Research uncovers the social dynamics of yellow jackets

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Assistant professor Michael Goodisman's research into the social dynamics of yellow jackets has shown that multiple mating by the queens does not cause conflict within a colony, but instead creates a more successful colony. Georgia Tech Photo: Gary Meek

Michael Goodisman could be called the Maury Povich of the yellow jacket world. In his laboratory, Goodisman determines the paternity of yellow jackets to study family dynamics within a colony. Even though only one family lives within a colony, each yellow jacket queen mates with several males, creating a complex family tree.

“Social insects such as yellow jackets have been described as one of the greatest achievements of evolution because of the incredible cooperative nature of their societies,” said Goodisman, an assistant professor in the

Georgia Institute of Technology's School of Biology. "I wanted to know why the females would risk this cooperative nature by having multiple partners."

Mating with multiple partners can also lead to disease and wasted time and energy, according to Goodisman. Plus, each new yellow jacket has siblings and half-siblings during the same breeding season, allowing for potential conflict and infighting between the subfamilies.

"Weird things can start happening within families, so we looked to see if there was any evidence of this kind of selfish behavior within the colony," explained Goodisman, whose projects are funded by the National Science Foundation (NSF).

Goodisman wondered if yellow jacket workers would kill new queens that had a different father or if they were more likely to turn their sister larvae into reproducing queens instead of sterile workers. Turning a worker into a queen is easier than it seems – it simply requires a comb nest with larger holes. The larger holes signal to the workers to feed the developing larvae different food, resulting in queens.

"You can actually take developing workers and if they're young enough, put them into queen cells and they will develop into queens," explained Goodisman.

Goodisman, graduate student Jennifer Kovacs and Eric Hoffman, formerly a postdoctoral researcher at Georgia Tech who is now an assistant professor at the University of Central Florida, tested the paternity of each insect to investigate whether any of the males in a colony fathered more queens than workers.

Similar to human paternity tests, comparing DNA sequences of two yellow jackets can show if one is related to another. Goodisman

determined the genetic makeup of each of the queen's male mates. He then determined what proportion of workers and new queens each male mate sired.

The results from the DNA fingerprinting showed that males fathered an equal number of queens and workers in a colony, allowing Goodisman to believe there is no conflict within a colony because of multiple mating.

"Instead of intense competition, yellow jackets seem to exhibit extreme cooperative and helping behaviors," noted Goodisman. Results of this study were published in the journal Molecular Ecology.

Since Goodisman found no disadvantage to having mixed families in the colony, he believed there must be a benefit to the colony for each queen having multiple partners.

Goodisman, Hoffman and Kovacs compared the number of times a yellow jacket queen mated to how successful her colony was. Success was judged based on the number of worker and queen cells in the nest. The findings of this study were published in the journal Evolution.

No correlation was found between the number of mates and the number of worker cells. However, queens that effectively mated four or more times produced significantly more queen cells in the comb than queens that effectively mated fewer than four times. Colonies typically survive only one year, so the number of queens produced at the end of the season represents the entire reproductive output of the colony and, by extension, the original queen. Only inseminated queens survive the winter and emerge in the spring. Thus, Goodisman found that the benefit to multiple mating is that the queen's colony is more successful.

Another avenue of Goodisman's research is to investigate how yellow jacket development leads to a caste system with queens, males and

workers – each with a different role in the colony. The queens mate with males to produce new queens and workers, but don't require a male to produce new males. The female workers maintain and expand the colony, while the new queens and males just hang out and eat until it's time to mate.

"The division of labor has made these animals so incredibly successful in cooperative behaviors, but workers and queens are genetically the same," explained Goodisman.

Goodisman aimed to determine how these insects start with the same DNA but end up as such different insects. With help from Hoffman and graduate student Brendan Hunt, Goodisman learned that yellow jackets of the same developmental age express many genes in common regardless of their caste or gender. They also found that certain genes are turned on or off to create the different castes.

This study was published in the journal *BMC Biology* and Goodisman plans to continue this gene expression research in collaboration with Soojin Yi, also an assistant professor in Georgia Tech's School of Biology.

"We're going to use more sophisticated techniques to look at thousands of genes at once to really make big statements about how different queens are from workers and males," said Goodisman.

Decision-making within a colony also intrigues Goodisman. Different events occur in the colony based on the time of year. For example, the queen constructs a nest and rears the first cohort of workers in the spring. Once the workers mature, they take over the task of colony maintenance and expand the nest by constructing a worker nest throughout the spring and summer. At the end of the summer, the colony begins to produce males and new reproductive queens.

“We want to know who’s telling the workers to stop making more workers and start making queens, so we’re studying the life cycle of yellow jacket colonies,” explained Goodisman. “Is it an environmental cue or possibly a cue from the queen?”

Even though some people think that yellow jackets are just a backyard nuisance, there are benefits to having yellow jackets around, contends Goodisman. They kill insects, suppress fly populations and eat roadkill, he says.

And he’s quick to point out, “Yellow jackets are not here for our pleasure. They’re reproducing, surviving and doing a great job at it.”

Source: Georgia Institute of Technology