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In Dueling Ants Vying to Become Replacement Queen, Behavioral and Molecular Cues Quickly Determine Who Will Win

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"Pseudoqueens" rapidly emerge after social structure is disrupted by the loss of queen

In Indian jumping ants, workers duel with their antennae to establish new leadership after the death of their queen. Photo credit: Giacomo Mancini, NYU

In one species of ants, workers duel to establish new leadership after the death of their queen. While these sparring matches stretch for more than a month, changes in behavior and gene expression in the first three days of dueling can accurately predict who will triumph, according to a New York University study published in the journal *Genes & Development*.

"Despite prolonged social upheaval in ant colonies following the loss of the queen, the winners of these dueling tournaments are rapidly determined," said Claude Desplan, Silver Professor of Biology at NYU. "Our findings may provide clues on adaptability in reproduction and aging, given that the workers who win the duel, or 'pseudoqueens,' gain the ability to lay eggs and live much longer than the average worker ant. This suggests that changes in the environment are able to dramatically affect the structure of a society."

The caste system in social insects creates a division of labor, with insects specialized to perform particular tasks. The queen is responsible for reproduction, while workers maintain the colony—caring for the young, foraging and hunting for food, cleaning, and defending the nest.

In many insect societies, when the queen dies, the entire colony dies along with her due to the lack of reproduction. However, in Indian jumping ants (*Harpegnathos saltator*), "caste switching" occurs after the queen's death. While the queen is alive, she secretes pheromones that prevent female worker ants from laying eggs, but when she dies, the workers sense the lack of pheromones and begin fighting each other to take on the top role.

The ants engage in dueling tournaments, striking each other with their antennae in matches that can last more than a month. While most ants quickly return to their usual work during the tournament, the winners become pseudoqueens—also known as gamergates—and acquire new behaviors and roles. Through this transition, their life expectancy dramatically increases (from seven months to four years) and they begin laying eggs, allowing the colony to survive.

In their study in *Genes & Development*, NYU researchers explored changes in the Indian jumping ants' social behavior and accompanying changes in gene expression during the early stages of the worker-to-pseudoqueen transition.

They found that, as early as after three days of dueling, the winners can be accurately predicted solely based on the dueling behavior. The workers who triumphed and became pseudoqueens had much higher levels of dueling—sparring roughly twice as much in the first five days—while the others who remained workers dueled less and went back to performing other tasks such as cleaning and hunting.

"Despite the fact that dueling tournaments last for several weeks, we were able to anticipate which ants would become pseudoqueens in only three days," said Comzit Opachaloemphan, a doctoral student in the Department of Biochemistry and Molecular Pharmacology at NYU Grossman School of Medicine and one of the study's lead authors.

Comparing biological samples and gene expression from dueling versus non-dueling ants, the researchers then determined the changes associated with the worker-to-pseudoqueen transition. Molecular analyses revealed that the brain may be driving the dueling and early caste determination in the ants, with other tissues taking cues from the brain.

The researchers found that the first genes to respond to the loss of the queen were in the brain, suggesting that the lack of queen pheromones perceived by the olfactory system affects brain neurohormonal factors. These changes in the brain then lead to altered social behavior and hormone-mediated physiological changes in other parts of the body, including the ovaries.

"Both behavioral and molecular data—especially changes in gene expression in the brain—show us that new pseudoqueens are quickly determined after a colony's social structure has been disrupted by the loss of the queen," said study author Danny Reinberg, the Terry and Mel Karmazin Professor in the Department of Biochemistry and Molecular Pharmacology at NYU Grossman School of Medicine, as well as an investigator for the Howard Hughes Medical Institute.

Additional study authors include co-first authors Giacomo Mancini and Nikos Konstantinides, as well as Apurva Parikh, Jakub Mlejnek, and Hua Yan. The research was supported by a Howard Hughes Medical Institute Collaborative Innovation Award (#2009005), the National Institutes of Health (R21-GM114457, R01-EY13010, R01-AG058762, and F32AG044971), EMBO (365-2014), and the Human Frontier Science Program (LT000122/2015-L).

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