Feature Article

Where are the Bees?

By Jim Bobb

I am often asked, what is happening to the bees? Since the story broke about Colony Collapse Disorder (CCD), the news has been filled with reports of the disappearance of bees around the world.

Although individual beekeepers had reported bee disappearances at times over the past century, it was not until Dave Hackenberg, a Pennsylvania beekeeper, alerted Penn State University and the Florida and Pennsylvania Departments of Agriculture, that the reports were taken seriously.

On November 12, 2006, Dave found that over 2,000 of his 3,000 hives, which had been bustling with bees only two weeks earlier, were empty of all but the queen, a small number of young bees, and large patches of brood (unhatched worker bees). It made no sense that the bulk of the workers would abandon the hive without taking the queen—the queen is the only member of the hive which can lay female (worker) eggs. The bees which left would not be able to reproduce and sustain a colony.

Since 2006, commercial beekeepers throughout the world have reported losses. The losses of hives were never distributed over all the beekeepers, but the catastrophic losses would hit different beekeepers each year. Richard Adee, one of the largest commercial beekeepers in the United States, with 80,000 hives located in five states, reported a 50% loss this past year.

What can be the cause of this plight? Malnutrition, pesticides, Genetically Modified Organism (GMO) crops, migratory beekeeping, lack of genetic biodiversity, beekeeping practices, parasites and pathogens, toxins in the environment, electromagnetic radiation, sunspots, climate change, parasitic flies which turn bees into zombies, cell phones, and even the rapture have all been proffered as causes for CCD. A logical person might ask, what changed?

Migratory Pollination

For over a hundred years, hives in the US have been moved to fields to pollinate crops. As fields have become larger and native habitat for honey bees and other pollinators has declined, the need for honey bees has increased. Commercial beekeepers in Pennsylvania will soon be moving hives out of pumpkin fields and sending them on tractor trailers to Florida, where they will pollinate citrus in winter. Then in spring, the hives will be transported north along the coastal states for apples and other orchard crop pollination in late March, blueberries in New Jersey and Maine, and cranberries in New England. During the summer, cucurbits need pollination in the Delmarva Peninsula.

What has changed? Over the past decade, 600,000 acres of almonds were planted in the central valley of California. Almonds bloom in February. This past winter, over half of all hives in the United States were transported to pollinate the almonds, including hives from most commercial beekeepers in Pennsylvania and the East Coast. After the bloom, those hives are returned to all areas of the country. Almonds need pollination to produce fruit. And the more honey bees, the more almonds are produced.

There are some problems with this model. Within two months, any new pest or disease can be spread across the US, first to the 50% of the hives in almond pollination, and then to the remaining colonies when the hives are returned home. Second, almond fields are monocrops. There are no blooming weeds or any other crop to supplement the pollen for the bees. If the bloom is delayed, there is no protein for the developing bees. Third, a single source of pollen for the bees might not be healthy. Although migratory pollination has not been found to cause CCD, it is a stressor on the bees.

Varroa Mites

The Varroa mite, *Varroa destructor,* entered the US in the mid-1980s. Originally a parasite of the Asiatic honey bee, *Apis cerana,* Varroa jumped species when the Italian honey bee was taken to the Orient. (The Italian honey bee, *Apis mellifera liguistica,* is the predominant honey bee kept by beekeepers in the US.) The Asiatic honey bee had developed techniques to control Varroa in their nest, performing a special dance to alert other bees

when a mite had fastened to their back in a spot where they could not reach. The other bee would then remove the Varroa mite from her back. Italian honey bees have not yet developed techniques to control Varroa mites in their hives.

After exposure to the Varroa mite, Italian honey bee hives were moved from Asia back to Italy, and within a year, the Varroa mite could be found in most every hive in that country. The following year, it spread to the rest of Europe, and the year after that, Varroa mites could be found in many hives in the US. The Varroa mites will attach to areas where the bees cannot groom themselves. They are spread from hive to hive fastened to drones, which tend to drift from colony to colony, and even from apiary to apiary

The Varroa mite reproduces within the pupa (cocoon) of the developing bee. Just before the cell is capped over with wax, a pregnant female mite will crawl into the cell and hide under the bee larva. Once the bee spins a cocoon, the mite will start to lay eggs. The first is a male egg and the rest female, one egg every 30 hours. Nymphs will hatch from the egg and the young mites will go through several molts before becoming mature, feeding from puncture wounds in the bee pupa. Once mature, the male mite will mate with his sisters and, when the worker bee hatches out of her cell, the mother mite and the most mature one or two of her daughters will emerge with the worker bee, already pregnant and ready to reproduce. The male and immature female mites cannot survive and die.

The Varroa mite puncture wounds in the pupa and adult bees do not kill the bees directly. However, it has been proved that Varroa mites can spread viruses when they puncture and feed on the bee. There is also some indication that the fluids which the mites inject into the bees affect the immune system of the bee.

The Varroa mite is perhaps the greatest problem for beekeepers world-wide. Beekeepers must take active measures to control Varroa mites in their hives. But, even controlling mite counts in hives has not been sufficient to stop CCD. A study of the apiaries afflicted by CCD showed some of the hives that survived ®had much larger Varroa mite counts than hives that were dying.

Although Varroa mites alone have not been shown to produce CCD, the increase of Varroa populations in a hive has been shown to activate and increase the virus activity in the hive. Varroa mites are a major stressor in bees.

Nosema

It has been known for many years that honey bees have had a parasite in their gut. *Nosema apis,* a microsporidian, becomes active under stress from travelling or from being confined in the hive for long periods of time over winter. Nosema can cause dysentery-like symptoms, often seen as yellow splotches on the outside of the hive.

Once researchers studied the gut of the bee, after CCD was reported, they found that in many places in the US and the world, *Nosema apis* has been displaced by another species, *Nosema ceranae,* which is much more virulent than *N. apis*. An antimicrobial treatment is available, but it is now uncertain as to how many healthy gut bacteria are killed by the treatment—some researchers are suggesting that the treatment is worse than the disease.

Although researchers in the US are still exploring the role that *N. ceranae* plays in CCD, Spanish beekeepers and researchers have found that *N. ceranae* in bees in Spain may be much more deadly, and that its presence strongly correlates with the incidence of CCD in that country.

Viruses

The USDA has identified ten viruses in honey bees, only two of which have any visible symptoms on the honey bee. The most visible virus is Deformed Wing Virus (DWV), which causes the worker bee to hatch with no wings or just stubs in place of wings. Although honey bees are now hosts to many of these viruses, the virus appears to need a stressor to activate it. Research conducted by the University of Sheffield has shown that the Varroa mite caused DWV to increase its frequency from 10% to 100% among honey bee hives. Dr. Stephen Martin, University of Sheffield reported, "Just 2,000 mites can cause a colony containing 30,000 bees to die."

Neonicotinoids

During the years leading up to CCD, a new class of pesticides was becoming widely used to replace organophosphate and carbamate insecticides. Neonicotinoids are nicotine-based insecticides that are relatively safe for mammals, but deadly to insects.

Many neonicotinoids are water-soluble, so they can be applied as a systemic liquid drench, the chemical being absorbed into the cells of the plant. As neonicotinoids break down very slowly, they provide protection as the plant grows, flowers, and produces nectar and pollen. Imidacloprid[1] became widely used, followed by clothianidin[2] and thiamethoxm[3]. Most corn is treated with either clothianidin or thiamethoxm, soybeans with thiamethoxm.

Neonicotinoids were designed to work in combination with GMO crops. However, reports in the news and on NPR this summer reveal that the corn rootworm larva has become resistant to the genes from *Bacillus thuringiensis* (Bt) inserted in the GMO corn, and farmers were forced to spike the use of neonicotinoids to save their crops.

[1] Sold as Admire®, Advantage®, Gaucho®, Merit®, Premise®, and Touchstone®.

[2] Sold as Acceleron®, Arena®, Belay®, Celero®, Clutch®, NipsIt Inside®, and Poncho®.

[3] Sold as Cruiser® and Platinum®.

Corn is not pollinated by bees, it is wind and gravity pollinated—the male pollen from the tassels drifts down onto the corn ear. Little thought was given to bees visiting corn as a protein source for the hives, especially when no other pollen was available. Honey bees can be seen in the summer, with their pollen sacks packed full of white corn pollen. Many commercial beekeepers now will not pollinate crops near corn fields in tassel.

How Can a Gardener Help?

- Plant things that bees like. Pollen is the protein needed to raise young bees. Plant flowers that produce pollen. Stay away from double flowers, as many of them have no stamens.
- Bees like all flower colors, especially yellow, blue, and purple, but not red—those flowers are for hummingbirds and butterflies.
- Southeastern Pennsylvania has many trees that bloom in spring, but summer has a dearth of nectar. Plant for summer bloomers. Annuals often do not produce much nectar, but herbs are great, especially the mint family. Try sage, salvia, oregano, lavender, ironweed, yarrow, hyssop, alfalfa, echinacea, bee balm, goldenrod, and thyme.
- Eliminate or reduce garden pesticides. If you must use pesticides, carefully follow the directions on the label. Pesticides should NEVER be used on flowering plants. Use companion planting instead of pesticides, if possible.
- Allow a few leafy vegetables in your home garden to 'bolt' (go to flower).
- Support your local beekeepers. Your local beekeepers are doing their part to keep bees in the area. Support them by purchasing local honey.
- Several townships have considered ordinances to restrict beekeeping. Educate your neighbors and encourage them to work with local beekeepers.

Pesticides Found in Hives

Penn State University researchers were astonished to find so many pesticides in tested samples of pollen, beebread (a mixture of pollen and honey stored by bees and fed to their young), and wax. The tests found sub-lethal levels of 70 pesticides and metabolites (substances produced when pesticides break down) in pollen. Each pollen sample averaged 6 pesticides with as many as 31 per sample. "It was a bit of a shock to see the levels and the widespread presence of these pesticides," said Maryann Frazier, PSU.

Although not thought to harm insects directly, fungicides found in the hive were found to dramatically increase the harmful effects of insecticides. A North Carolina study found that some neonicotinoids, in combination with certain fungicides, synergized to increase toxicity 1,000-fold in lab studies. The EPA only looks at exposure to individual pesticides, not the cumulative effect of multiple pesticides.

The researchers are now studying the effects of long-term exposure to sub-lethal levels of pesticides.

Other Research

Another study showed that fungicides in the hive increased probability of *Nosema ceranae* infection in bees that consumed pollen with a higher fungicide load.

A separate study looked at the gene activity of bees infected with Varroa or Nosema. Individual bees were infected and reintroduced into the hive. A few days later the effect of the infection on the bees and their behavior was monitored. In addition to having a higher viral infection, infected bees tend to leave the colony earlier to perform foraging activity, which could lead to a significant depopulation of the colony.

European Union Restrictions

In July, the European Union restricted the use of the insecticide fipronil[4]. A scientific risk assessment carried out by the European Food Safety Authority (EFSA) in May said seeds treated with pesticides containing fipronil pose an acute risk to Europe's honey bee population. The restrictions will ban the use on corn and sunflower seeds. In May, the Commission banned for two years the neonicotinoid insecticides imidacloprid, clothianidin, and thiamethoxam.

Summation

There has not been a single smoking gun causing CCD. Most consider control of Varroa mites to be essential to a healthy hive—however, that alone does not guarantee success. The impact of *Nosema ceranae* is still uncertain. Sub-lethal effects of insecticides in the hive need more exploration. Fungicides are being found to play a synergistic effect, increasing the toxicity of insecticides by as much as 1,000-fold. Researchers are now studying much more complex test models with multiple factors and stressors. Perhaps the CCD research can be summed up in the Socratic statement, "The more I learn, the more I learn how little I know."

***Jim Bobb** serves as the Chairman of the Eastern Apicultural Society of North America, which just held an international bee conference for 800 beekeepers at West Chester University in August 2013. You can see his workers flying around Morris Arboretum, Longwood Gardens, Henry Foundation for Botanical Research, the Barnes Foundation, and the Academy of Natural Science.*

[4] Sold as Regent®, Termidor®, Frontline®, Frontline® Top Spot®, and PetArmor®.