Acrobatic geckos, highly maneuverable on land and in the air, can also race on water

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An Asian house gecko running on water by slapping the surface rapidly and using surface tension to keep its body above the surface. Credit: Pauline Jennings photo, PolyPEDAL Lab, UC Berkeley

Geckos are renowned for their acrobatic feats on land and in the air, but a new discovery that they can also run on water puts them in the superhero category, says a University of California, Berkeley, biologist.

"They can run up a wall at a meter per second, they can glide, they can right themselves in midair with a twist of their tail and rapidly invert under a leaf running at full speed. And now they can run at a meter per second over water. Nothing else can do that; geckos are superheroes," said Robert Full, a UC Berkeley professor of integrative biology.

Full is the senior author of a paper that will appear this week in the journal *Current Biology* describing four separate strategies that geckos use to skitter across the surface of water. First author Jasmine Nirody, a biophysicist at the University of Oxford and Rockefeller University, conducted much of the research with Judy Jinn, both as Ph.D. students at Berkeley.

According to Full, who discovered many of the unique maneuvers and strategies geckos employ, including how their toe hairs help them climb smooth vertical surfaces and hang from the ceiling, the findings could help improve the design of robots that run on water.

Nirody first became intrigued by geckos' water-running behavior after co-author Ardian Jusufi, now a biophysicist at Max Planck Institute for Intelligent Systems and another former UC Berkeley Ph.D. student, noticed that geckos in the forests of southeast Asia could skitter across puddles to escape predators.

In fact, they are able to run at nearly a meter, or three feet, per second over water and easily transition to speeding across solid ground or climbing up a vertical surface. Geckos sprinting on the water's surface exceed the absolute swimming speeds of many larger, aquatic specialists including ducks, minks, muskrats, marine iguanas and juvenile alligators, and are faster in relative speed than any recorded surface swimmer, other than whirligig beetles.

How, she wondered, do they do that?

Smaller animals like insects—spiders, beetles and water striders, for example—are light enough to be kept afloat by surface tension, which allows them to easily glide across the surface. Larger animals, such as swans during takeoff or the basilisk lizard, and even dolphins rising up on their tails, rapidly slap and stroke the water to keep above the waves.

"Bigger animals can't use surface tension, so they end up pushing and slapping the surface, which produces a force if you do it hard enough," Full said.

But the gecko is of intermediate size: at about 6 grams (one-fifth of an ounce, or the weight of a sheet of paper), they are too large to float above the surface, but too light to keep their bodies above water by slapping forces only.

"The gecko's size places them in an intermediate regime, a middle ground," Nirody said. "They can't generate enough force to run along the surface without sinking, so the fact they can race across water is really surprising."

In experiments with flat-tailed house geckos (Hemidactylus platyurus), common in south and southeast Asia, she discovered that they actually use at least two and perhaps four distinct strategies to run atop the water surface.

Surface tension is essential, she found, because when she applied a surfactant or soap to eliminate surface tension, the geckos were much less efficient: their speed dropped by half.

Even without surface tension, however, they can move using slapping, paddling movements with their four legs like larger animals. Leg slapping created air pockets that helped keep their bodies from being completely submerged, allowing them to trot across the water in much the same way they run on land.

But they also seem to use their smooth, water-repellent skin to plane across the surface, similar to hydroplaning but referred to as semi-planing, a technique used by muskrats.

Finally, they also use their tail to swish the water like an alligator, providing propulsion as well as lift and stabilization.

"All are important to some extent, and geckos are unique in combining all these," Full said.

"Even knowing the extensive list of locomotive capabilities that geckos have in their arsenal, we were still very surprised at the speed at which they could dart across the water's surface," Nirody said. "The way that they combine several modalities to perform this feat is really remarkable."

In the lab, she and her colleagues built a long water tank, placed the geckos on a plank and startled them by touching their tails. Using high-speed video, they were able to closely study the geckos' techniques and estimate the forces involved.

More information: *Current Biology*, Nirody & Jinn et al.: "Geckos Race Across the Water's Surface Using Multiple Mechanisms" www.cell.com/current-biology/f … 0960-9822(18)31469-6 , DOI: 10.1016/j.cub.2018.10.064

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