© 2018. Published by The Company of Biologists Ltd | Journal of Experimental Biology (2018) 221, jeb177642. doi:10.1242/jeb.177642

INSIDE JEB

Sticky tree frogs can also get a grip

A White's tree frog climbing a rough cylinder. Photo credit: Iain Hill.

A self-cleaning reusable adhesive that works in the wet and sticks to pretty much anything is the holy grail of many materials engineers, yet a charismatic group of frogs beat them to it when several families ascended into the trees to make their homes. They evolved sticky toe pads that never wear out, and Jon Barnes, from the University of Glasgow, UK, has been mesmerised by the minute amphibians since the early 1990s. Discovering that these frogs depend on a thin layer of fluid exuded from the toes for attachment to smooth surfaces and that they detach their feet by peeling them away, Barnes has also learned that repeated use self-cleans the toes to keep them in tip-top condition. However, many other species are equally adept at scaling heights without the benefits of adhesives. 'We wanted to find out whether tree frogs could also use gripping forces', says Barnes, who was curious to find out how the diameter of the structures that the amphibians ascend affects their ability to get a grip.

Teaming up with Iain Hill from Glasgow and visitors from the Nanjing University of Aeronautics and Astronautics, China – Benzheng Dong and Aihong Ji – Barnes tested how well White's tree frogs (*Litoria caerulea*) and Cuban tree frogs (*Osteopilus septentrionalis*) coped when climbing Perspex cylinders ranging in diameter from simulated stout branches (120 cm), which were too wide for the frogs to encircle with their legs, to medium branches (44 mm), which the frogs could span with their forelimbs, and thick twigs (13 mm), which they could wrap their toes around. 'Both [species] are excellent climbers', says Barnes, who recalls that the Cuban tree frogs trotted up the narrowest cylinder at average speeds around 14 cm s^{-1}, while ascending the medium curved cylinder at sprightly walks of around 13 cm s^{-1} and walking up the broadest cylinders at more sedate speeds of 12 cm s^{-1}.

However, the frogs struggled when the team coated the Perspex cylinders with sandpaper to force them to rely on grip alone. Neither of the two species was able to grip on to the broadest cylinder: 'Basically, they would try to cling to the surface and immediately fall into our hands', recalls Barnes. Although both species only managed to scale the medium cylinder on four occasions, they were always able to grasp on to the narrowest cylinder by wrapping their toes around it to ascend with ease.

Barnes, Hill and Thomas Endlein then analysed how the frogs used the adhesive structures on their feet to stick to the smooth surfaces, and were impressed to see that the tiny climbers were increasingly using the subarticular tubercles, adhesive structures that are found on the toes, as the curvature of the cylinders increased. Explaining that the subarticular tubercles rarely contribute to adhesion when the frogs ascend flat plates of glass, the team was impressed to see that they contributed increasingly as the cylinders became more curved, contributing up to 57% of the footprint area on the medium-sized cylinder in contrast to 25% on the largest cylinder.

So tree frogs can use a combination of strategies when manoeuvring through their complex arboreal homes, using adhesive structures on their feet to cling on to smoother structures, gripping with their flexible toes when the surface is too rough and using a combination of the two on smooth slender structures. 'The way they climb in response to changes in both surface texture and diameter demonstrates just how adaptable they are to the challenges they face', says Barnes, who is keen to build a generation of versatile climbing robots that ascend as nimbly as tree frogs.

10.1242/jeb.177642

Hill, I. D. C., Dong, B., Barnes, W. J. P., Ji, A. and Endlein, T. (2018). The biomechanics of tree frogs climbing curved surfaces: a gripping problem. *J. Exp. Biol.* **221**, doi:10.1242/jeb.168179.

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