Nature helps to solve a sticky problem

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The arrays of fine adhesive hairs or 'setae' on the foot pads of many insects, lizards and spiders give them the ability to climb almost any natural surface. Research by James Bullock and Walter Federle from the University of Cambridge in England found that the different forces required to peel away these adhesive hairs from surfaces are what allows beetles to adhere to diverse surfaces, thereby reducing the risk of detachment. Their study, published online in the Springer journal *Naturwissenschaften – The Nature of Science*, reports the first adhesive force measurements from single microscopic setae in a live animal.

The adhesive hairs on the feet of leaf beetles are known to take three distinct shapes; pointed, flat (spatula-tipped) and disk-like. They are arranged in specific patterns across the beetle's feet, indicating different biological functions for each hair type. Given their small size (only 1/200th of a millimeter across), there existed no way to determine their individual properties. Bullock and Federle therefore devised a method for measuring the in vivo stickiness of each hair using a fine glass cantilever. By observing the deflection of the cantilever through a microscope, the force needed to detach each hair was calculated.

Results in male beetles showed that the disk-like hairs adhered with the highest force, followed by spatula-tipped and then pointed hairs. Disk-like hairs were also stiffer than either flat or pointed hairs, likely providing stability to the pad. Bullock and Federle suggest that it is these disk-like hairs in particular which allow male beetles to achieve strong adhesion on smooth surfaces. This ability is also important for the males during copulation to hold on firmly to the back of the females. The other

hair types, being easier to 'un-stick', may help the beetle to rapidly detach its feet when running upside down.

Before these natural structures can be replicated as synthetic adhesives, a better understanding of their detailed function is needed. The authors conclude, "The question of how forces in natural adhesive systems run from the single-hair to the whole-animal level is a central, unresolved problem. Its understanding will be a prerequisite for the design of bio-inspired synthetic adhesives."

More information: Bullock JMR and Federle W (2011). Beetle adhesive hairs differ in stiffness and stickiness: In vivo adhesion measurements on individual setae. *Naturwissenschaften – The Science of Nature*. DOI:10.1007/s00114-011-0781-4

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