

INSIDE JEB

DEET insect repellent at risk: mosquitoes can learn it means dinner



A yellow fever mosquito (*Aedes aegypti*) biting a human. Photo credit: US Department of Agriculture. Public domain, via Wikimedia Commons.

Insects are essential components of the food chain, but humans have an uneasy relationship with some. They eat crops, carry disease and no one likes being bitten by them. But in the 1940s, the United States Department of Agriculture (USDA) seemed to solve the biting problem, when they developed DEET, an insect repellent that is yet to be surpassed. Yet there may be a chink in the quintessential repellent's armour. 'If mosquitoes are repeatedly exposed to DEET, it becomes less effective as a repellent', says Claudio Lazzari, from University of Tours, France, raising concerns that in some situations the repellent may even begin to attract some biting insects. In a bizarre twist of Pavlov's famous experiment, where dogs learned to associate the arrival of food with a ringing bell, could yellow fever mosquitoes (*Aedes aegypti*) learn to love the scent of DEET instead of fearing it?

'*Aedes aegypti* is largely distributed across the world, transmitting diseases to humans and animals', says Lazzari,

who first had to find a way of knowing when the voracious insects were attracted to something tasty. Yellow fever mosquitoes like nothing more than a meal of warm blood, so David De Luca (University of Tours) restrained the insects behind a fabric mesh before offering them a bag of warm blood placed just out of reach, to see how enthusiastically the insects stabbed at it with their proboscises in the hope of grabbing a bite. Sure enough, the insects were keen, especially when De Luca rewarded them by lowering the bag within reach, so they could feast. However, when the team offered the insects a blood meal when surrounded by the scent of DEET, the mosquitoes steered clear.

But could the insects learn to associate the scent of DEET with the offer of dinner? The team fed the insects with warm blood for 20 s, squirting the scent of DEET into the enclosure during the final 10 s of dining, repeating the procedure three more times before checking how the insect responded to the scent of DEET alone.

This time, the mosquitoes went almost wild, with more than 60% trying to take a bite when they smelled a whiff of DEET. And when the team offered the trained insects the choice between Ayelén Nally's (University of Buenos Aires, Argentina) hands, one of which was bathed in DEET while the other was clean, the insects tried to bite Nally's DEET-scented hand. Finally, Charly Dufour (University of Tours) tried an alternative strategy, attempting to train the mosquitoes to associate a sugary treat with the scent of the repellent, and the mosquitoes got the idea, biting enthusiastically whenever they picked up the scent of DEET.

So, mosquitoes can learn to associate the scent of DEET with the prospect of dinner, which could make people wearing DEET more attractive to biting insects under the right circumstances. 'If a mosquito bites someone who applied DEET to their skin several hours earlier and the concentration of the repellent is too low to repel the mosquito, but still strong enough for the insect to smell it, the mosquito may be more likely to bite people who smell of DEET', says Lazzari.

The mosquitoes' ability to learn to associate the repellent with food could also tell the researchers something about how the repellent works. 'It is the information that DEET conveys to insects that may cause them to decide not to bite', says Lazzari, explaining that the repellent probably mimics some natural plant insect repellents, which keep insects at bay. So, DEET is still the gold standard for insect repellents, protecting people from mosquito-borne diseases. 'It saves lives!', Lazzari exclaims.

Lazzari, C. R., De Luca, D., Nally, A., Dufour, C. and Vinauger, C. (2026). Associative learning switches DEET valence from aversive to appetitive in *Aedes aegypti*. *J. Exp. Biol.* **229**, jeb251935. doi:10.1242/jeb.251935

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