Humidity makes gecko feet stickier

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Close-up of the underside of a gecko's foot as it walks on a glass wall. Van der Waals force interactions between the finely divided setae (hairs on the toes) and the glass enables the gecko to stay in place and walk on the seemingly smooth glass. Image: Bjørn Christian Tørrissen, via Wikipedia.

Geckos have amazingly sticky feet. Their stickability comes from billions of dry microscopic hairs that coat the soles of their feet. However, when humidity increases, gecko feet stick even tighter to smooth surfaces, so how do they do it? Kellar Autumn and his colleagues have found that increased humidity softens the keratin that makes up the sticky foot-hairs, allowing them to deform and stick tighter to surfaces than hairs in dry conditions.

Human adhesives are famed for their fallibility. Gooey glues soon lose their grip, are easily contaminated and leave residues behind. But not gecko feet.

Geckos can cling on repeatedly to the smoothest surfaces thanks to the self-cleaning microscopic spatula-shaped hairs (setae) that coat the soles of their feet. Back in 2002, Kellar Autumn found that these dry hairs are in such intimate contact with surfaces that the reptiles 'glue' themselves on by van der Waals forces with no need for fluid adhesives. More recent studies had suggested that geckos might benefit from additional adhesion in humid environments through capillary action provided by microscopic droplets of water sandwiched between setae and the surface.

But Autumn wasn't so sure, so he and his lab at Lewis and Clark College and the University of Washington, USA, began testing gecko grip to find out how increasing humidity helps them hold tight Autumn publishes his team's discovery that humidity helps geckos grip tighter by softening the surface of their feet on 15 October 2010 in *The* Journal of Experimental Biology.

Knowing that geckos replace lost setae when they moult, Autumn, his postdoc Jonathan Puthoff, and Matt Wilkinson collected patches of the 'sticky' hairs from gecko feet and attached them to a mechanical testing device, known as 'Robotoe', that reproduces the way the reptile drags its foot as it contacts a surface. Dragging the setae across two surfaces (one that repelled water and another that attracted water) at different velocities and in environments ranging from 10% to 80% humidity, the team tested whether microscopic water bridges formed in high humidity were helping the geckos hang on.

They reasoned that if the reptiles were using microscopic water bridges then the setae would bond more tightly to the surface that attracted water than the surface that repelled water. But when they measured the setae's adhesion and friction it was essentially the same on the two surfaces. And when the team compared the adhesion of setae that were moving too fast to form water bridges with that of slowly moving feet that could possibly form water bridges, there was no difference. The geckos were not supplementing their van der Waals attachment forces with capillary forces from water bridges. So how were they holding on tighter?

Graduate student Michael Prowse decided to take a closer look at the material properties of the reptile's feet. Knowing that setae are composed of keratin and keratin is softened by high humidity, Autumn wondered whether having softer setae could improve the reptiles' contact with surfaces and increase their van der Waals adhesion. The team decided to measure the setae's softness and how it changed as the humidity rose.

Repeatedly stretching and releasing a strip of setae at three different rates (0.5, 5 and 10 Hz) in environments ranging from 10% to 80% humidity, Autumn's team measured the force transmitted through the strip to calculate the strip's elastic modulus – how much elastic energy is stored – to see how it changed. As the humidity rose, the elastic modulus decreased by 75% and the strip of setae became softer. So the strip of setae became more deformable as the humidity rose, but could the increased softness explain the gecko's improved attachment under damp conditions?

Puthoff built a mathematical model to see if softer, more deformable, setae could explain the gecko's improved attachment at high humidity and found that it did. Not only did increased softness strengthen the contact between the setae and the surface but also it made it easier for the reptile to peel its foot off. So instead of improving gecko's attachment through microscopic bridges, higher humidity softens the setae that coat the reptile's feet to help them hold fast and peel free with ease.

More information: Puthoff, J. B., Prowse, M. S., Wilkinson, M. and Autumn, K. (2010). Changes in materials properties explain the effects of humidity on gecko adhesion. *J. Exp. Biol.* 213, 3699-3704. jeb.biologists.org/

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