What's New with Honeybees?

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COLONY COLLAPSE DISORDER

It's been three years since commercial beekeepers began reporting a strange malady affecting their beehives. Since November 2006, entomologists have been looking at every infectious or environmental agent known to affect bees as a possible cause. In late 2007, researchers thought they had a marker—though not a cause—when they detected the presence of Israeli acute paralysis virus in affected hives (12 October 2007 *Science*).

But more recent studies of affected and nonaffected hives point to multiple possible causes of what has come to be known as colony collapse disorder (CCD), which empties beehives of adult bees but leaves brood cells intact. Two separate groups have looked at markers for CCD from different angles. In one study of 91 bee colonies consisting of both healthy hives and hives described as CCD affected, researchers identified 61 variables related to CCD (PLoS ONE 4: e6481; doi:10.1371/journal.pone. 0006481). Researchers examined the protein content of bees to determine their nutritional status; conducted morphometric analyses of forewings to determine symmetry; quantified macroparasites, such as mites and microsporidia, and identified pathogens using primer pairs; analyzed pesticides present in hives, brood, and bees; and evaluated the condition of colonies and neighboring colonies. Still, no single factor stands out as an indicator of CCD.

The specific causes of CCD are unknown, so researchers look for several characteristics to identify the disorder. The authors proposed adding one more hive characteristic to the definition of CCD: "at the time of collapse, varroa mite and nosema populations are not at levels known to cause economic injury or population decline." Varroa mites are an important cause of honeybee disease and death in their own right, and nosema, a microsporidian, is known to shorten bee life spans by infecting a bee's gut.

Dennis vanEngelsdorp, acting state apiarist for the Pennsylvania Department of Agriculture and coauthor of the study, explains that both healthy colonies and CCD-affected colonies had similar levels of varroa mites at the time the colonies were assayed. But miticide levels were higher in the healthy hives than in the CCD hives, indicating that the bees in the healthy hives were more resistant to pesticides, or that they had been more aggressively or regularly treated with miticides earlier in the season. CCD-affected colonies may have been treated later in the season, removing mites, but controlling them only after they had damaged the colonies' ability to fight off viral infections. Thus, although mites were not a factor at the time of colony collapse, mites (which also transmit bee viruses) cannot be eliminated as an ultimate cause of CCD.

In general, CCD colonies had bees with multiple infections, whereas healthy colonies had bees with fewer infectious agents. This would explain why CCD colonies are devoid of most adult bees. "When bees are infected, it may cause them to commit altruistic suicide so they don't infect their nest mates," vanEngelsdorp says.

In another study (*Proceedings of the National Academy of Sciences* 106: 14790–14795), researchers identified an increased abundance of poly(A) ribosomal RNA (rRNA) fragments in bees from CCD-affected hives. The authors hypothesized that the higher level of these rRNA fragments may be related to the presence of picorna-like viruses, such as deformed wing virus, which may disrupt protein synthesis in the bee. Gene Robinson, of the University of Illinois at Urbana-Champaign and a coauthor of the paper, explains: "The ribosomal fragments do not point to one organism" as the cause of CCD. "Our data are consistent with the possibility of multiple causes, as many people are thinking already." More studies of larger samples of bees will determine if elevated levels of the rRNA fragments are consistently seen in CCD.

STINGING BEHAVIOR

Aggression in honeybees has long been known to have a hereditary basis, according to Gene Robinson, primary author of a new study (*PNAS Early Edition*, available online at *www.pnas.org/cgi/doi/10.1073/pnas.0907043106*). Using microarrays, Robinson and colleagues studied the expression of genes that affect aggressive behavior of Africanized honeybees (which are aggressive hybrids of African and European honeybees), European honeybees, Africanized bees fostered in European bee colonies, and vice versa. They showed that expression of aggressiveness genes is affected by both environmental and genetic factors. They also found that aggressive bees exhibited down-regulation of genes associated with brain metabolism.

"The differences in aggression [either direction] arose as a result of evolutionary changes in gene regulation in the brain," Robinson says. "In particular, it is those genes related to responsiveness to alarm pheromone [isopentyl acetate], which is what provokes aggression in bees."

Greg Hunt, of Purdue University and a coauthor of the study, is looking at genes that influence aggression in bees. "We have mapped genes that influence colony-level aggression and shown that these same quantitative trait loci influence individual behavior." He adds, "Genes that influence colony stinging behavior influence becoming a guard bee at the colony entrance."

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