Inside JEB highlights the key developments in *The Journal of Experimental Biology*. Written by science journalists, the short reports give the inside view of the science in JEB.

Inside JEB

FOUR VORTICES KEEP BATS ALOFT


Tatjana Hubel

Any animal that moves through a fluid leaves behind a tell-tale trail of spinning vortices that can be interpreted to reveal the aerodynamic forces that keep them aloft. While several species of bird have been put through their paces in wind tunnels to reveal the intricate vortex patterns and lift forces that keep them airborne, less is known about the vorticity trails left by bats. Tatjana Hubel and her colleagues from Brown University, USA, flew four lesser dog-faced fruit bats (*Cynopterus brachyotis*) at a low ($\sim 5\,\mathrm{m\,s^{-1}}$) and medium speed ($\sim 6.7\,\mathrm{m\,s^{-1}}$) in a wind tunnel while filming the animals' wing beat patterns and wake structures to find out how the vortices in their wakes correlated with their wing beats and how much the wake and wing beat patterns vary between individuals (p. 3427).

The team found a distinctive wake pattern containing four different vortices at both speeds that was dominated by a strong wingtip vortex that developed during the downstroke. Persisting almost to the end of the upstroke, the vortex closely tracked the position of the wingtip during the downstroke, but shifted slightly towards the bat's body during the upstroke. At the same time as the wingtip vortex appeared, a second, clockwise spinning vortex was generated next to the body during the first half of the downstroke and two additional vortices were generated just above the wingtip during the final third of the upstroke.

The team also compared the wing beat pattern of each bat with that of the others, and saw that each animal had its own distinctive wing beat signature when changing speed. Also, most individuals varied the wing beat amplitude, body-to-wingtip distance and stroke plane angle as they increased their speed.

Having revealed the lesser dog-faced fruit bats' wake vorticity patterns, the team are keen to compare it with the vorticity patterns of other bats that hunt insects, hover at flowers and even migrate, to find out how they adapt their wing beat and lift patterns to radically different lifestyles.

10.1242/jeb.051755

Hubel, T. Y., Riskin, D. K., Swartz, S. M. and Breuer, K. S. (2010). Wake structure and wing kinematics: the flight of the lesser dog-faced fruit bat, *Cynopterus brachyotis*. *J. Exp. Biol.* **213**, 3427-3440.

MANTIS SHRIMP TELSONS WITHSTAND BLOWS LIKE HUMAN BODY ARMOUR

Mantis shrimps pack a mighty punch. An average sized shrimp can hurl a claw at speeds up to $23\,\mathrm{m\,s^{-1}}$ with forces up to 1500 N – thousands of times its own body weight – and the whole incident is over in the blink of an eye. 'These animals are unbelievably fast,' says Jennifer Taylor from the University of California, Berkeley. But mantis shrimps don't just use their claws to pulverise passing prey. They indulge in ritualised duels over burrows; taking it in turns to thump each other on the tail (telson) without injury until one of the contestants backs down. Realising that the telson must be incredibly robust to take such a pounding, Taylor and Sheila Patek decided to look at its responses to high impact collisions to find out how the telson emerges unscathed from duels (p. 3496).

Simulating the impact of a claw by dropping a small steel ball on the central ridge segment (carina) of a telson, Taylor filmed the impact at a staggering 15,000 frames $\mathrm{s^{-1}}$. 'The telson from this stomatopod feels so stiff you wouldn't expect to see any deformation but you actually see it moving in the video,' says Taylor. And when she looked closer, she realised that instead of the site of impact deforming, the entire domed section (composed of three carinae) depressed. 'The cuticle in between the carinae was more flexible and allowed for the deformation that I saw,' explains Taylor.

Curious to find how the telson dissipates collision energy without shattering, Taylor measured the telson's coefficient of restitution (e) – the ratio of the separation velocity to the impact velocity (ranging from 0 to 1), used by engineers and sports scientists to analyse impacts – to find out if the telson behaves like a rebounding trampoline (high *e*) or an energy absorbing punch bag (low *e*). Carefully measuring the velocity of the ball over the final 10 frames of the descent and the first 10 frames after the impact, Taylor found that its coefficient of restitution was 0.56: the ball lost 69% of its energy in the impact. The telson was behaving more like a punch bag or stiff spring than a trampoline. And when she measured the duration of the impact and impulse (change in ball momentum) as the ball smashed into different sized telsons, Taylor realised that the larger the telson the longer the impact and the smaller the impulse, information that mantis shrimps could use to tell them about their opponent's size.

Finally, having measured the telson's responses to high impact collisions, the duo decided to look at the distribution of minerals in the telson to see if they could find any patterns to explain its resilience. Patek CT scanned the telson and found that all three carinae were highly mineralised, while the surrounding regions had relatively low mineralisation. 'It appears that the carinae provide stiffness, while the cuticle surrounding them provides compliance,' say Taylor and Patek, who point out that man-made impact resistant armour, composed of stiff regions interspersed with flexible sections, uses exactly the same strategy to protect humans from impact injuries.

Having discovered how mantis shrimp telsons withstand blows that would shatter other crustacean's shells, Taylor is keen to find out whether telsons have adapted to withstand these forceful impacts, but this will have to wait until she sets up her own lab later this year.

10.1242/jeb.051748

Taylor, J. R. A. and Patek, S. N. (2010). Ritualized fighting and biological armor: the impact mechanics of the mantis shrimp's telson. *J. Exp. Biol.* **213**, 3496-3504.

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We would like to thank Jim for all his outstanding contributions over the time that he has contributed to Outside.

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