

Mosquitoes don't let the rain get them down

High-speed video reveals how flying pests remain airborne when raindrops strike.

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Less is more, the saying goes. But for a mosquito in flight dodging a barrage of raindrops up to fifty times its own body weight, less is best. According to a study published today in the *Proceedings of the National Academy of Sciences*¹ a mosquito's key defence when struck by a plummeting drop is its tiny mass. Researchers say the findings could one day help to improve the durability of 'micro-airborne vehicles', insect-sized flying robots developed for applications such as surveillance or rescue operations.

The match-up between a mosquito and a raindrop is decidedly uneven. Mosquitoes are typically 3 millimetres long, and they weigh about 2 milligrams. At 2–8 millimetres in diameter, raindrops are similar in size to mosquitoes, but they can weigh up to 100 milligrams and plunge through the air at speeds of up to 9 metres per second. So to avoid a knockout punch, mosquitoes have evolved a zen-like ability to become one with the drop.

"It's like getting into a boxing match with a balloon, it just goes with the punch. Mosquitoes just move along with raindrops," says team leader David Hu, who studies biocomotion at the Georgia Institute of Technology in Atlanta. "It's their [low] mass that makes this possible."



The trait is useful for insects that thrive in hot, humid climates where rainfall is common. Hu estimates that during a typical shower a mosquito is hit by a raindrop about once every 20 seconds. But he and his co-authors wondered what happens to the mosquito during such an encounter.

To simulate rainfall in the lab, Hu and his team built a soaked-mesh-covered box with a pump that could deliver drops of water 3–5 millimetres in diameter travelling up to 2 metres per second. With the help of high-speed videography, they computed the forces and accelerations involved when a mosquito was hit by a drop, and catalogued the placement of each impact. Switching to a water jet allowed them to increase the drop velocity to 9 metres per second to better simulate the force of drops in a steady downpour.

In general, raindrops were more likely to hit a bug's legs than its abdomen, causing it to roll sideways and quickly recover. But even getting hit dead centre was not a problem. "The mosquito combines with the drop and makes this drop-cum-mosquito package that falls down together for up to 20 body lengths," says Hu. The mosquitoes then separate from the drop and go buzzing about their business — although precisely how they manage this separation remains unclear.

"We think that their long wings and legs might be important here," says Hu.

Hu adds that this strategy is effective only while the mosquito is airborne. A drop of the same size and speed would easily crush a mosquito standing on solid ground.

The accelerations that mosquitoes tolerate upon impact is "pretty incredible," says Andrew Dickerson, a graduate student in Hu's lab and study co-author. "A drop hits them with 100-plus gs of acceleration, which is more than we could survive."

Robert Dudley, a biologist who studies animal flight at the University of California, Berkeley, says that the team's results raise more questions about the way mosquitoes interact with precipitation. "There's no real study out there on when and why insects stop flying in rain, or how they compensate," he says, adding that the next step would be to link the laboratory experiments to mosquito performance in a natural setting.

The team is already expanding its investigations to consider a broader range of conditions, from fog to deluge, which they say could prove useful in implementing mosquito controls for disease or for designing miniature robots that can mimic mosquitoes in flight. "There are a lot of complex conditions that mosquitoes have to fly through that haven't really been looked at before," says Hu. "Everyone knows that they have to be robust, but no one really knows how."

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References

1. Dickerson, A. K., Shankles, P. G., Madhavan, N. M. & Hu, D. L. *Proc. Natl Acad. Sci.* <http://www.pnas.org/cgi/doi/10.1073/pnas.1205446109> (2012).