Geckos are sticky without effort

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Photo of a tokay gecko clinging to a smooth surface. Credit: William Stewart.

(Phys.org) —Geckos, found in places with warm climates, have fascinated people for hundreds of years. Scientists have been especially intrigued by these lizards, and have studied a variety of features such as the adhesive toe pads on the underside of gecko feet with which geckos attach to surfaces with remarkable strength.

One unanswered question that has captivated researchers is: Is the strength of this adhesion determined by the gecko or is it somehow intrinsic to the adhesive system? In other words, is this adhesion a result of the entire animal initiating it? Or is the adhesion fundamentally "passive," its strength resulting from the way just the toe pads work?

Biologists at the University of California, Riverside have now conducted experiments in the lab on live and dead geckos to determine the answer. Their experiments show, for the first time, that dead geckos can adhere with the exact same strength as living geckos.

Study results, appearing online Dec. 3 in *Biology Letters*, could have applications in the field of robotics.

"With regards to geckos, being sticky doesn't require effort," said Timothy E. Higham, an assistant professor of biology, who conducted the research alongside William J. Stewart, a postdoctoral researcher in his lab. "We found that dead geckos maintain the ability to adhere with the same force as living animals, eliminating the idea that strong adhesion requires active control. Death affects neither the motion nor the posture of clinging gecko feet. We found no difference in the adhesive force or the motion of clinging digits between our before- and after-death experiments."

Photo of a tokay gecko clinging to a vertical surface. Credit: Emily Kane

Higham explained that there have been suggestions in the literature for many years that gecko adhesion at the organismal, or whole-animal, level (where the intact animal initiates adhesion) requires an active component such as muscle activity to push the foot and toes onto the surface in order to enhance adhesion. This has, however, never been tested.

Higham and Stewart took on the challenge and tested the hypothesis. The researchers used a novel device involving a controlled pulling system. This device applies repeatable and steady-increasing pulling forces to the gecko foot in shear. Specifically, the device measures clings by pulling a gecko foot in a highly controlled manner along a vertical acrylic sheet while simultaneously recording shear adhesion with video cameras.

The experiments showed that the adhesive force or motion of a gecko

foot when pulled along a vertical surface was similarly high and variable when the gecko was alive and immediately – within 30 minutes – after death.

Geckos can climb a variety of surfaces, including smooth glass. Their sticky toes have inspired climbing devices such as Spider-Man gloves. The toe pads on the underside of gecko feet contain tiny hair-like structures called setae. The setae adhere to contacted surfaces through frictional forces as well as forces between molecules, called van der Waals forces. These tiny structures are so strong that the setae on a single foot can support 20 times the gecko's body weight.

Photo shows the underside of the gecko’s foot. Underneath the toes are “setae,”

millions of very fine hair-like structures, which provide increased surface area and close contact between the foot and the surface on which it rests. The setae are curved inward, toward the center of the foot. When the gecko pulls back a toe, the setae get straightened. Credit: Emily Kane

The controlled experiments the researchers performed are the first to show that dead animals maintain the ability to adhere with the same force as living animals. The results refute the notion that actions by a living gecko, such as muscle recruitment or neural activity, are required for gecko feet to generate forces.

"The idea that adhesion can be entirely passive could apply to many different kinds of adhesion," Higham said. "This is clearly a cost-effective way of remaining stationary in a habitat. For example, geckos could perch on a smooth vertical surface and sleep for the night – or day – without using any energy."

The new work suggests that the "active" component of gecko adhesion is actually a reduction of adhesion force when the gecko "hyperextends" its digits – that is, lifts them off the ground by curling up only the tips of the digits while the rest of the foot remains on the surface.

"We found that the dead animals were more likely to experience damage to their adhesive system, which suggests that the active control may actually prevent injury," Stewart aid. "In other words, when the forces become too high, the gecko likely releases the system using its muscles."

More information: Passively stuck: death does not affect gecko adhesion strength, *Biology Letters*, rsbl.royalsocietypublishing.or … .1098/rsbl.2014.0701

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