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The Buzz about Colony Collapse Disorder: Causes, Effects, and Cures

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Part I – Introduction

Mark and Tanya were enjoying a cup of coffee, trying to take their minds off of their slowly depleting bee colonies when Dave rushed into the kitchen out of breath.

"Mark!" Dave gasped, "One more bee colony is gone."

"What?" Mark asked in confusion.

"Oh no!" yelled Tanya.

Dave continued, "I was just out at the almond fields checking on our honeybee colonies, and another large portion is missing. The bees have just disappeared again! I don't understand what could be causing this."

Mark belongs to a family of bee workers. Every year they travel across the country helping to pollinate crops in California, Florida, Maine, and countless places in between with their honeybee colonies. The almonds they pollinate in California will one day be shipped throughout the country as plain, roasted, salted, or in containers of mixed nuts. Mark, aware of the important role honeybees play in agriculture, grabbed his laptop to check if any progress had been made to figure this mystery out.

"Let's review what we know," Mark suggested. "A fourth of the beekeepers in the United States are also experiencing big losses in their honeybee colonies. According to my past research, 30% of all colonies have died."

Dave added, "No dead bees are ever found in the colonies."

"That's right," said Mark. "The worker bees must die when they're collecting nectar. The queen and a few young are almost always found in the abandoned colony."

"This is troubling," Tanya said, "because the agricultural production from apples and blueberries to broccoli and melons depend on pollination from honeybees like ours. Without bees, fruits and vegetables that everyone enjoys could not be produced on a large scale, which means many would go without."

"Over 100 commonly used crops, with a value upwards of $14 billion, would be left unpollinated," Mark responded, a certain sadness marking his voice. "A tragedy indeed."

Questions

1. What kinds of plants are pollinated by honeybees?
2. What are some short- and long-term economic, social, and environmental repercussions of a widespread disappearance of honeybees?
3. Are larger or smaller honeybee operations more likely to experience Colony Collapse Disorder (CCD)?
4. Hypothesize possible reasons for Colony Collapse Disorder.

Part II – In Search of the Cause

"We should investigate further. Maybe something new about Colony Collapse Disorder has been found," Mark said. He was worried, not only because of the effects this was having on the emotional and economic standing of his family, but for what this meant for pollinating honeybee colonies all over the United States.

Tanya entered the room reading an article titled "Solving the Mystery of the Vanishing Bees" that she had found in *Scientific American*.

"Look at this excerpt from an article by Diana Cox-Foster and Dennis vanEngelsdorp, the top CCD researchers," said Tanya.

> *… no single culprit has been identified. Bees suffering from CCD tend to be infested with multiple pathogens, including a newly-discovered virus, but these infections seem secondary or opportunistic much the way pneumonia kills a patient with AIDS. The picture now emerging is of a complex condition that can be triggered by different combinations of causes.*

"This makes sense. There were no signs of *Varroa* mites on our remaining bees. The mites feed on hemolymph, and their small dark bodies can be seen on the bees under close inspection. I noticed the presence of *Nosema*. The parasitic fungus infects a bee's gut after the bee ingests its spores. The spores damage the bee's digestive tract, cause dysentery, and can expose the bee to other viruses and parasites. But honeybees are infected by them every spring, and the mites did not seem to overwhelmingly harm the bees in the past."

Mark commented, "I have always been nervous about letting our colonies pollinate genetically engineered crops. I looked into that right away, but have not found any conclusive data yet. Most studies say that the toxin caused by the bacterium *Bacillus thuringiensis* (Bt) that is inserted into the crop as an insecticide does not affect pollinators such as bees. However, a study done in Germany noticed that bees used in their study that were fed a concentrated Bt poison feed were more susceptible to parasites than those that were not."

Dave added, "But look at places like Illinois. They use genetically modified crops all over the place and they are not having as many issues with CCD. What I am worried about are all of the pesticides and chemicals we have used on the bees ourselves. The mites and fungi gain resistance faster than chemical companies can keep up. Consider neonicotinoids."

"Neonicotinoids?" Tanya asked. "Those pesticides were banned in some places in Europe, right?"

"Yes, they were," Dave responded. "They mimic the effects of nicotine, which is what tobacco plants use as a defense against some insects. Some people do not think these would hurt bees but the pesticide can enter the pollen and nectar of the plant, thereby affecting honeybees. Neonicotinoids affect honeybees' learning and memory, which in turn affects the bees' ability to find both the plants it pollinates and its way back to the hive."

Tanya interjected, "Look at these studies I just found. In colonies with highly concentrated amounts of neonicotinoids, no larva or young bees died, but worker development was delayed. Good thing we stayed away from them."

"Ugh," Mark muttered. "There are so many possibilities. How are we ever going to figure this out?"

"Wow! This is something new!" Dave exclaimed. "The Israeli acute paralysis virus, or IAPV, was found in almost all of the colonies suffering from CCD. Within two weeks of being infected, honeybees begin dying while having paralytic seizures, most often while away from the hive. This strong correlation means that IAPV could be a marker, or even the cause, of CCD."

"A new virus makes more sense as a cause of CCD," said Tanya. "We all know how to keep our bees healthy, and we know the signs of disease or infection. This was something entirely new."

Dave commented, "Now that scientists know IAPV is involved with CCD, they can create a vaccine to help colonies like ours."

"No, Dave," said Mark. "Bees do not have the same immune system as vertebrates. Because they don't have the ability to produce antibodies the way we do, a vaccine would not work."

Tanya added, "I read that researchers do not think IAPV is the only cause. Do you guys think that poor nutrition and stress are causing CCD?"

"What?" Dave asked. "We feed our bees protein supplements to make sure we are covering all of the bases."

"They might not be enough. Look at the almond fields," said Mark. "The bees are surrounded entirely by almonds, without any weeds. Compare a natural habitat to apple orchards, pumpkin fields, or even suburban lawns. One plant doesn't meet all of their nutritional needs, so agricultural fields do not have the variety of plants bees require for proper nutrition. Could this result in a weakened immune system in the bees?"

Tanya chimed in, "Other honeybees, or moths that usually take over an abandoned hive, will not inhabit a hive infected with CCD. This points to some contaminant or disease still present in the hive itself."

Questions

1. As a class, list possible causes of CCD that Mark, Dave, and Tanya read about.
2. How do *Varroa* mites and *Nosema* spores damage honeybee health? What are the disadvantages of using pesticides or fungicides against the mites and spores?
3. How do neonicotinoids affect a honeybee's learning and memory?
4. Do you think genetically modified (GM) crops could contribute to symptoms of CCD?
5. Why don't scientists think Israeli acute paralysis virus (IAPV) is the only causative agent of CCD?
6. What changes in agricultural practices could improve the environments of the honeybees?

Part III – RNA Interference

Dave was especially interested in how bees gain resistance to viruses such as IAPV. He now knows a vaccine to protect honeybees against viruses is impossible because the immune system of invertebrates does not create antibodies in response to a vaccine, as in vertebrates.

As he read more about current research, he came across RNA-interference (RNAi). He investigated the topic further and discovered that bees can be fed double-stranded RNA (dsRNA) of IAPV sequences. This silences the virus' effects and reduces bee mortality.

Questions

1. Investigate RNA interference and the methods used to effectively silence IAPV in honeybees.
2. Form a hypothesis and design an experiment to determine whether feeding dsRNAs to a honeybee colony reduces or prevents IAPV infection.

Part IV – How Can We Help?

Current research points to no one source of Colony Collapse Disorder. The most likely explanation of CCD takes into consideration a combination of poor nutrition and pesticides working to weaken the immune response, increasing honeybees' susceptibility to parasites and viruses, such as IAPV, thereby resulting in massive losses in honeybee populations.

Mark, Dave, and Tanya wasted no time improving the diets of the bee colonies under their care. They asked the farmers they worked with to plant hedgerows and flowers around the fields. Adding this variety of nutritional sources helps to keep honeybee stress levels low while providing them with full nutrition.

Mark suggested frequently checking their colonies for parasites and viruses, and using chemicals to treat mites and other pests more cautiously and less frequently. Also, they kept any surviving honeybees, in hopes that they were resistant to causes of CCD. By adding new bees to these colonies, a CCD resistant strain could appear.

"With all of the new improvements we've made," said Mark to his family, "our move to help pollinate the blueberries in Maine should be successful."

Questions

1. In Part I, you formed a hypothesis about what you think is causing CCD. Now that you have learned more about the subject, what changes would you make to your hypothesis?
2. What actions could the general population take to support the health of honeybees and other pollinators?

Further Reading

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