Extreme temperature tolerance of army ants could inform how animal populations will respond to changing climates

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The Neotropical army ant Eciton burchellii provides a compelling test case for colony differences in thermal physiology. Credit: Sean O'Donnell

Drexel University researchers sampled a variety of army ant (Eciton burchellii parvispinum) colonies to test how their habitat distribution affected the ants' tolerances of extreme low and high temperatures.

What they found was colonies' thermal tolerances differed by elevation zone—but outstandingly—significant colony differences in thermal tolerance existed within similar zones, leading the team to believe that local adaption to temperatures is not the only factor contributing to differences in thermal physiology.

"Investigating how animals are able to tolerate extreme high and low temperatures can shed light on how climate change may affect animal behavior and ecology," said Sean O'Donnell, Ph.D., biologist and professor in Drexel's College of Arts and Sciences. "The ants used in this study are uniquely exposed to the temperature conditions of their habitat because they are out in ambient conditions all the time while foraging—whereas other ants conduct a large part of their activities underground which buffers them from the temperature."

The team sampled colonies in northwestern Costa Rica, across a wide elevation range—accounting for body size and geography.

"We compared mean colony thermal tolerances between the low and high elevation zones to assess whether colony performance physiology was associated with local thermal climates, and we tested whether significant colony differences were evident after accounting for body size and elevation, said Kaitlin Baudier, a co-author on the study and assistant professor at the University of Southern Mississippi.

O'Donnell and Baudier a former Drexel Ph.D. student found three important patterns within their data, recently published in *Ecological Entomology*:

1. Colonies differed significantly in their thermal tolerances. Both the minimum and maximum temperatures workers could tolerate differed among colonies. This means that animal social groups are likely to be affected differently by changing climates.

2. Local adaptation to temperature conditions is one piece of the puzzle. Colonies from cooler high-elevation sites were more sensitive to high temperatures and more tolerant of low temperatures.
3. Within colonies, low and high temperature tolerances were not correlated. This addresses an important open question in thermal biology research: it suggests the mechanisms that affect abilities to tolerate extremely hot conditions are distinct from the ability to tolerate extreme cold.

"This work expands our understanding of how thermal performance varies across levels of biological organization, from individual ants to entire colonies," said Baudier.

The team notes, that in addition to the physiological characteristics that make the ants a good model to study, the colonies are ecologically important to the function of the forests they inhabit.

"The army ant colony is operating as a unit and is comparable to larger predatory animals like the jaguar or Harpy eagle—but instead of a singular animal, it's made up of hundreds of thousands of individuals that are really thermally sensitive," said O'Donnell. "Larger bodied predator animals will be able to regulate their body temperatures, and while climate changes aren't irrelevant to these animals—it's likely their response to thermal changes will be a lot more buffered."

The colonies' physiological and ecological importance could make them a good benchmark for identifying early effects of climate change.

The researchers hope that by learning about the army ant colony's ability to tolerate extreme high and low temperatures, they will be able to connect the data to the overall understanding of thermal environment variation and possible effects of climate change on animal behavior and ecology.

"We don't quite know yet why this is—what the causes for these colony differences are among groups within a testing site," said O Donnell. "While some of the difference is described by local adaptation to temperature conditions, we hypothesize that there is also a genetic basis for the differences among the neighboring colonies."

The group plans to continue its work by looking at the genetics of the colonies in hopes of better understanding why colonies differed in the ability to tolerate temperature extremes.

"If significant colony variation in thermal physiology is associated with genetic differences, thermal environments could drive evolutionary changes in thermal physiology," said O'Donnell.

More information: Sean O'Donnell et al, Significant colony differences in thermal tolerances and decoupling of high and low critical temperatures in the army ant Eciton burchellii parvispinum, *Ecological Entomology* (2023). DOI: 10.1111/een.13258

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