Water-skiing beetles get a bumpy ride

March 2 2016

Blink and you've missed it: Manu Prakash from Stanford University, USA, describes how one moment a waterlily beetle (*Galerucella nymphaeae*) is sat on the surface of a pond and the next it has vanished. 'The phenomenon is so incredibly fast that you don't see anything', says Prakash, describing the ripples remaining on the surface that are the only evidence that the insect was ever there. Having observed the beetles' remarkable disappearing act, Prakash knew he had to find out how they pull off the stunt.

'Initially, I filmed them without confining them in my kitchen...because it is hard to find them [when they get loose] in the lab', he chuckles, recalling that dinner plates of water provided ideally sized ponds when filming. And when he saw the first movie, he knew that he was on to something exceptional. The beetles looked as though they were water skiing, but travelling at incredible speeds of up to 0.5 m s?1 - equivalent to a human travelling at around 500 km h?1 - propelled by their wings alone, as if they were flying while remaining attached to the surface. Prakash was hooked and knew he had to learn more about the mysterious beetles' interfacial flight. He publishes the discovery that the beetles are water-skiing on four legs as they fly along the surface in *Journal of Experimental Biology*.

'It was incredibly difficult to image these guys', says Prakash, who worked with summer interns Thibaut Bardon and Dong Hyun Kim, and graduate student Haripriya Mukundarajan, filming the beetles' antics with a high-speed camera. Mukundarajan describes the insects' movements, saying, 'They have an elaborate way of preparing for flight', before outlining how the insects initially raise the middle pair of legs - to prevent them from impeding the wings during flight - before drying each leg and gently dipping the claw at the end of the limb back into the water ready for departure. Once balanced on the tips of all four legs, the beetles open the wing case on their backs and beat the wings a couple of times to unfurl them before switching into flight mode and flapping the wings in a characteristic figure-of-eight pattern at around 115 Hz to thrust themselves forward. However, instead of gliding smoothly across the glassy surface, the insects looked as if they were careering along a roller coaster as they flew across the ripple ridges that they generated as they moved. 'Almost like going on a road full of potholes', says Mukundarajan, 'Although these potholes are being generated by the insect itself', laughs Prakash.

Puzzled by the beetles' unexpectedly bumpy ride, Mukundarajan and Prakash analysed the forces acting on them as they slide across the surface and realised that the insects were playing a finely tuned balancing act between surface tension clinging to their tarsus claws and the lift generated by their wings, with surface tension keeping them firmly anchored at the surface. And when Mukundarajan assembled a series of equations that described the insects' movements, they explained how the tell-tale ripples - the only visible indication of the insects' high-speed performance - were produced. According to Prakash each wingbeat generates a force that momentarily pushes the insect down, making it bounce along the surface of the water. An additional set of waves - known as capillary gravity waves - are also generated spontaneously as the insect reaches a specific speed. The duo adds that there are only a narrow range of situations where an insect can fly along the surface of a pond and remain attached without popping off into the air. Prakash is also optimistic that the new mathematical model could explain how other exotic species skate, including marine flies that are content bobbing about on the waves.

More information: Mukundarajan, H., Bardon, T. C., Kim, D. H. and Prakash, M. (2016). Surface tension dominates insect flight on fluid interfaces. *J. Exp. Biol.* 219, 752-766. DOI: 10.1242/jeb.127829

Provided by The Company of Biologists