With their puny legs and graceful wings, it’s clear that bats evolved to fly, not walk. Yet some bats are surprisingly good at scurrying along the ground in pursuit of their prey. Vampire bats are particularly agile crawlers and have chunkier legs than other bats. This has led to the suggestion that other bats are poor walkers because their hind limbs are too weak to cope with the forces associated with pounding the ground; their fragile legs would simply snap if they tried to support their body weight. Armed with a specially designed walkway for bats, Daniel Riskin at Cornell University set out to test this hindlimb-strength hypothesis (p. 1309).

Riskin reasoned that if bats’ crawling ability is limited by hindlimb strength, and vampire bats are better walkers because their legs are stronger than other bats’ legs, then vampire bats’ legs should generate larger forces during walking than the delicate legs of other species. To see if this is true, he decided to measure the forces acting on bats’ hind legs as they crawled along.

Force plate expert John Bertram helped Riskin design and build a bat walkway consisting of an elongated box with an ultra-sensitive force plate bottom to measure the delicate pressures exerted by bats’ hindquarters as they clambered around. Satisfied that the device was small enough to take into the field, Riskin and John Hermanson boarded a plane to Trinidad to find some bats. Unfortunately, Riskin says, ‘our contraption looked like a bomb, so it took ages to get it through airport security.’ Having convinced the officials that they were not a threat to national security, the pair made it safely to Trinidad.

Using a tempting herd of cattle and coop of chickens to entice the bats, Riskin and Hermanson soon had enough ‘volunteers’ – two species of vampire bat and a particularly clumsy insectivorous bat to compare with the expert walkers. Placing bats in the box, Riskin blew on them to persuade the creatures to shuffle away. He recalls that the vampires were true to form, striding deftly across the force plate walkway. But the ungainly insectivores struggled with the task, ‘lifting their bodies up and thrashing manically with their legs until they collapsed forwards.’ Viewing digital recordings of the bats’ locomotor attempts, Riskin and Hermanson identified brief periods during which only the creature’s hind limbs touched the force plate. When they compared the peak forces produced by the vampires with those of the insectivores during these periods, they found that the poor crawlers actually exerted larger forces with their hind limbs than the vampires! The insectivores’ spindly legs are obviously strong enough for crawling. The pair also found that the vertical component of the peak force (which supports the animal’s body weight) was the same for all three species, suggesting that the legs of all three species support the same proportion of their body weights. Finally, they modelled bending stress to compare hindlimb support capabilities among 50 bat species and found that vampire bats’ hindquarters really aren’t more robust than those of other bats.

Clearly, the hindlimb-strength hypothesis is wrong; the frail legs of non-terrestrial bats can easily withstand the forces produced during walking. Riskin concludes that some other factor must limit the crawling ability of most bats. He admits that he’s not sure what this is, so bat locomotion researchers now have their work cut out for them.

10.1242/jeb.01561


EVOlUTION CONSERVES HORMONE RECEPTORS

Investigating a small class of five receptors in Drosophila two years ago, Paul Taghert’s group at Washington University School of Medicine discovered that one of these is a receptor for diuretic hormone 44, which regulates osmotic balance. Suspecting that some of the other four receptors in this class may play similar physiological roles, they embarked on an international collaboration with groups led by Julian Dow and David Schooley to search for the ligand for another receptor in this class, CG17415 (p. 1239).
Taghert explains that the interaction between a receptor protein and its peptide ligand is very specific, like a lock and key, causing a change in the receptor protein that triggers a series of intracellular signals. In some cases accessory proteins, which assist in receptor–ligand binding, need to be present for receptors to function properly. Drosophila’s CG17415 receptor is closely related to a mammalian receptor that needs accessory proteins to work, so the team reasoned that this might also be the case for the fruit fly receptor.

The group set out to identify which unique ligand pairs up with the CG17415 receptor, and to see whether it needs accessory proteins. They transfected the CG17415 receptor gene into mammalian tissue cultures so that these cells now expressed the gene and contained the receptor in their cell membrane, acting like an antenna for the right ligand. When a ligand binds to its receptor, the concentration of a messenger molecule (in this case cyclic AMP) increases. If the team saw an accumulation of this messenger after adding a potential ligand to the cell cultures, they would know that they had found the right ligand. They exposed the cells to 23 potential peptide ligands, but did not see an accumulation of cyclic AMP in response to any of these until they added mammalian accessory proteins to the cells. With the accessory proteins assisting the process, the team saw a clear response to just one of the 23 peptides: diuretic hormone 31. Clearly, CG17415 is a diuretic hormone 31 receptor, and just as they had suspected, it needs accessory proteins to work properly.

But the team still didn’t know where this receptor is expressed in the fruit fly. If CG17415 is a diuretic hormone receptor, the team reasoned that they should find the receptor in the fruit fly’s ‘kidney’, the Malpighian tubules, which regulate fluid balance. Sure enough, when the team used antibodies for the CG17415 receptor to stain and localise the receptor protein, they saw that the receptor is expressed in the tubules.

The immunostaining also revealed something unexpected. The team were surprised to find that a small cluster of 30 neurons in Drosophila’s brain express both the diuretic hormone 31 receptor and the diuretic hormone 44 receptor that the team discovered two years ago, which suggests that these two hormones have convergent signalling pathways. Taghert explains that the diuretic hormone 31 receptor is related to the mammalian calcitonin gene-related peptide (CGRP) receptor, while the diuretic hormone 44 receptor is related to the mammalian corticotrophin-releasing factor (CRF) receptor. ‘Co-expression of CGRP and CRF has also been suggested in mammals,’ says Taghert. He concludes, ‘the convergence of these two receptors in fruit fly brains and mammalian brain circuitry suggests striking evolutionary parallels between insect and mammalian hormone signalling pathways.’


EATING ON THE MOVE

Jellyfish are passive creatures when it comes to feeding; they rely on water flow generated by their swimming movements to draw hapless prey towards their stinging tentacles. Intrigued by previous observations that jellyfish snack while swimming, John Dabiri at the California Institute of Technology hoped that scrutinizing the fluid dynamics of jellyfish swimming would shed some light on this interaction (p. 1257).

Dabiri explains that jellyfish swim by contracting and relaxing their soft umbrella-shaped bodies. During the power stroke, the animal collapses inwards and water is ejected from its subumbrellar cavity as a jet. The swirling fluid that forms in the animal’s wake is called the starting vortex ring, which propels the animal forwards. But nobody had really considered what happens to water flow when the animal relaxes its body.

To see what happens during jellyfish recovery strokes, Dabiri needed water flow measurements during jellyfish swimming. So he was delighted when jellyfish behaviour experts Sean Colin and John Costello sent him video footage of swimming jellyfish and asked if he could use it to quantitatively reconstruct the flow field around the animals. Colin and Costello had videotaped the creatures in their home, a Croatian marine lake, so their footage revealed jellyfish behaviour in natural conditions. To visualise water flow during swimming, they had squirted fluorescent dye around the jellyfish. When Dabiri saw the fluorescent swirling vortices, he remembers being ‘amazed at how clearly you could see the flow. I immediately knew we could learn something from this one-of-a-kind data.’

Dabiri began to quantify the intricate flow patterns generated by the jellyfish. To measure how much fluid the animals eject during swimming, he needed to measure the inner surface of each animal’s subumbrellar cavity, which is tricky, since these jellyfish are transparent. Undaunted, Dabiri constructed algorithms to determine the inner surface of each animal. Calculating this for each frame of video, he soon had a time frame of expelled water volume changes as the jellyfish swam. He noticed that vortex rings downstream of the jellyfish had a larger volume than when they were ejected from the animal. ‘As a vortex rotates, it grows by sucking in surrounding water,’ Dabiri explains. The more momentum the flow in the animal’s wake has, the more momentum the animal’s body has in the opposite direction. As the starting vortex ring swims, it increases downstream fluid momentum, ‘which translates into increased forward thrust for the jellyfish’ says Dabiri. He adds, ‘the existence of this mechanism for enhanced thrust challenges the common notion that swimming via jet propulsion is inherently inefficient.’

It turns out that jellyfish benefit from the starting vortex in other ways too. Dabiri was excited to see that, during the recovery stroke, jellyfish produce a stopping vortex that rotates in the opposite direction of the starting vortex. When these two vortices interact downstream, they form a complex superstructure. ‘The start vortex propagates away from the animal,’ says Dabiri, ‘but when it bumps into the stop vortex, it slows down, giving the animals’ tentacles more time to pick prey out of the swirling water.’ By creating a vortex superstructure, jellyfish not only have a very efficient propulsion mechanism, but can also eat on the move.
Male crickets sing to attract females by scraping the blade-like edge of one forewing over a file of teeth on the other forewing. The ‘clockwork cricket’ sound production model suggests that the catch-and-release of the scraper along the toothed file, producing a clock’s familiar ticking sound, provides impulses that maintain the vibration of the sound-producing wing regions. Since katydids are closely related to crickets, they might also use the ‘clockwork cricket’ mechanism – but nobody had tested this, until Fernando Montealegre and Andrew Mason came along (p. 1219).

To find out exactly how spiny devils (Panacanthus pallicornis) produce their serenades, Montealegre and Mason used high-speed video to track the movement of the katydids’ scrapers over their toothed files. They saw that male spiny devils use the entire file surface, unlike some crickets and katydids. Sticking reflective tape onto the insects’ wings, they accurately traced the scrapers’ movements as the katydids sang, using a photodiode to catch light reflecting off the tape. They found that, like in crickets, every sound wave corresponds with a tooth impact. In the ‘clockwork cricket’, the file-bearing wing has to vibrate at high amplitude in order to release the scraper from each tooth. But when Montealegre and Mason recorded katydid wing vibrations with a laser vibrometer, they found that the function of katydids’ file-bearing wings is damping rather than vibrating at high amplitude; katydids don’t use the ‘clockwork cricket’ mechanism.

So how do katydids sing? Examining their tooth files with an electron microscope, Montealegre and Mason noticed that intertooth spacing increases along the file. This means that katydids must increase their scraper’s velocity as it traverses the file to maintain the same tooth contact rate, which is necessary to produce a pure tone. It seems katydids serenade their ladies by sweeping their wings at a range of speeds.

10.1242/jeb.01562

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