Brain, behavior may have changed as social insect colonies evolved

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A new study suggests that brain and behavior relationships may have changed in a profound way as larger, more complex insect societies evolved from smaller, simpler ones.

Researchers headed by Sean O'Donnell, a University of Washington associate professor of psychology, found that a key region in the brains of a primitively social paper wasp is better developed in dominant females than in subordinate ones.

"This finding, the first of its kind, contrasts with most of the prior work on social insect brain development. Earlier studies, including one of ours, were done on highly social species with large colony sizes. Among these species, age plays an important role in task performance and workers that leave the nest to forage generally have better-developed brains," he said.

"We found the opposite pattern with a primitively social wasp. Here, the stay-at-home dominant females had better brain development. In this species, direct dominance interactions among the females dictate task performance. Dominance and social interactions were more important than foraging tasks in explaining brain development."

In the new study, O'Donnell and colleagues from the University of Texas studied the brain development of the primitively social wasp Mischocyttarus mastigophorus in the tropical cloud forest near Monteverde, Costa Rica. These wasps live in colonies ranging in size from a handful to several dozen individuals where the division of labor is governed by aggression. The researchers examined an area of the insects' brain called the mushroom bodies. There is one mushroom body on top of each hemisphere of the wasp brain and these structures have a vague resemblance to the cerebrum in human and other vertebrates. The researchers were particularly interested in the calyx, a part of the mushroom body where neural connections are made.

The researchers collected and marked individuals including the queens from seven wasp nests, and observed their behavior. Later these individuals were recaptured and their brains were examined. Data showed that calyces were larger among the queens and the stay-at-home females. This is the opposite of what a number of researchers have found among highly social species with large colonies sizes. Several years ago, O'Donnell and his UT collaborators found that among Polybia aequatorialis, a highly social wasp that also lives in the same region of Costa Rica, there is more individual work specialization and individuals take on a sequence of jobs as they age. In such highly social species, workers that leave the nest to forage generally have better-developed brains.

"It seems pretty clear that primitively social colonies were the ancestral condition and that highly social colonies developed and evolved from them, said O'Donnell. He added that what is intriguing is that the pattern of brain development found in Polybia, a highly social group of wasps, is the same as in honey bees, another highly social insect.

"This shows that what job you do puts pressure on brain development in the highly social species," he said. "In contrasts, status seems to be the major brain demand in the primitively social species. This research suggests that task behavior and brain development has changed in a fundamental way between primitively social and the larger more complex social insect colonies."

The work is important because O'Donnell said social insects are a great model for understanding the design of brains and the relationship between brain design and social complexity. "And it has implications for human society because the evolution of our own society may affect brain development. Social behavior places pretty heavy demands on the human brain."

Source: University of Washington

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