WHY HAVE MORE THAN ONE PAD PER LEG?

Determining the mechanical and adhesive properties of hairy attachment pads in beetles

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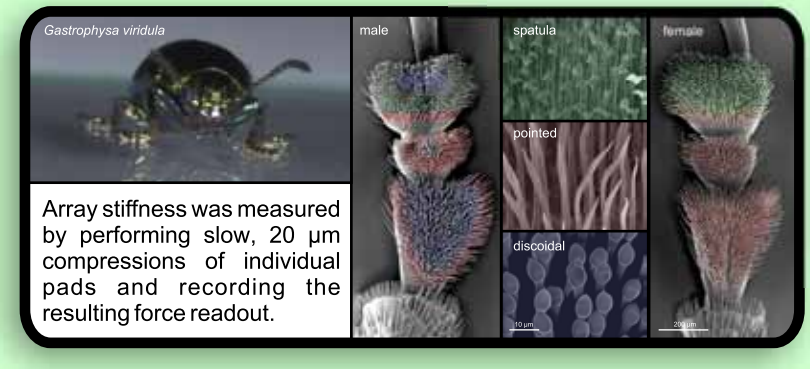
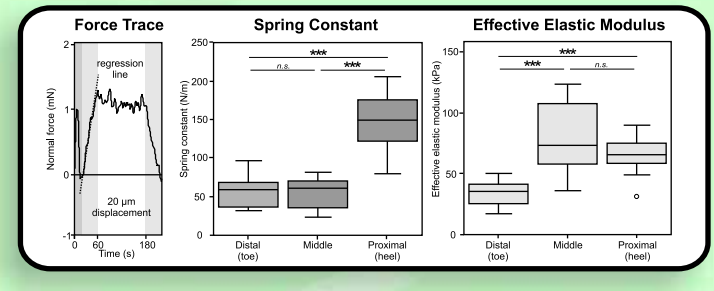
DO THE PADS DIFFER IN THEIR STIFFNESS?

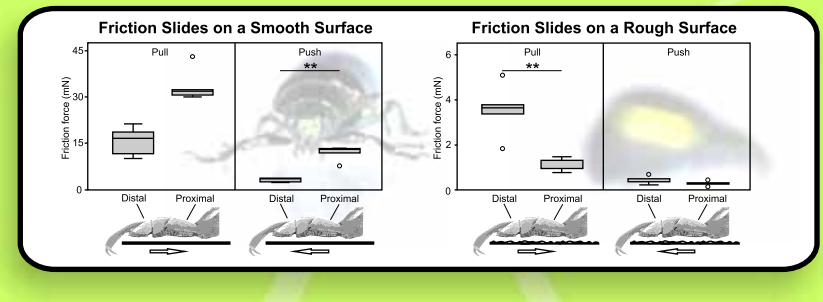


Array stiffness was measured by performing slow, 20 µm compressions of individual pads and recording the resulting force readout.



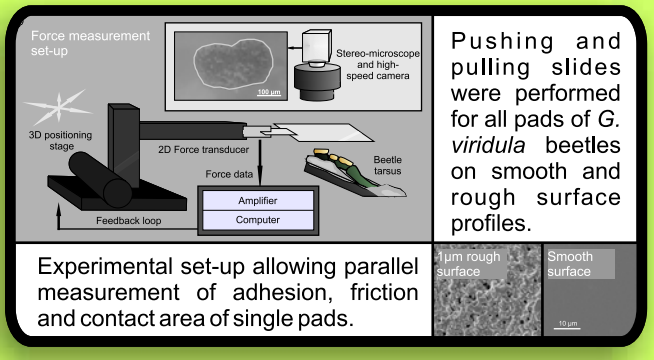
The force trace shows a typical compression curve resulting from the single pad displacement. Spring constant and effective elastic modulus plots show that **distal toe pads are soft**, whereas **proximal heel pads are stiff.**

DOES THIS MEAN THE PADS HAVE DIFFERENT FUNCTIONAL PROPERTIES?



All pads are **direction-dependent:** i.e. forces are higher in the pulling direction

1. On a **smooth surface**, **stiff proximal heel pads push** with higher forces
2. On a **rough surface**, **soft distal toe pads pull** with higher forces

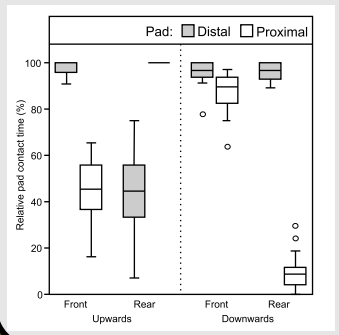


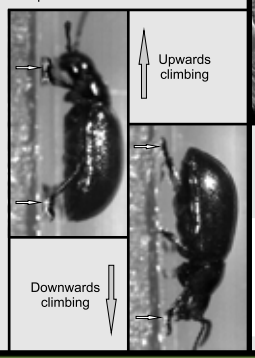
Pushing and pulling slides were performed for all pads of *G. viridula* beetles on smooth and rough surface profiles.

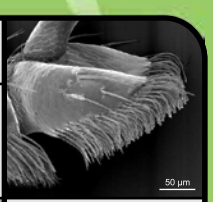
Experimental set-up allowing parallel measurement of adhesion, friction and contact area of single pads.

HOW THEREFORE ARE THE PADS USED DURING CLIMBING AND WALKING?

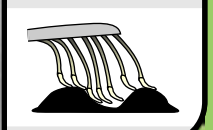
G. viridula beetles were filmed climbing upwards and downwards on a smooth surface, to observe which footpads were used on each leg. The amount of time each pad contacted the surface was recorded, and plotted as a fraction of the total step time.







Despite being made of stiff cuticle, arrays of high aspect ratio hairs are able to bend and adapt to substrate roughness.



Beetles use soft, adhesive distal pads to pull and use stiff, stable proximal pads to push whilst climbing on a smooth surface. This effective division of labour technique maintains both a direction-dependent mechanism for detachment and an ability to push. Soft distal pads are then able to make good contact with rough surfaces.

~ Pushing and Pulling Whilst Climbing and Walking on Rough and Smooth Surfaces

CONCLUSIONS:

~ Proximal heel pads are stiffer than distal toe pads

~ Stiff proximal pads are used effectively for pushing during vertical climbing

~ Soft distal pads allow strong attachment for pulling on rough surfaces

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