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Toxoplasmosis: morbid attraction to leopards in parasitized chimpanzees

Researchers from the Centre d'Écologie Fonctionnelle et Évolutive (CNRS/Université de Montpellier/Université Paul Valéry Montpellier 3/EPHE) have shown that chimpanzees infected with toxoplasmosis are attracted by the urine of their natural predators, leopards, but not by urine from other large felines. The study, published on 8 February 2016 in *Current Biology*, suggests that parasite manipulation by *Toxoplasma gondii* is specific to each host. It fuels an ongoing debate on the origin of behavioral modifications observed in humans infected with toxoplasmosis: they probably go back to a time when our ancestors were still preyed upon by large felines.

Parasites such as those that cause toxoplasmosis take various pathways, some of them complex, in order to develop into their adult form and reproduce in a so-called definitive host. These pathways may include stages consisting in the infection of an intermediary host. In order to pass from one such host to another, some parasites are able to induce behavioral changes in their hosts. However, this process, known as parasite manipulation, is rarely observed in mammals.

The agent of toxoplasmosis, *Toxoplasma gondii*, is an exception. This protozoan, which infects a wide range of species including humans, can only reproduce in felines, which become infected by ingesting a parasitized prey. Studies on mice have shown that this parasite induces olfactory modifications in parasitized rodents: unlike healthy individuals, parasitized mice appear to be attracted by the odor of cat urine, thus making it more likely for the parasite that its intermediate hosts, mice, are eaten by cats, a definitive feline host. In humans, other studies have shown changes in behavior in parasitized individuals, such as personality changes, prolonged reaction times and reduced long-term concentration. However, no beneficial effects for the parasite have been observed, since modern humans are no longer hunted by felines.

In order to understand the origin of such behavioral change in humans, the researchers performed behavioral tests based on olfactory cues on chimpanzees, humans' closest relatives, which are still preyed upon in their natural environment by a feline: the leopard. The tests showed that, whereas uninfected individuals avoided leopard urine, parasitized individuals lost this aversion. More surprisingly, this behavioral modification is not observed when parasitized chimpanzees are exposed to the urine of felines (lions and tigers) that are not their natural predators, thus suggesting that parasite manipulation induced by *Toxoplasma gondii* is highly specific.

These findings fuel an ongoing debate on the origin of behavioral and olfactory modifications observed in humans: rather than being simple secondary effects of toxoplasmosis, such modifications probably go



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back to a time when our ancestors were still preyed upon by large felines. In addition to chimpanzees, the researchers now hope to focus on a wider range of species undergoing different predation pressures, so as to shed light on the evolutionary history of *Toxoplasma gondii* and unravel the circumstances under which the parasite manipulates its hosts.

Bibliography

Morbid attraction to leopard urine in Toxoplasma-infected chimpanzees. Clémence Poirotte, Peter M. Kappeler, Barthelemy Ngoubangoye, Stéphanie Bourgeois, Maick Moussodji, Marie J.E. Charpentier. *Current biology*, 8 February 2016.

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