Multiple sensory cues draw mosquitoes to hosts

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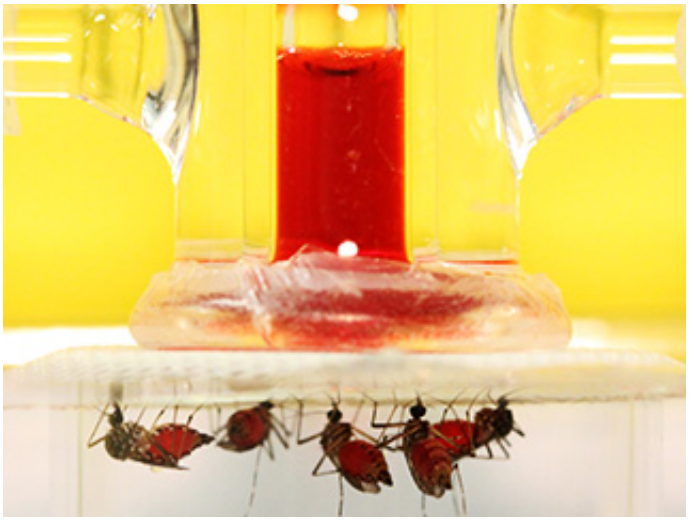

Female Aedes aegypti mosquitoes, which spread yellow fever, feed on warm blood in the presence of carbon dioxide. Mutant mosquitoes engineered to be unable to detect carbon dioxide were not as attracted to the blood feeder, suggesting that mosquitoes use a combination of sensory cues — CO2, heat and odor — to detect a host. Credit: Conor McMeniman

It may seem like mosquitoes will bite anything with a pulse, but they're actually quite strategic in picking their victims. A new study from The Rockefeller University looked at the interaction of different sensory cues—carbon dioxide, heat and odor—that attract mosquitoes to humans, and found that it takes a combination of at least two of these to send the bugs biting.

While scientists have known that CO2 drives mosquitoes to humans, researchers from Leslie Vosshall's Laboratory of Neurogenetics and Behavior wanted to flesh out the details of how this worked. So they used a genome editing technique to engineer a mutant version of the Aedes aegypti mosquito, which spreads yellow fever. The mutant was missing a specific gene, known as Gr3, which codes for a carbon dioxide receptor. Without Gr3, the mosquitoes were unable to detect the gas.

Led by postdoc Conor McMeniman, the researchers first looked at the mutant mosquitoes' behavior inside a chamber that held a plate heated to the temperature of human skin. Normal mosquitoes weren't attracted to the warmth unless carbon dioxide was also emanating from it, and mutants weren't drawn to the plate at all. The team found a similar interaction between lactic acid—a compound in human breath and skin odor—and CO2: attraction to the odor was dependent on the presence of carbon dioxide.

"Relying on multiple sensory cues helps organisms make informed decisions about context-dependent behaviors," says McMeniman. "In the case of a female mosquito, this would allow her to accurately hone in on a human host to blood feed."

When the scientists tested the ability of these CO2-blind mutants to find humans in a real-world set-up, the difference between mutants and normal mosquitoes was less significant. The insects were examined in a humid, greenhouse-type enclosure in Australia, where human volunteers sat and captured the insects as they landed on them. McMeniman devised a way to make the mutant mosquitoes glow in the dark, and counted them afterward. The mosquitoes without CO2-sensing abilities were only impaired by 15 percent. The mutants were clued in by other factors—the combination of heat and odor coming off the human subjects. However, when a similar concept was tested on a larger scale, with a mouse as the subject, the mutants were much less likely to bite,

meaning that without carbon dioxide as a cue, the effect of odor and heat are diminished as the insect moves farther away from the host.

For mosquitoes, access to blood is crucial. It is only the female mosquitoes that bite, and the blood they collect is necessary to produce fertile eggs.

"Because blood feeding is such an important behavior for the mosquito, evolution has built in these mechanisms that ensure the most efficient use of the insect's energy," says McMeniman. "There are a lot of things that give off heat, and it would be a waste for a mosquito to try to bite all of them. But with several factors present, the insect can increase her chances of a fruitful bite in a cluttered sensory environment."

Understanding the genetic basis of mosquito attraction to humans can help inform the design of chemical repellents to block host-seeking behavior in both Aedes aegypti and Anopheles gambiae, which spreads malaria.

"There is some research being done into repellents that target a single sensory modality, such as preventing the mosquito from perceiving odor, but we've shown that this would not be sufficient," says McMeniman. "Manipulating mosquito sensory perception from several angles would be a better strategy toward to deterring them from finding and infecting humans."

More information: "Multimodal Integration of Carbon Dioxide and Other Sensory Cues Drives Mosquito Attraction to Humans." Conor J. McMeniman, Román A. Corfas, Benjamin J. Matthews, Scott A. Ritchie and Leslie B. Vosshall. *Cell* 156: 1060-1071 (February 27,2014) DOI: 10.1016/j.cell.2013.12.044

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