Social wasps show how bigger brains provide complex cognition

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Apoica pallens wasps at their nest in the afternoon. The species is nocturnal -- unusual for social wasps -- and foragers hunt at night. The photo was taken in a tropical rainforest in Corcovado National Park, Costa Rica. Credit: Sean O'Donnell, University of Washington.

Across many groups of animals, species with bigger brains often have better cognitive abilities. But it's been unclear whether overall brain size or the size of specific brain areas is the key.

New findings by neurobiologists at the University of Washington suggest that both patterns are important. The researchers found that bigger-bodied social wasps had larger brains and devoted up to three times more of their brain tissue to regions that coordinate social interactions, learning, memory and other complex behaviors.

Within a species, queens had larger central processing areas - the brain regions that manage complex behaviors - than did worker wasps.

"As the brain gets larger, there's disproportionately greater investment in the size of brain tissue for higher-order cognitive abilities," said Sean O'Donnell, lead author and UW psychology professor. "As larger wasp brains evolve, natural selection favors investing most heavily in the brain regions involved in learning and memory."

Wasps in the species *Polistes instabilis* form small, simple colonies of a few dozen adults. The open cells of the nest contain the young brood, mostly larvae. The white-capped nest cells contain pupae inside silken cocoons, and adult wasps will emerge from these. This nest was in a tropical dry forest in Guanacaste, Costa Rica. Credit: Sean O'Donnell, University of Washington.

For smaller-brained species, cognitive power may be limited by their inability to invest in central brain regions. "In many kinds of animals, it's only with a larger brain - which is determined by body size -

that more complex and flexible behaviors are achieved," O'Donnell said.

The results appear in the April 11 online edition of the *Proceedings of the National Academy of Sciences*.

O'Donnell and his co-authors collected samples of 10 types of adult social wasps from four field sites in Costa Rica and Ecuador. As in other studies, they found that the larger the wasp, the larger the overall brain size. But increase of brain size was not uniform across all brain regions.

The researchers dissected the wasp brains and measured the volume of two brain regions. They focused on the central processing region known as the mushroom bodies that, like the cerebral cortex in humans, handles elaborate cognitive functions such as learning, memory and social interactions. They also measured the peripheral processing regions - the optic lobes and the antennal lobes - that deal with vision and smell and are thought to perform more basic cognitive functions.

Across the 10 species, brain areas that process peripheral sensory information increased only slightly with overall brain size. But the wasps with larger bodies - and correspondingly larger-sized brains - had disproportionately larger central processing regions.

This two-foot tall nest found in Yasuni National Park in Ecuador probably housed thousands of adult wasps in the *Polybia dimidiata* species. The nest was made of tough, water-resistant paper. Credit: Sean O'Donnell, University of Washington.

"These findings suggest that absolute brain size matters a lot, because it sets limits on central cognitive processing tissue," O'Donnell said.

The researchers also found that in nine out of 10 wasp species, the queens had larger central processors than worker wasps. This was surprising to the researchers because, in social wasps, queens seem to not perform complex tasks like food collection. They're relatively inactive, staying in the nest to lay eggs while the workers go out to forage.

But O'Donnell said the greater brain power possessed by social wasp queens may be due to having to defend their social status. "Queens are constantly tested for their potency. They must be up for those social cognitive demands," he said.

The researchers are now testing the prediction that large-brained species will have enhanced cognitive

abilities compared with smaller-brained species, which could have ecological payoffs for challenges like invading new habitats and expanding their geographic range.

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