Solutions to Colony Collapse Disorder

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Abstract

Although no sole cause has been identified for Colony Collapse Disorder, which is affecting honeybees, many proposals have been thought up in hopes of curing this epidemic. If the cause of CCD is mites, organic miticides such as oil of wintergreen and oil of lemongrass is the ideal answer. However, many other possible causes of CCD such as genetically modified crops and pesticide overuse require humans to exhibit self-control and ban necessary components. The combined stress of many factors is possibly compromising the immune system of the honeybee, so the ideal *prevention* of CCD is to raise honeybees with the lifestyle of “organic” bees.

Solutions to Colony Collapse Disorder

Colony Collapse Disorder is a pressing concern that is currently affecting honeybees throughout the world. Because of the numerous resources that the bees provide us, mainly pollination, the 36% of hives hit by this disease will drastically affect the agriculture and economy of the U.S. Unfortunately, no exact cause has been determined for CCD, so there are no solutions that have shown to be completely effective in the long run. However, a variety of proposals have been made to *prevent* colony collapse disorder from occurring in the first place.

A dissected bee in a collapsed colony was shown to have deformed wing virus, black queen cell virus, and many infections, demonstrating that the bee's immune system was extremely weak. Malnutrition is a possible factor—bees kept for commercial use in pollination are fed high-fructose corn syrup, which contain none of the proteins that honeybees need in a balanced diet. However, it is considered cheap and gives the bees the energy boost needed to pollinate millions of flowers each year. Gloria DeGrandi-Hoffman and her colleagues thus created MegaBEE, a dietary supplement that contains protein, fat, sugar, minerals, and vitamins in liquid or flapjack form. In one study, bees being fed the MegaBEE bouillabaisse had three times as many brood after winter than the bees being fed high-fructose corn syrup. The MegaBEE colonies were shown to be healthy, energetic, and ready for almond pollination in the spring. Yet, this is an expensive solution, and one that has not proved whether it can fully prevent CCD. Have we really come to a point where we must manually feed bees in order to keep them alive?

Other scientists believe that the varroa mite, a parasite that has attacked honeybees for the last few decades, is the true cause of CCD. Mites lay eggs in the cell of a bee larvae, and the hatchlings suck on the blood of the bees. This does not necessarily kill them, but it transforms the honeybee into a malformed and malnourished cripple, which cannot produce royal jelly—a key ingredient in feeding young bees. After a few generations, the entire colony is weak and unstable. Fluvinate was first used before mites gained resistance to it, and coumaphos, an organophoshate, soon took its place. However, this highly toxic chemical had rampant effects on the honeybees too. Queens raised in this environment were only accepted 5% of the time, and reduced weight, function, and longevity was found in 75% of these hives. For some beekeepers, the cons outweighed the pros, so they sought organic pesticides.

David Vander Dussen used formic acid paper strips to kill the varroa mite. The small molecules in the powerful vapors penetrated the cuticle of the mites, killing both the adults and the eggs. The hives treated with formic acid were mite-clear for four to five months. The downside of this treatment is that the formic acid also kills newly hatched honeybees, possibly because they have not developed a cement-like layer over its cuticle like the adults have. Queen bee pheromones are hidden behind the fumes, so worker bees are prone to attack her. The mites would take millions of years of evolution to evolve a cement-like shielding too, so this treatment is highly effective. Other scientists have discovered the healing effects of essential oils—mainly oil of thyme, which are used in conjunction with the formic acid.

Another essential oil used is wintergreen, which is fed to honeybees in patties containing vegetable shortening and salt. This, too, was effective at killing the varroa

mite. Oil of lemongrass was often included because it attracted the honeybees to consume the wintergreen. For reasons unknown, wintergreen oil was not on the approved list of marketable products for beekeeping, so scientists decided to switch wintergreen with spearmint. Although spearmint had no mite-killing properties, it improved the health of the overall colony and the individual honeybees, possibly by boosting their immune systems. Some researchers hypothesize that the essential oils fortify the stomach of the honeybee. Spearmint may be a cytophylactic, meaning it actively stimulates the immune system to fight pathogens. Many parasites and pathogens penetrate mid-gut cells to infect the honeybee, so this acts as a shield for the honeybee, as they have a genetic weakness for detoxification enzymes in the stomach. More studies need to be conducted to prove the hypothesis, as the two essential oils have a combined 194 chemical compounds. However, when they were used with formic acid treatments, queen bee deaths were down 25% compared to formic acid being used independently. Mites were destroyed with 97% effectiveness in this case, while only 25%-75% of mites treated with fluvinate or coumaphos died. With more research, the essential oil and formic acid treatments may be sold in the future for commercial use.

Another concept being developed by beekeepers is shrinking the diameters of cells. Hives are currently made by imprinting hexagonal patterns on the foundation that have 5.4-millimeter diameters. This large size would encourage the honeybees to produce more honey and breed bigger honeybees, but it also weakened the strength of the community. One beekeeper decided to make his hive foundations out of cells with 4.9-millimeter diameters, after being inspired by the hives of killer bees, which just so happen to be immune to the varroa mite. Indeed, the honeybees became resistant to many

parasites after a few generations. At first, new hatchlings had trouble drawing out of the small comb, but they eventually began shrinking in size. One theory is that the small cell size allows nurse bees to hear the scrapings of intruders and evict them before they can do any harm. The development time of the egg and pupa are shortened by one day, which greatly reduces the chances of an infestation by around 75 %. Despite this miracle, most beekeepers aren't willing to lose 90% of their stock and upgrade all their equipment for a solution that won't immediately work anyway.

With further research, scientists discovered that a natural beehive had cells of various different diameters, ranging from 4.6 to 6 millimeters. From the small cells came a brood core that could outlast harsh weather in the winter, and from the large cells came the powerful workers that went food gathering in the late summer. This balance may be the key to a healthy bee colony, but many beekeepers believe that cell size has nothing to do with colony health. Natural-cell hives also aren't durable enough to stand up to forklifts and industrial honey extractors, rendering them useless for commercial business, and again, it would be too expensive to replace every single beehive in the United States.

Other solutions simply require the self-control of humans. Genetically modified crops such as *bacillus thuringiensis* in corn grow insecticides "naturally," providing an easy way to ward off pests. However, the insecticide chemicals in corn are present in their nectar, which bees take in. There are some disputes to this theory, as Europe has a ban on GM crops but is still affected by CCD. If there *is* a cause and effect relationship, then the only solution would be to completely ban genetically modified crops, which will not be done until further research.

Interestingly enough, pesticides not used in GM crops may be much more harmful. Imidacloprid is a neonicotinoid, so it greatly affects the nervous system of insects. They completely penetrate through a plant, although they have no effect on humans in low concentrations. Although studies show that it takes about 50-100 parts per billion of Imidacloprid to be fatal to a bee, only a few parts per billion are necessary to disrupt its independent and social life. Since communication and interaction in a hive are crucial to its success, such a chemical would be enough for a colony to collapse. The effect can be compared to alcohol in humans—general loss of controlled movement and sense of direction, as well as a lack of olfactory discrimination—crucial for bees to determine the nectar it needs to take back to the hive. The polluted pollen brought back by worker bees would spread the chemical to the whole hive. Even if the amount of Imidacloprid isn't enough to affect a bee, some believe that the chemical could be passed down through generations and weaken descendents. They may even "synergize" with miticides like coumaphos to become even more potent to honeybees. Countries like France have already placed bans on Imidacloprid and pesticides with similar effects: fipronil, thiamethoxam, and clothianidin. In 2005, the bees in France came back in areas where the Imidacloprid had finally been worn off in the air and ground. However, the numbers of bees fluctuated in the years after that, due to drought, heat, and possibly other factors in CCD. Seeing from this success, banning the pesticides mentioned above seems promising. Yet, America claims it needs more research and evidence before pesticides can be deemed a conclusive factor of CCD and banned.

On another note, some people believe that the entire beekeeping system needs to go—that means letting the honeybees go through a test of the fittest, with no help.

Perhaps the way we forcefully breed bees is causing the genetic pool to shrink—the weaknesses of certain honeybees never goes away, since we only look for traits that bring out maximum honey production. If we let the bees fare by themselves, natural selection will decide which honeybees carry a strong immune system and resistance to parasites. Unfortunately, our nation is so dependent on honeybees as our prime pollinators that letting the bees go would be too costly in the short-term. Breeding such bees would also require a place isolated from any other honeybees and factors that could contribute to CCD. Many have suggested turning back to wild pollinators such as bumblebees to replace the honeybees; nobody knows how many of them there are left, and if it's enough to save the system.

If not wild pollinators, we can import Russian bees, which are hardy and resistant to the varroa mite, and apparently immune to CCD. They have a 70% overwinter survival rate, and consistently weed out the weak individuals to bring out a strong colony. But like a nightmare, cross-breeding Russian bees and honeybees brought out the worst of both worlds—the resulting bees didn't have a strong immune system, or make the same quality and quantity of honey as honeybees. The importation of Russian bees has already started, and may be able to bolster our pollination business and outlive honeybees, even if they can't do the job as well as them.

As for other possible causes of CCD, the microsporidian Nosema was shown to wipe out colonies in eight days. However, symptoms of CCD and Nosema did not match, so Nosema may be a factor, but not the sole cause. It is also found in healthy colonies. Still, if Nosema is detected in a colony, fumagillin is a highly effective antimicrobial that can be added to a honeybees diet to wipe out Nosema. Another suggested cause is the

Israeli acute paralysis virus, which was identified in the genome of a diseased bee. It has been found in 25 out of 30 CCD afflicted colonies, but only 1 out of 21 healthy colonies. But researchers have discovered that IAPV has been in honeybees for hundreds of years, just waiting to be identified until now. More likely, IAPV starts ravaging a honeybee after its immune system collapses from the true causes of CCD. In one experiment, irradiation of hives seemed to make CCD vanish, but this was only because the radiation provided a sterile environment where there were few pathogens. Once the effects faded off, CCD came back stronger than ever and rendered the hive empty.

In conclusion, there is no definite cure for CCD. We have yet to identify the cause of CCD, but a major clue is that “organic” bees do not contract it. Organic bees are kept far away from genetically modified crops and pesticides, are not forcefully bred to large size and numbers, live in natural hives, and aren’t trucked thousands of miles each year. Could it be that the added stress of everything is breaking down the honeybee’s immune system? If so, then it is we who must change, not the honeybees. By following the lifestyle of organically raised honeybees, we can hypothetically eliminate CCD after many generations of a natural life. Yet, our nation’s economy is not willing to slacken the reigns and lose profit to revitalize the honeybees. If that is the case, Colony Collapse Disorder will never be solved.

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