Honey bees on cocaine dance more, changing ideas about the insect brain

December 23 2008

In a study that challenges current ideas about the insect brain, researchers have found that honey bees on cocaine tend to exaggerate.

Normally, foraging honey bees alert their comrades to potential food sources only when they've found high quality nectar or pollen, and only when the hive is in need. They do this by performing a dance, called a "round" or "waggle" dance, on a specialized "dance floor" in the hive. The dance gives specific instructions that help the other bees find the food.

Foraging honey bees on cocaine are more likely to dance, regardless of the quality of the food they've found or the status of the hive, the authors of the study report.

The findings, detailed this month in the *Journal of Experimental Biology*, shed new light on the famous honey bee dance language, said University of Illinois entomology and neuroscience professor Gene Robinson, who led the study. The research also supports the idea that in certain circumstances, honey bees, like humans, are motivated by feelings of reward.

"The honey bee dance is this incredibly complex set of activities," Robinson said. "It's a very integrated communication system, very elaborate and very elegant, one of the seven wonders of the animal behavior world."

The dance is also an important tool for understanding social behavior in animals – in particular altruism, the "social glue" in all societies, including our own, he said.

Robinson's interest in the waggle dance led him to study octopamine, a neurochemical known to be important to insect behavior – particularly in regard to movement and eating.

"A variety of solitary insects respond to treatment with octopamine by eating more," he said. Honey bees don't eat more when treated with octopamine, but accept a lower quality of food. This fact led Robinson to wonder whether octopamine also influenced the waggle dance, a behavior unique to foraging honey bees. In an earlier study, Robinson found that foragers have higher levels of octopamine in the brain than all other bees in the hive.

In a study published in 2007, Robinson and his colleagues reported that treatment with octopamine caused foraging honey bees to dance more often. This indicated that octopamine played a role in honey bee dance behavior. It also suggested a framework for understanding the evolution of altruistic behavior, Robinson said.

"The idea behind that study was that maybe this mechanism that structures selfish behavior – eating – was co-opted during social evolution to structure social behavior – that is, altruistic behavior," he said. "So if you're selfish and you're jacked up on octopamine, you eat more, but if you're altruistic you don't eat more but you tell others about it so they can also eat."

But it was not even known if insects have a bona fide reward system. That question led the researchers to study the effects of cocaine on honey bee behavior. Cocaine – a chemical used by the coca plant to defend itself from leaf-eating insects – interferes with octopamine

transit in insect brains and has undeniable effects on reward systems in mammals, including humans. It does this by influencing the chemically related dopamine system.

Dopamine plays a role in the human ability to predict and respond to pleasure or reward. It is also important to motor function and modulates many other functions, including cognition, sleep, mood, attention and learning.

One aspect of reward in the human brain involves altruistic behavior, Robinson said. Thinking about or performing an altruistic act has been found to excite the pleasure centers of the human brain.

"There are various lines of thought that indicate that one way of structuring society is to have altruistic behavior be pleasurable," he said.

Because cocaine causes honey bees to dance more – an altruistic behavior – the researchers believe their results support the idea that there is a reward system in the insect brain, something that has never before been shown.

To determine whether the cocaine was merely causing the bees to move more or to dance at inappropriate times or places, the researchers conducted a second set of experiments. These tests showed that non-foraging honey bees don't dance, even when exposed to cocaine. They showed that foragers on cocaine do not move more than other bees (except when dancing), and that they do not dance at inappropriate times or in locations other than the dance floor.

The researchers also found that the bees on cocaine do not dance every time they go on a foraging excursion. And, most important, their dances are not distorted.

"It's not like they're gyrating wildly on the dance floor out of control," Robinson said. "This is a patterned response. It gives distance information, location information. That information is intact."

In a final experiment that also shows parallels to human behavior, the researchers found that honey bees on cocaine experience withdrawal symptoms when the drug is withheld.

"This study provides strong support for the idea that bees have a reward system, that it's been co-opted and it's now involved in a social behavior, which motivates them to tell their hive mates about the food that they've found," Robinson said.

The findings also indicate that honey bees will make good subjects for substance-abuse research, he said.

Source: University of Illinois at Urbana-Champaign