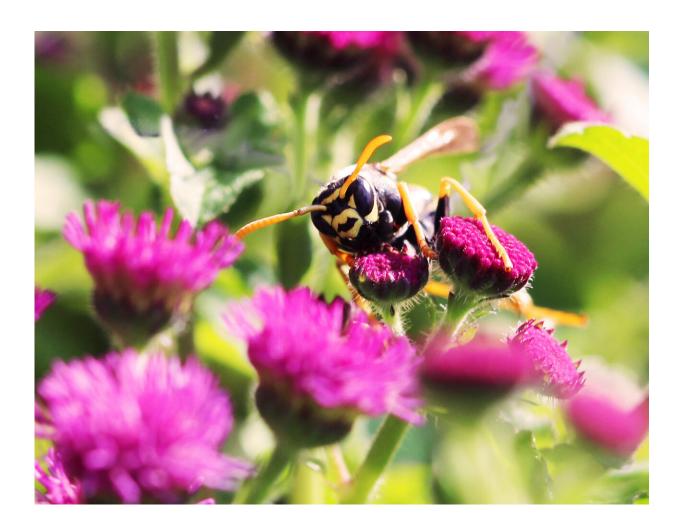# Paper wasps capable of behavior that resembles logical reasoning

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A *Polistes dominula* paper wasp on a flower. Credit: Elizabeth Tibbetts.

A new University of Michigan study provides the first evidence of

transitive inference, the ability to use known relationships to infer unknown relationships, in a nonvertebrate animal: the lowly paper wasp.

For millennia, transitive inference was considered a hallmark of human deductive powers, a form of logical reasoning used to make inferences: If A is greater than B, and B is greater than C, then A is greater than C.

But in recent decades, vertebrate animals including monkeys, birds and fish have demonstrated the ability to use transitive inference.

The only published study that assessed TI in invertebrates found that honeybees weren't up to the task. One possible explanation for that result is that the small nervous system of honeybees imposes cognitive constraints that prevent those insects from conducting transitive inference.

Paper wasps have a nervous system roughly the same size—about one million neurons—as honeybees, but they exhibit a type complex social behavior not seen in honeybee colonies. University of Michigan evolutionary biologist Elizabeth Tibbetts wondered if paper wasps' social skills could enable them to succeed where honeybees had failed.

To find out, Tibbetts and her colleagues tested whether two common species of paper wasp, Polistes dominula and Polistes metricus, could solve a transitive inference problem. The team's findings are scheduled for online publication May 8 in the journal *Biology Letters*.

"This study adds to a growing body of evidence that the miniature nervous systems of insects do not limit sophisticated behaviors," said Tibbetts, a professor in the Department of Ecology and Evolutionary Biology.

"We're not saying that wasps used logical deduction to solve this

problem, but they seem to use known relationships to make inferences about unknown relationships," Tibbetts said. "Our findings suggest that the capacity for complex behavior may be shaped by the social environment in which behaviors are beneficial, rather than being strictly limited by brain size."

To test for TI, Tibbetts and her colleagues first collected paper wasp queens from several locations around Ann Arbor, Michigan.

In the laboratory, individual wasps were trained to discriminate between pairs of colors called premise pairs. One color in each pair was associated with a mild electric shock, and the other was not.

"I was really surprised how quickly and accurately wasps learned the premise pairs," said Tibbetts, who has studied the behavior of paper wasps for 20 years.

Later, the wasps were presented with paired colors that were unfamiliar to them, and they had to choose between the colors. The wasps were able to organize information into an implicit hierarchy and used transitive inference to choose between novel pairs, Tibbetts said.

"I thought wasps might get confused, just like bees," she said. "But they had no trouble figuring out that a particular color was safe in some situations and not safe in other situations."

So, why do wasps and honeybees—which both possess brains smaller than a grain of rice—perform so differently on transitive inference tests? One possibility is that different types of cognitive abilities are favored in bees and wasps because they display different social behaviors.

A honeybee colony has a single queen and multiple equally ranked female workers. In contrast, paper wasp colonies have several

reproductive females known as foundresses. The foundresses compete with their rivals and form linear dominance hierarchies.

A wasp's rank in the hierarchy determines shares of reproduction, work and food. Transitive inference could allow wasps to rapidly make deductions about novel social relationships.

That same skill set may enable female paper wasps to spontaneously organize information during transitive inference tests, the researchers hypothesize.

For millennia, transitive inference was regarded as a hallmark of human cognition and was thought to be based on logical deduction. More recently, some researchers have questioned whether TI requires higher-order reasoning or can be solved with simpler rules.

The study by Tibbetts and her colleagues illustrates that paper wasps can build and manipulate an implicit hierarchy. But it makes no claims about the precise mechanisms that underlie this ability.

In previous studies, Tibbetts and her colleagues showed that paper wasps recognize individuals of their species by variations in their facial markings and that they behave more aggressively toward wasps with unfamiliar faces.

The researchers have also demonstrated that paper wasps have surprisingly long memories and base their behavior on what they remember of previous social interactions with other wasps.

  More information: Transitive inference in Polistes paper wasps, *Biology Letters*, royalsocietypublishing.org/doi … .1098/rsbl.2019.0015