they burrow into the wax and can render the combs inhospitable to bees.

These whitish-gray larvae are certainly not a pleasant sight in a beehive, leaving trails of silk behind them as they move and dig into the wax (see color plate H). Freezing the wax honey frames after the honey has been extracted can kill wax moths eggs and larvae. Wax moths also do not like the fumes of various chemicals, such as paradichlorobenzene (PBD), which is an appropriate (and legal) preventative treatment against these pests and does not hurt the bees. PBD cannot be used in colonies that are actively storing honey because this fumigant is not safe for human exposure or consumption.

Bee lice

A bee louse is actually a tiny wingless fly, *Braula coeca,* which lives inside bee colonies. They cling to a honey bee and take food directly from its mouth. If a hive is infested with them, several adult flies may live on a queen, but usually only one will be found on a worker. Bee lice do little damage to bee colonies, and so they are not thought of as parasites, but rather as commensal animals with bees—meaning their presence is usually tolerated by the bees. Because bee lice are killed by medications given to remove *Varroa* mites from bee colonies, they are rarely seen inside beehives. Elizabeth Evans has been keeping bees for nearly twenty years and has never seen one.

Small hive beetles

Small hive beetles, *Aethina tumida,* are the newest pest in North American beehives. First discovered in the United States in Florida in 1998, the honey-eating beetles were somehow imported from African subspecies of honey bees, where they seem to live quietly in beehives. In the European subspecies of bees that are common in the United States, small hive beetle infestations can cause serious damage to the stored honeycombs and to the honey crop. The beetle grubs (larvae) burrow through and damage the honeycombs, which results in honey running out of the combs and fermenting or becoming frothy. The larvae defecate in the honey and it becomes discolored, and because they can live in honeycombs that have been removed from beehives, they can ruin comb honey that is waiting to be extracted. It is unclear why the small hive beetle can coexist in African beehives as a minor pest but can become a serious threat in North American hives.

Question 4: Which other animals prey on bees?

Answer: The stored honey and the protein-rich brood can make a hearty meal for an animal that is equipped to steal from the hive's environment. Mice are regular marauders in honey bee colonies and will nest in a hive in winter. Larger animals and birds that attack beehives must have strong claws, tough skin, and dense hairs or feathers, especially around their mouths. In North America, skunks, raccoons, opossums, and black bears are known to do damage to beehives. Opossums and skunks will catch the sluggish wintering bees, suck them dry of honey and soft body parts, and drop their exoskeletons near the hive. In tropical rain forests in Southeast Asia, the sun bear *Helarctos malayanus,* also called a honey bear, is a known predator of beehives. Another carnivorous mammal, the honey badger *Mellivora capensis,* also feeds on bee colonies in western Asia and in Africa.

Honeyguides are birds that live in sub-Saharan Africa and parts of Asia and eat beeswax and bee brood. These birds have a fascinating technique to help them overcome the fact that they cannot typically get access to bee nests, nor can they defend themselves effectively from a honey bee attack. Although they are drab in color, it is said that honeyguides attract the attention of a larger vertebrate predator of bees (such as a sun bear, a honey badger, or even a human) using a distinctive call. The bird will then hop around, call again, and then fly a short distance away and resume calling. In this way, the honeyguide earned its name—it guides the larger mammal to a bee colony and dines on the leftovers after the mammal has endured the danger of opening the nest. One bird in this group is named

Fig. 33. There are twenty-six species of bee-eaters that feed on flying insects, primarily on honey bees. These birds are in the family Meropidae. *(Drawing by John F. Cullum.)*

Indicator indicator because of this behavior. However fascinating the stories are about these birds, their true interactions with beehive predators have not been well studied scientifically. We think these birds deserve more attention for the possibilities of interspecies communication, whether or not the bee-bird-mammal fables are true!

There is a family of migratory birds, Meropidae, that are rightfully named bee-eaters, although they also eat other flying insects. They live in southern Europe and eastward into southern Asia during the summer, but when the cold weather comes and bees stop foraging, the birds migrate to spend the winter in West Africa. There are many colorful species in this family, and they live together in large flocks, some foraging together in groups numbering in the hundreds. They chase bees and other insects and snatch them out of the air. Then they retreat to a perch with the insect in their beak, and they remove the sting from a bee or wasp before eating it by repeatedly hitting the insect on a hard surface, expelling most of its venom. There is a wonderful exhibit of bee-eaters in the San Diego Zoo.

Question 5: Does a bee heal if it gets injured?

Answer: To a limited extent, yes, bees can heal—but scientists do not have a detailed understanding of how they fight off infections. Bees do not have a well-developed immune system like the human immune system that develops antibodies against some pathogens after exposure to them. However, bees can survive the accidental removal of an antenna or part of a leg; and, although it is rare, it is possible to see bees with missing parts in an observation hive.

Question 6: Do bees get viruses or fungal infections?

Answer: There are many viruses that infect honey bees, some that have an impact on the developing brood and others that show themselves in the adults. One particular virus, aptly named the Deformed Wing Virus, results in adults with crumbled or shrunken wings. This problem only shows up in colonies that have very high levels of infection—even bees that look normal can test positive for the virus. Since the naming of colony collapse disorder in 2007, scientists are learning a lot more about viruses and how they affect bee behavior and colony health (see this chapter, question 10: What is colony collapse disorder?).

The primary fungus that affects honey bees appears in the brood but doesn't affect the adults. The infection is known as "chalkbrood" because it turns the larval bees into white, chalk-like pieces that beekeepers call "mummies." Adult bees will try to remove these dry larval remnants, and in the process they pick up spores from the fungus and accidentally spread it around the colony. Otherwise healthy colonies with good numbers of individuals in the hive can usually keep their colonies clear of chalkbrood infection, but if they are stressed by cold or wet conditions, it can become a big problem.

Question 7: How are bee diseases spread?

Answer: Insects, like humans, face a greater risk of catching and spreading diseases when they are crowded together. Biologist Adam Stow and his colleagues in Australia washed off the protective coatings from the bodies of a variety of bees that ranged from very social to solitary. They applied a solution made from each species' coating to staph bacterium, *Staphlococcus aureus,* and found that the antimicrobial coating from the most social bees was 314 times stronger than that from the most solitary bees. Even the most mildly social bees were 10 times better protected than the solitary bees.

Even though bigger colonies may tend to have better immune defenses, because there is almost constant physical contact between individuals in a colony, the risk of diseases being spread is still a major concern. Once a colony has an established infection or infestation, it is likely that nearby colonies will also show signs of disease. The actual routes of infection are often not known, but because bee diseases do spread so readily, it is assumed that foraging bees are the likely carriers. There is some evidence that bees can pick up a disease or a pathogen from a flower if they visit it after it was visited by an infected bee. When food sources are limited, honey bees sometimes will steal food from nearby colonies, and in the process they can pick up infections and bring them home.

Question 8: Do bees ever need antibiotic drugs?

Answer: There are two bacterial infections that can devastate a honey bee colony: one is called European Foul Brood (EFB) and the other is American Foul Brood (AFB). AFB is very deadly, infecting larvae that are less than three days old and causing them to die in their cells. Each infected larva contains millions of spores, and in the United Kingdom and in the United States all infected colonies are compulsorily destroyed, and movement of bees or equipment from the infected apiary is prohibited, including *all* of a beekeeper's hives, even if only one is infected. Once this infection takes hold, the bees cannot clear their colony of the stringy bacteria. There may be some variations in state and regional laws that apply.

EFB is less deadly to a colony because its bacteria does not form spores, though it can survive cold weather and continue to infect a colony the next season if it has not been eradicated. It is particularly dangerous if the colony is already under stress, but a healthy colony can be treated with an antibiotic if the infection is not too severe. To prevent infections, beekeepers will sometimes treat their colony with a powdered antibiotic called terramyacin, mixing it with sugar and shaking the powder on the inside of the colony. The risk of prophylactic treatments is that they may lead to resistant bacteria.

In the case of both infections, the larvae ingest the bacteria along with the brood food, and the bacteria then multiply rapidly in the gut of the larvae, causing death in a few days. Hive bees that clean the nest spread the infection, and even the honey becomes contaminated and spreads the disease.

Question 9: What is dysentery for a bee?

Answer: Honey bees are very clean animals and usually only eliminate wastes when they fly outside of the colony. During the winter months, cold temperatures might prevent them from flying, which can create some gastrointestinal distress for them—and a protozoan infection can begin. Evidence of these gut parasites, called *Nosema,* can be seen in the form of brown spots that appear inside and outside of the colony as the bees fly out during warm winter days and the springtime on cleansing flights to void stored wastes. The infection is usually short lasting and can be prevented through the application of a medication fed to the bees in a simple sugar syrup. There are new, more virulent strains that result in the death of colonies.

Question 10: What is colony collapse disorder?

Answer: Colony collapse disorder (CCD) is characterized by almost all of the adult worker bees flying away from their hive, abandoning the stored honey and pollen as well as their larvae and pupae. Usually all the bees leave in less than a week, and in a few cases, whole colonies have been found dead in their hives.

Beekeepers expect approximately a 20 percent loss in a normal season, but when losses are from 30 to 60 percent, as has been reported recently, there is concern that the problem can have drastic consequences for human food supplies because of the absence of pollinators to fertilize the crops. These losses have occurred as demand for pollination services has soared due to the prevalence of highly mechanized commercial farms that grow huge quantities of only one crop (monoculture). Between 1947 and 2005, colony numbers nationwide declined by over 40 percent, from 5.9 million to 2.4 million, primarily due to the accidental introduction in the 1980s of two bloodsucking parasitic mites (see this chapter, question 3: What parasites and insects prey on bees?).

Regular surveys conducted by the National Agricultural Statistics Service focus on honey production and other farming operations, but not on pollination services or colony health, so the information that has been available about these losses has not been particularly precise. The problem has been publicized as "mysterious," but, in fact, similar massive bee die-offs have been observed at least since 1869, when the first one was recorded. In 1915 when this phenomenon occurred it was called Disappearing Disease. It occurred in 1963, 1964, and 1965, and then it was called Spring Dwindling, Fall Collapse, and Autumn Collapse, respectively. The early outbreaks were localized and the causes were never determined.

There were massive bee die-offs again in 1975, 1995, 2004, and 2005, but they were overcome relatively quickly. But starting in the fall of 2006, beekeepers along the East Coast of the United States began reporting large bee losses. By February 2007 the losses had spread to some Western states until the tally reached twenty-two states in which die-offs of up to 80 percent of the colony population were reported. Recent outbreaks are being reported throughout parts of Canada and Europe.

In September 2007, a team of scientists led by Diana Cox-Foster of Pennsylvania State University reported that they had found a strong correlation between CCD and a virus from Israel that may have arrived in the United States via shipments of live bees from Australia. In 2004, it was permitted to import bees for the first time since 1922 to compensate for losses due to *Varroa* mites, and the imports came from Australia. The virus, Israeli Acute Paralysis Virus (IAPV), was identified just three years ago by researchers at Hebrew University, and it is transmitted by the *Varroa* mite. IAPV is described as a significant marker for CCD because in the recent studies it was found only in bee populations with colony collapse disorder. Although this seems like an important finding, the virus is not known to be the cause of CCD; there were many other pathogens identified in the Cox-Foster study. Their research is continuing and these results are being interpreted cautiously.