Harpoon heads, sweeping tails: How predatory mosquito larvae capture prey

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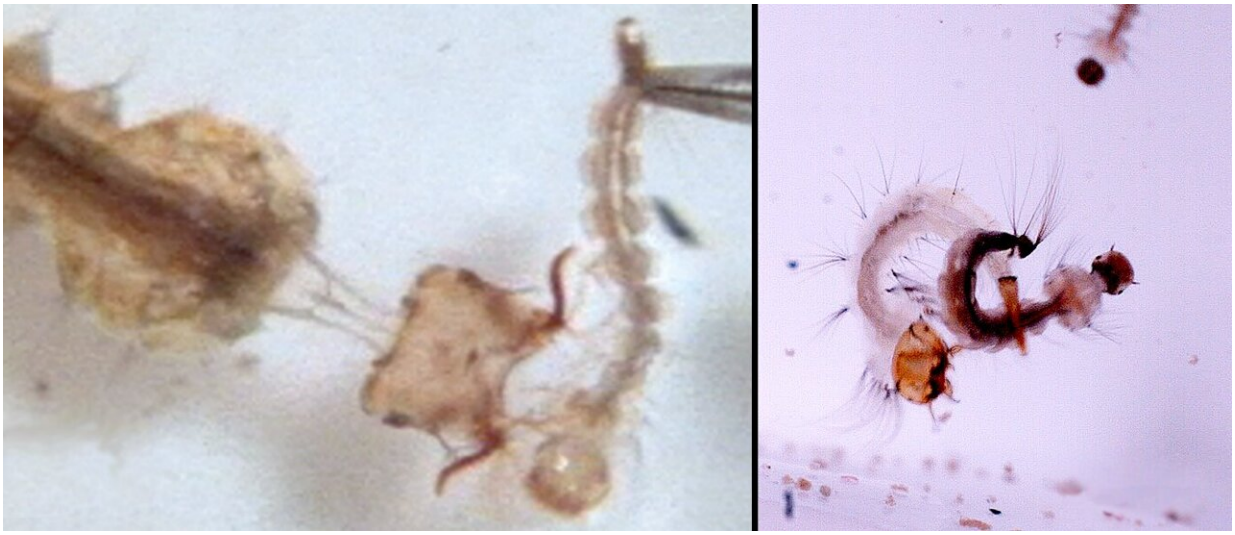

In this side-by-side image, at left, a Psorophora ciliata larva strikes a prey larva, exhibiting a unique, sudden neck extension to launch its head away from its body and toward the prey. At right, a Sabethes cyaneus larva attacks a prey larva by using its tail to sweep the prey toward its head. Credit: *Annals of the Entomological Society of America* (2022). DOI: 10.1093/aesa/saac017

With striking high-speed video footage, scientists have for the first time detailed how predatory mosquito larvae attack and capture prey in aquatic habitats. Published today in the *Annals of the Entomological Society of America*, this new research sheds light on behavior that has long proven too small and too fast to study, until now.

Before taking flight, mosquitoes spend their youth in water, anywhere from flood plains to flowerpots. While most mosquito larvae eat algae, bacteria, and other microorganisms, some are predators that feed on other aquatic insects—including other mosquito larvae.

These predatory species have been a source of fascination for Robert G. Hancock, Ph.D., professor of biology at Metropolitan State University of Denver, for much of his career, he says. He first observed their strikes under a microscope in a medical entomology class as an undergraduate.

"It was so incredibly fast," he says. "The only thing that we saw was a blur of action."

But in the years since, advances in video and microscope technology have enabled Hancock and his students to slow that action down and gain a view into a world that no one had ever seen before.

Hancock's report in *Annals of the Entomological Society of America* shares 10 videos of mosquito larvae strikes and analyzes the anatomical detail and sequence of motions involved.

Five of the videos show the similar method employed by two species, Toxorhynchites amboinensis and Psorophora ciliata, that are obligate predators—i.e., their diet requires eating other insect larvae—and whose biology and behavior are highly adapted for capturing prey. The other five videos feature Sabethes cyaneus, a species that both feeds on microorganisms and sometimes preys on other larvae (i.e., a facultative predator) and which has evolved a significantly different predation technique.

In both Toxorhynchites and Psorophora species,the larva strikes prey with a sudden neck extension to launch its head away from its body and toward the prey. Simultaneously, its mandibles and several whisker-like

brushes spread open and then snap closed on the prey upon impact. The unique, harpoon-like head-propulsion action appears to be generated by the larva first building pressure within its abdominal segments and then rapidly releasing it, the researchers say.

Hancock recalls his amazement when his team first successfully captured the strike on film. "I saw it first and my jaw dropped, and it still does every time I watch it," he says.

Sabethes mosquito larvae lack the head-extension mechanism. Instead, a Sabethes larva snares prey by using its tail to sweep the prey toward its head.

Meanwhile, the larva opens its mandibles and maxillae (pincer-like mouthparts) and clamps onto the prey as it is brought in. Use of the tail—called a "siphon" because it serves as a breathing tube for mosquito larvae as they hang upside down at the water's surface—was also a surprise, Hancock says.

Both strike styles, in all three species in the study, take about 15 milliseconds. That speed indicates a highly developed, almost reflexive behavior called a fixed-action pattern, Hancock says. He likened it to the action of a swallow, which involves multiple, small individual muscle actions. "All of this stuff has to work in concert—we all do it so automatically," he says. "And that's exactly what these mosquito larvae strikes have to be. It's a package deal."

Toxorhynchites and Psorophora mosquitoes are well known for their predator status. Toxorhynchites species, in particular, have been studied as a potential tool for control of mosquitoes that carry disease-causing germs, because a single Toxorhynchites larva might consume as many as 5,000 prey larvae before maturing into adulthood. As a result of that larval diet, adult Toxorhynchites and Psorophora species are among the

largest mosquitoes in the world. Sabethes cyaneus, meanwhile, are less formidable predators, but they grow into adults featuring iridescent blue coloration and broad, feather-like paddles on their legs.

The footage of Toxorhynchites and Psorophora strikes were first captured on 16-millimeter film with a microscope and camera setup designed—through much trial, error, and wasted film, Hancock says—during his time at the University of the Cumberlands in the 1990s. He returned to the effort in 2020 with students at MSU Denver, this time with a digital high-speed camera in a similar setup, to film Sabethes strikes.

The lights needed to illuminate the mosquito larvae under the microscope are so hot and bright that they require heat-protective filters "to not just cook" the larvae, and "the darkest sunglasses I could buy" to protect the researchers' eyes, Hancock says. Nonetheless, the new digital camera technology enables much easier and more advanced research on mosquito larvae.

While the high-speed film camera captured footage at up to 600 frames per second, the new digital camera can surpass 4,000 frames per second. And a 32-gigabyte SD card can store, by Hancock's estimate, the equivalent of about $12,000 worth of film and development.

Hancock has studied mosquitoes for most of his career, and he uses them regularly as model organisms for research conducted by the students he teaches. He says this new knowledge of how predatory mosquito larvae capture prey can be a tool for "continuing to unveil mysteries of nature around us, especially in anything that's aquatic," and that the videos might open people's eyes to the ecosystems living in even the smallest pools of water.

"Small containers of water that don't move are primarily the domain of

mosquitoes," he says.

More information: Robert G Hancock et al, Mosquitoes Eating Mosquitoes: How Toxorhynchites amboinensis, Psorophora ciliata, and Sabethes cyaneus (Diptera: Culicidae) Capture Prey, *Annals of the Entomological Society of America* (2022). DOI: 10.1093/aesa/saac017

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