Wasps use ancient aggression genes to create social groups

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This image shows *Polistes fuscatus* colony-founding queens fighting in a laboratory setting. Credit: Jennifer Jandt, Iowa State University

Aggression-causing genes appeared early in animal evolution and have maintained their roles for millions of years and across many species, even though animal aggression today varies widely from territorial fighting to setting up social hierarchies, according to researchers from Iowa State University, Penn State and Grand Valley State University.

If these "mean genes" keep their roles in different animals and in different contexts, then perhaps model organisms—such as bees and mice—can provide insights into the biological basis of aggression in all

animals, including humans, the researchers said.

"This is one of the first investigations to utilize large datasets consisting of thousands of different genes to ask whether there are shared genes relating to similar forms of behavior across a very wide range of animals," said Amy Toth, assistant professor of ecology, evolution and organismal biology, Iowa State. "Specifically, we looked at aggressive behavior in wasps, bees, fruit flies and mice and found a few genes that are consistently associated with aggression. This suggests that even after hundreds of millions of years of evolution, some genes may retain their ancestral roles in similar forms of behavior, like aggression."

The team investigated the expression of aggression genes in the brains and ovaries of paper wasps—*Polistes metricus*. Specifically, they looked at wasps belonging to different castes including dominant colony-founding queens, subordinate colony-founding queens, established queens, dominant workers and subordinate workers. These individuals displayed widely different levels of reproductive dominance and, linked to that, aggressive behavior. The team then compared the wasp results to gene expression data already available in honey bees, fruit flies and mice.

"We found that in wasps, which are primitively social insects, aggression genes control the establishment of an individual's dominance over a group," said Christina Grozinger, professor of entomology and director of the Center for Pollinator Research, Penn State. "In contrast, in honey bees, which are advanced social insects, aggression genes control altruistic defensive behavior—for example, when guard bees sting a predator or even a beekeeper, and die in the process. In solitary species, like fruit flies and mice, the same set of aggression genes controls fighting between males over territory. So the same genes are involved in aggression across species, but are now being used in different ways by different organisms."

According to Grozinger, the results suggest that model organisms—such as bees and mice—can be used to study aggression in humans because they share some of the same genes that regulate aggression behaviors, even if those behaviors are now quite different.

In addition to learning that aggression genes are shared among organisms, the team also found that these genes are extremely sensitive to the external environment.

"We found that the most important influence on expression of genes in the brains of paper wasps was external factors, such as the season and how large the colony was at the time," Toth said. "This indicates the important role of external cues in shaping the molecular processes that regulate behavior."

The results, which appear today (Feb. 10) in *BMC Genomics*, provide new insight into the debate between nature and nurture, according to Grozinger.

"Everyone agrees that both nature—including genes and physiology—and nurture—including diet, environment and social interactions—contribute to the likelihood that an individual will behave in a certain way or develop a disease," Grozinger said. "But our results show that the external environment plays a much greater role in regulating expression of genes in the brain, which ultimately regulates behavior, than physiology. This is very surprising."

The scientists plan to use their findings to conduct experiments in which they will manipulate the expression of single genes to see how they affect behavior.

"One thing we would like to investigate is what will happen if we ramp up expression of one of the genes involved in aggression," Toth said.

"Can we create hyper-aggressive wasps? This type of question allows us to go beyond correlation between the gene and the behavior and address causation. Does the gene of interest actually cause aggressive behavior?"

Grozinger added, "If there are hyper-aggressive wasps, what effect does that have on wasp society?"

Provided by Pennsylvania State University

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