© 2019. Published by The Company of Biologists Ltd | Journal of Experimental Biology (2019) 222, jeb207118. doi:10.1242/jeb.207118

INSIDE JEB

Hollow peg holds key to click beetles' explosive flips

Two click beetles, *Ampedus linteus* (left) and *Ampedus nigricollis* (right). Photo credit: Ophelia Bolmin.

Struggling to right themselves when stranded on their backs, click beetles have a remarkable correction strategy. Arching the joint between the front and second section of the thorax, the beetles suddenly release the deformation and spring spontaneously into the air. 'The jump is almost vertical, but only 50% of cases result in the beetle landing on its feet', explains mechanical engineer Aimy Wissa, from the University of Illinois Urbana-Champaign, USA, who is fascinated by the tiny insects' acrobatics. And entomologist Marianne Alleyne, from the University of Illinois Urbana-Champaign, USA, adds, 'Considering that insects have a small internal volume and, therefore, limited space for large musculature, it is rather amazing how high they can jump without using their legs to push off the ground'. Instead, the beetles depend on a latch structure – situated in the joint between the thorax and the abdomen – which locks the body in position, storing the energy that was released slowly by the muscles that arched the body, ready to be released as soon as the latch lets go. But it was not clear how the two halves of the latch click together, so Wissa, Alleyne and their engineer colleague Alison Dunn teamed up to scrutinise the structure in fine detail.

As there are almost 10,000 click beetle species, the team focused on the beetles that reside in their neighbourhoods. 'We let colleagues, family and friends know that we were in need of living click beetles', says Alleyne, who recalls how insects were delivered for identification by Alexander Hazel from as far afield as Michigan and Ohio; 'even the mechanical engineers got involved', she chuckles. Then, Ophelia Bolmin scrutinised the latch structure of four different click beetles – *Alaus oculatus*, *Parallelostethus attenuatus*, *Lacon discoideus* and *Melanotus* spp. – in microscopic detail using environmental scanning microscopy. Meanwhile, Lihua Wei CT scanned the head and thorax region of *A. oculatus*, *P. attenuatus* and *Melanotus* spp. to learn about the latch's internal construction.

Describing the latch structure, Alleyne explains that a peg on the front section of the thorax slots perfectly onto the lip of the second portion of the thorax, locking the insect's body into an arched position. Also, rows of hairs around the lip cavity guide the peg in to place, and the friction plate toward the tip of the peg locks the latch. Most surprisingly, the CT scans revealed that the peg is hollow. 'Maybe we shouldn't have been surprised', says Wissa, explaining that that hollow elongated structures such as pipes and tubes have a higher strength-to-weight ratio than similarly shaped solid structures. And when Dunn calculated the strength of the hollow peg and compared it with the strength of a solid beam, she confirmed that the hollow peg was much stronger, suggesting that a solid peg may be too flexible to hold the latch in place.

So click beetles wedge open the latch that allows the insects to store the explosive energy required to fling themselves into the air with a hollow peg. Also, the team suspects that the latch slips when the tension is too high and friction can no longer hold it in place. In addition, they are keen to apply the lessons about power amplification that they have learned from the click beetle to design agile robots that can get out of tight corners.

10.1242/jeb.207118

Bolmin, O., Wei, L., Hazel, A. M., Dunn, A. C., Wissa, A. and Alleyne, M. (2019). Latching of the click beetle (Coleoptera: Elateridae) thoracic hinge enabled by the morphology and mechanics of conformal structures. *J. Exp. Biol.* **222**, jeb196683. doi:10.1242/jeb.196683

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