Leaping larvae! How do they do that without legs?

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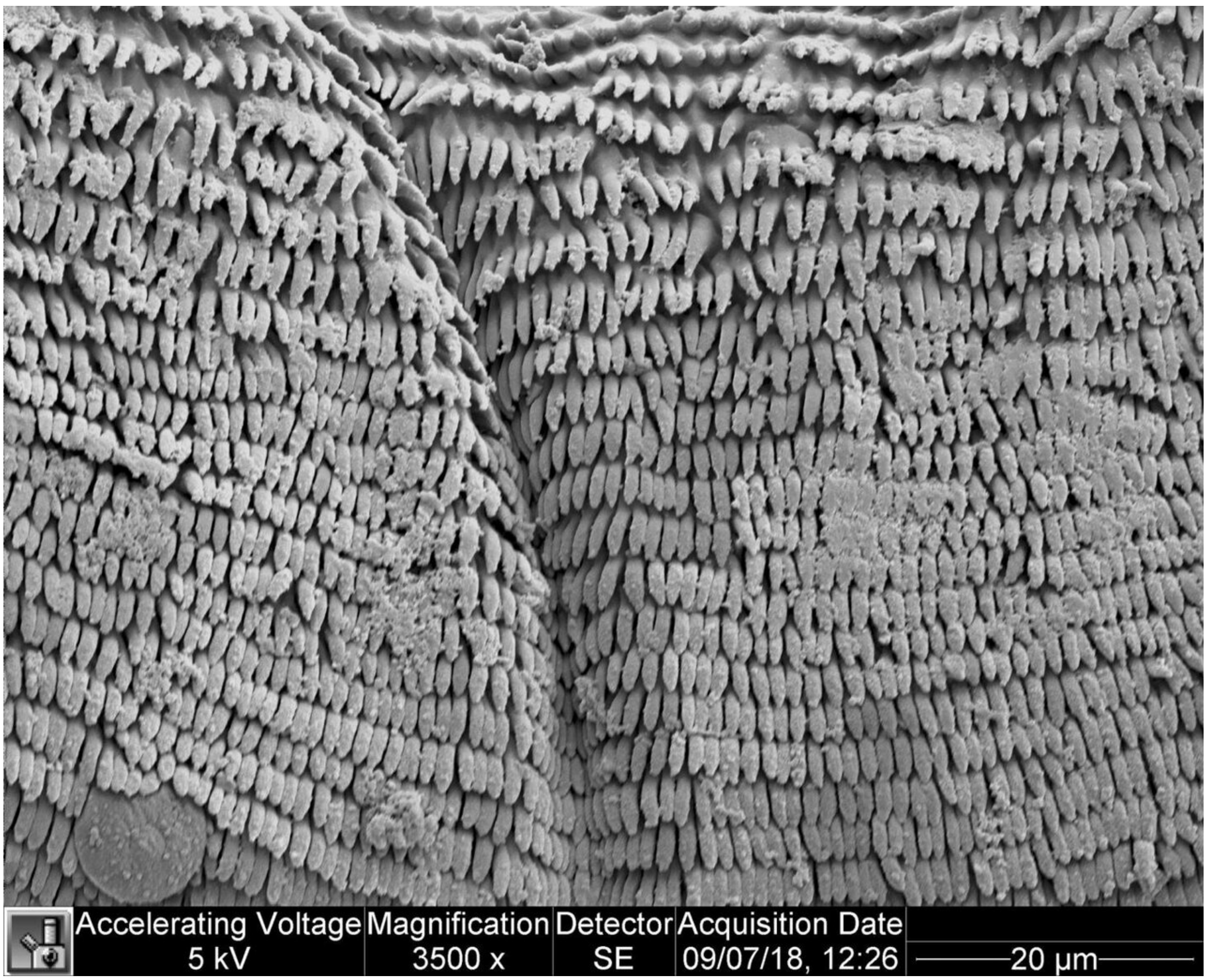


A scanning electron microscope image shows the 1-micron projections on the adhesive patches of a leaping gall midge larva. Researchers aren't sure yet what makes them so sticky. Credit: Grace Farley, Duke University

Attaching its head to its tail to form a ring, a 3-millimeter larva of the goldenrod gall midge squeezes some internal fluids into its tail section, swelling it and raising the pressure like an inner tube.

When the adhesive bond between the head and tail can no longer hold, the tension is sprung, launching the worm into a high, tumbling flight that will carry it 20 to 30 body-lengths away in a tenth of a second at speeds comparable to a jumping insect with actual legs.The direction of flight is somewhat random and the worm-like larva bounces a bit on landing, but it's apparently none the worse for wear. Still, as locomotion choices go, it seems a little reckless.

But this "hydrostatic legless jumping," as it's known by a team of Duke researchers who studied the launches with ultra-high-speed cameras, is about 28 times more energy efficient (and a heck of a lot faster) than crawling like a regular old caterpillar.

Their analysis of the remarkable leaping larvae appears Aug. 8 in the *Journal of Experimental Biology*.

What's new isn't the realization that legless larvae can leap. The behavior has been identified many times in the literature for more than 50 years, said Duke professor of biology Sheila Patek, whose lab led the analysis. The wonder here is in the details, which were captured with a 20,000-frames-per-second video camera and scanning electron microscopes.

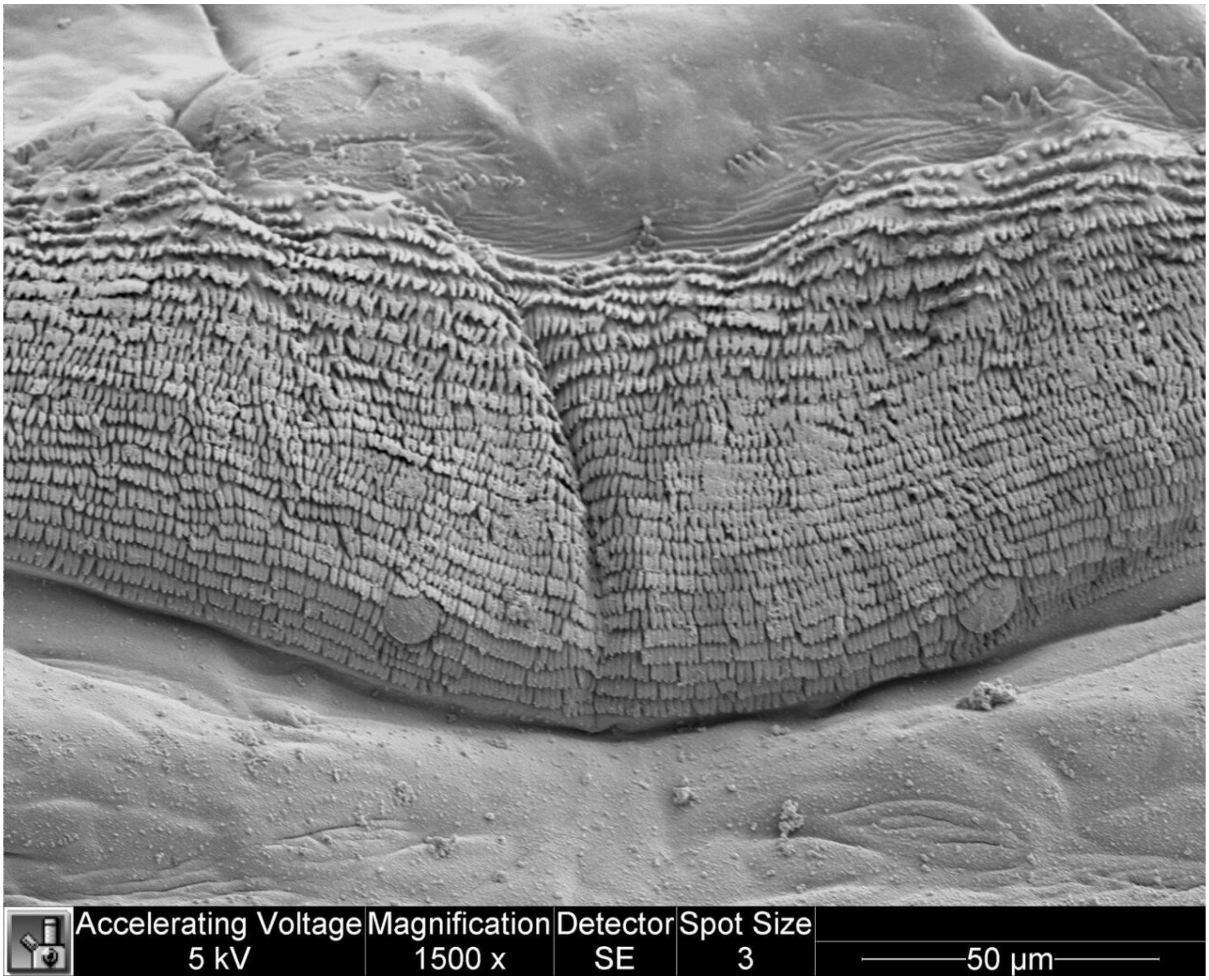
"Sometimes they fall over and don't go very far," said Patek lab manager Grace Farley, who spent countless hours trying to keep the restless worms in focus and in the frame before they launched. Almost every chaotic flight travelled far enough to leave the camera's field of view.

What Farley learned from all those jumps is that there is a hinge in the worm's body about a third of the way from the tail that makes that lower portion what they call a "transient leg" to deliver the thrust to the surface.

While other ring-forming worms seem to use stiff appendages called pegs and mouthparts to create a firm latch between head and tail, the gall midge larva just has some sticky patches of skin that do the trick.

On close examination under an electron microscope, the sticky bits turn out to be rows of little finger-like scales, just 1 micron across, that are quite similar to the sticky pads found on a gecko's feet.

Farley said it's not clear yet whether these scales interlock with each other somehow or whether they adhere merely from the van der Waals effect, the weak electromagnetic attraction between atoms put into close proximity, which is how the gecko walks on window panes.



A scanning electron microscope image shows the 1-micron projections on the adhesive patches of a leaping gall midge larva. Researchers aren't sure yet what makes them so sticky. Credit: Grace Farley, Duke University

The adhesive patches appear to be similar to the "head-arresting system" that helps damselflies and dragonflies lock their heads in place, Patek said. But it's also possible the gall-midge larvae secrete some sort of fluid on the pads. They don't know the details yet.

In a way, it's a wonder these animal mechanics researchers even found this worm. It is one of several dozen species of gall midges that feed within the tissues of a hundred different species of goldenrods. This bright orange worm, a member of the Asphondylia genus that hasn't even been formally named and described by science yet, is partial to the silverrod, Solidago bicolor, a white-flowered species of goldenrod.

"They're really small and inconspicuous, so not a lot of people study them," said Michael Wise, a Roanoke College biologist who is one of the people who does indeed study goldenrods and the midges that love them.

It was Wise, a former graduate school classmate of Patek at Duke, who somewhat inadvertently started the project.

Having carefully collected several specimens of goldenrod galls in the Virginia mountains two Augusts ago, Wise was cutting open the swollen portions of the plants under a microscope to extract the little orange worm within each capsule.

"After dissecting about a dozen galls, I looked in the petri dish and there were only two larvae in the dish," Wise said. "They were jumping all over the office!"

He knew Patek had this high speed camera for her science on jumping, snapping and punching creatures and suggested they ought to take a look.

"So, we just decided to film them for fun," Patek said. "Then we realized, this might actually be an interesting new field."

The latching mechanism formed by "adhesive microhairs" between each segment of the worm is apparently new, and the calculations about how much more efficient jumping is than crawling may be of interest to the field of soft robots, Patek said. This work also fits with her larger inquiries about the spectacular accelerations achieved by fleas, ants, mantis shrimp and other creatures that tend to use a spring and latch mechanism rather than muscle power to achieve amazing feats.

Closely related species of this gall midge worm are known to jump from their home plants to find places to burrow into the ground and pupate. But this particular worm never leaves the gall—it pupates right there and emerges as a fully formed flying midge. Why would it even need to leap?

Perhaps it's a leftover skill from some earlier evolution of the worm, Wise suggests. Or perhaps it's to avoid predators and curious biologists.

More information: G. M. Farley et al, Adhesive latching and legless leaping in small, worm-like insect larvae, *The Journal of Experimental Biology* (2019). [DOI: 10.1242/jeb.201129](DOI: 10.1242/jeb.201129)

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