Ants as a model of complex societies

August 5 2015, by Katherine Unger Baillie

Researchers track individual ants, sometimes marked with paint pens, to understand the evolution of complex societies.

In small plastic tubs lining the shelves of a basement laboratory at the University of Pennsylvania, a million organisms live in complex societies.

The societies have distinct castes, fine-tuned strategies to avoid disease outbreaks and dedicated workers that procure food and rear young, features that have arisen over 100 million years of evolution.

Timothy Linksvayer, an assistant professor of biology in Penn's School of Arts & Sciences, is the person responsible for these lives. Fortunately, these creatures need little more than water and mealworms to survive. Each is just larger than a pinhead.

With a new award from the National Science Foundation, Linksvayer is expanding his research into how genetics and behavior allow complex societies, like those of his lab's pharaoh ants, to survive and thrive. What he finds may shed light on the mechanisms that other organisms, humans included, have evolved to live in large, orderly social groups.

"Humans are highly social, but we've only been living in large groups for thousands of years," Linksvayer says. "Ants have been highly social for over a hundred million years. That's what makes ants such an interesting model system."

Ants have been a source of fascination for Linksvayer since childhood.

"As a kid I just liked following them around," he says.

That childhood interest cemented itself during his undergraduate years, when he traveled to Costa Rica to study leaf-cutter ants, and it solidified through graduate and postdoctoral research that focused on how ants' social interactions influenced their evolution.

"What's attracted me generally to ants is the fact that it's not just one solitary insect, it's a bunch of insects that are behaving as if they are functioning as a whole organism," he says. "When you watch them there is a sense that they are doing things together."

At Penn, Linksvayer's lab studies not only pharaoh ants but also acorn ants and honey bees, all highly social species. Linksvayer's newly awarded NSF Faculty Early Career Development Award, which comes with more than $800,000 of funding during five years, will support his pharaoh ant research.

Outside the lab, these ants are considered an invasive pest. Inside, however, the species is well suited for research. While most ant species mate in the air, which can't be replicated in the lab, pharaoh ants don't; a fertile male and female will mate if placed in the same container. And where other ant species can have long generation times, with some queens living as long as 30 years, pharaoh ant queens live just 9 months and workers have lifespans of about 6 weeks, allowing researchers to breed new generations rapidly. In addition, pharaoh ant workers are sterile.

"We know exactly who is reproducing, which means that we can control breeding really easily," Linksvayer says.

Taking advantage of these unique characteristics, Linksvayer is developing and implementing novel approaches to study the genetic basis and evolution of ant traits and social behavior using his lab's 500 pharaoh ant colonies, each comprised of 2,000 individuals on average.

His studies are propelled by the concept that, in social systems like ant colonies, an individual's traits and fate are influenced not only by its own DNA but also by the DNA, traits and behavior of many other members of the colony. For example, an individual's body size and whether it becomes a queen or a worker are influenced by how it is fed as a larva by worker ants known as nurses.

"In the past researchers have tried to tease apart the relative importance of genes versus the environment, or 'nature versus nurture,' for trait variation," Linksvayer says. "We're studying how important an individual's own genes are versus the genes of their social partners."

Linksvayer and his lab members have been using sophisticated techniques, such as RNA sequencing analyses, to measure which genes are being expressed and at what level and how gene expression varies from individual to individual.

Such techniques allow the scientists to learn how gene expression differs between, for example, an individual who will become a queens versus one destined to be a worker. They will also look at how gene expression varies in the workers caring for larvae with different fates.

Behavioral observations and experiments go hand-in-hand with the genetic analyses. Students in Linksvayer's lab track individual ants by labeling them with fine-tipped paint pens and filming or observing them over time, a potentially tedious but revealing task.

As data pour in from the ant research, Linksvayer will leverage it to increase scientific literacy beyond his own lab. Part of his NSF award will go toward creating curricula and training opportunities for budding scientists from the high school level to undergraduates at Penn and all the way to postdoctoral researchers.

In one effort, the Early Access to Graduate Research program, a partnership between Penn, Philadelphia's Franklin Institute and the Science Leadership Academy, Linksvayer and his graduate students are developing teaching modules for SLA high school students. One lesson focuses on ant behavior, and Linksvayer is also creating a lesson plan on the links between behavior and genetics. Graduate students will teach the courses to SLA students.

"In the longer term we'd like to expand to other parts of the Philadelphia school system and also online to really broadcast these modules to teach cutting-edge research," Linksvayer says.

For graduate students and postdocs, Linksvayer and other researchers will lead workshops that allow trainees hands-on practice in techniques such as analyzing gene expression. The workshops will rely on data collected in working laboratories, including Linksvayer's own.

Beyond an intrinsic fascination with the complex and interdependent nature of ant societies, Linksvayer's interest in ants extends to what they may reveal about humans.

"There are social strategies that ants use to avoid disease transmission and ways they approach collective decision making that could be relevant to human societies," he says. "By developing this ant study system where we can mate them across generations and study their genetics, we can learn about some things that may affect human societies but can't be studied in humans."

Provided by University of Pennsylvania

Citation: Ants as a model of complex societies (2015, August 5) retrieved 27 April 2024 from https://phys.org/news/2015-08-ants-complex-societies.html