

Cat-born parasite *Toxoplasma* induces fatally bold behavior in hyena cubs

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A spotted hyena cub in Kenya's Masai Mara National Reserve. Credit: Zach Laubach

Best known for its presence in house cats and a tendency to infect and alter the behaviors of rodents and humans, the parasite *Toxoplasma*

gondii (*T. gondii*) is also associated with bold behavior among wild hyena cubs and risk of death during interactions with lions, finds new research from the University of Colorado Boulder.

The findings, published this week in *Nature Communications*, reinforce previous research that has found the parasite can prompt profound behavioral changes in its hosts, and potentially in the 2 billion people worldwide estimated to be infected by it. While *T. gondii* has been well studied in laboratory settings with humans and wild-caught rodents, this is one of the first studies to examine how the parasite affects wild host [behavior](#) during interactions with wild cats.

The research uses a rich data set from more than three decades of continuous field research in the Maasai Mara National Reserve in Kenya. It reveals that hyena cubs, but not subadults or adults, infected by *T. gondii* behave more boldly in the presence of lions, and that infected cubs have a greater risk of being killed by lions.

"This project is one of a handful of long-term continuous studies on a long-lived mammal," said Zach Laubach, co-lead author on the study and postdoctoral fellow in ecology and evolutionary biology. "Our findings suggest that infection early in life leads to bolder behavior and is particularly costly for young hyenas."

Many strains of *T. gondii* are found throughout the world, infecting warm blooded animals—including humans who have house cats—during different life stages through contaminated soil, drinking water or eating meat of other infected animals. It can also be passed down from mother to baby.

The researchers found that in the hyena populations they studied, infections are widespread but more common in older animals, meaning that it's most likely that they become infected by consuming

contaminated meat or water.

For infected cubs—hyenas up to one year old—they found infected animals are bolder, approaching lions from closer distances than uninfected cubs, and that infection among cubs also corresponds to a higher probability of being killed by lions. In this study, lions were the responsible for all hyena cub deaths among infected animals, but only 17% of uninfected cubs died before the age of one due to [lion](#) attacks.

This is a vulnerable time in the life cycle of spotted hyenas, who despite being proficient hunters, take a long time to develop and rely on support and protection from their mothers, according to Laubach.

"Hyena moms invest a ton of both time and resources into their offspring. They nurse until they're about a year old and don't reach independence until they're about two or more years old," said Laubach. "But after they're one year old, we found no difference in how close they got to lions, regardless of infection status."

Some scientists theorize that this parasite manipulates its hosts' behavior (whether that host is a hyena or human) in order to get back to cats, where it can sexually reproduce. But the data from this study doesn't provide enough evidence to disentangle the theory supporting an adaptive mechanism for the parasite from other plausible alternative theories. It does, however, show that *T. gondii* has a direct and detrimental impact on hyena fitness.



Spotted hyenas in Kenya's Masai Mara National Reserve. Credit: Zach Laubach

Measuring the cost of confidence

Maasai Mara National Reserve is a biological hot spot in southwestern Kenya, between Lake Victoria and the bustling city of Nairobi. For more than 30 years now, the Mara Hyena Project, led by co-author Kay Holekamp, has been gathering data on the health and behavior of spotted hyenas in one of the best places in the world to study a diverse array of large, carnivorous mammals.

"It's really a one-of-a-kind system, especially for studying large carnivores in a natural setting, which is a rare opportunity," said

Laubach. "I can't think of another place in the world where you can see the same numbers and diversity of species of large mammalian carnivores; it's pretty spectacular."

Laubach notes there are many misconceptions about hyenas. They're quite social and live in large groups, some with more than 120 individuals. They're also formidable in size and strength, at up to 170 pounds when full grown (twice the size of a large dog), and they have one of the strongest jaws in the animal kingdom.

"They can eat bone, their bite can crack the femur of a giraffe," said Laubach.

Yet hyenas and lions compete with one another for territory and food, and these interactions with lions are the leading natural cause of hyena injuries and mortality.

Because previous research has shown that *T. gondii* can impact behavior in animals in laboratory settings, what the researchers wanted to know was: How does *T. gondii* affect wild hyenas' behaviors around lions, and what are the consequences?

Laubach and co-lead author Eben Gering analyzed archived data collected by numerous research assistants and graduate students. They gathered blood samples and documented the hyenas' interactions with each other and when they interacted with lions. From the safety of their vehicle, researchers Benson (Malit) Pioon and Holekamp of the Mara Hyena Project administered tranquilizers to 166 hyenas, in order to draw and test their blood for the parasite. They found 108, or 65%, had been previously exposed.

Over the years, researchers spent many hours each morning and evening out in the field, recording hyena behaviors of individuals that can be

identified by their unique spot patterns on their coats. The data revealed that infection with the parasite *T. gondii* was related to boldness and greater risk of lion mortality among [hyena](#) cubs but not older animals. The lack of an effect in older animals could be because they've had time to learn, while cubs have less than one year of experience to compete with the influence of the parasite.

"One limitation of this work is that it was an observational study. But limitations are interesting, because it points to what one might do next," said Laubach. "We'd like to go back and tease apart how behaviors change in individuals by comparing how their behaviors differ before versus after infection."

More information: Eben Gering et al, *Toxoplasma gondii* infections are associated with costly boldness toward felids in a wild host, *Nature Communications* (2021). [DOI: 10.1038/s41467-021-24092-x](https://doi.org/10.1038/s41467-021-24092-x)

Provided by University of Colorado at Boulder

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