Rhythmic vibrations guide caste development in social wasps

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A queen paper wasp (Polistes fuscatus) perches atop her nest in the University of Wisconsin-Madison Arboretum in 2006. Eggs and water droplets are visible in the nest cells. Photo: courtesy Sainath Suryanarayanan

(PhysOrg.com) -- Future queen or tireless toiler? A paper wasp's destiny may lie in the antennal drumbeats of its caretaker.

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While feeding their colony's larvae, a paper wasp queen and other dominant females periodically beat their antennae in a rhythmic pattern against the nest chambers, a behavior known as antennal drumming.

The drumming behavior is clearly audible even to human listeners and has been observed for decades, prompting numerous hypotheses about its purpose, says Robert Jeanne, a professor emeritus of entomology at the University of Wisconsin-Madison. Many have surmised that the drumming serves as a communication signal.

"It's a very conspicuous behavior. More than once I've discovered nests by hearing this behavior first," he says.

Jeanne and his colleagues have now linked antennal drumming to development of social caste in a native paper wasp, Polistes fuscatus. The new work is described in a study published in the Feb. 8 issue of Current Biology by Jeanne, UW-Madison postdoctoral researcher Sainath Suryanarayanan and John Hermanson, an engineer at the USDA Forest Products Laboratory in Madison, Wis.

Paper wasp colonies, like many other social insects, have distinct castes — workers, which build and maintain the nest and care for young, and gynes, which can become queens, lay eggs and establish new nests.

Both workers and gynes hatch from eggs laid by the colony's queen, but gynes develop large stores of body fat and other nutrients to help them survive winter or other harsh conditions, start a new nest, and produce eggs. Workers have very little fat, generally cannot lay eggs and die off as the weather turns cold.

"The puzzle has been how the same egg, the same genome can give rise to two such divergent phenotypes," says Suryanarayanan, who led the work as part of his doctoral studies.

Among honeybees, the key has been traced to the nutritional quality of the food fed to developing larvae: future queens receive the nutrient-rich "royal jelly," while future workers receive stored pollen and nectar.

However, there is no evidence that paper wasps feed their young workers and gynes differently, he says.

Rather, the new work shows that exposure to simulated antennal drumming biases developing larvae toward the physiological characteristics of workers rather than gynes. The finding indicates that the wasps may use antennal drumming to drive developing larvae toward one caste or the other.

The researchers brought colonies into the lab and hooked up piezoelectric devices, designed by Hermanson, to the nests to produce vibrations that simulate antennal drumming. When they introduced the signal to late-season nests that would normally be producing gynes, the hatched wasps resembled workers instead, with much lower fat stores.

Suryanarayanan and Jeanne previously reported field studies that show antennal drumming is very frequent early in the season, when colonies are pumping out workers to expand and maintain the nest and take care of young. The behavior drops during the course of the season to nearly zero by late summer, the time when the reproductive wasps — males and future queens — are being reared.

"We think it initiates a biochemical signaling cascade of events," Suryanarayanan says. "Larvae who receive this drumming may express a set of genes that is different from larvae who don't, genes for proteins that relate to caste." Some possibilities might include hormones, neurotransmitters or other small biologically active molecules, he adds.

Much is known about the effects of stressors, including mechanical stress or vibrations, on animal development and physiology. Intriguingly, one study found that young mice exposed to low-frequency vibrations developed less fat and more bone mass than other mice. But the wasp's use of vibration to communicate with its own young sets it apart.

"This is the first case we know of a mechanical vibratory signal that an animal has evolved to modulate the development of members of its own species," says Jeanne.

Provided by University of Wisconsin-Madison