

Inside JEB is a twice monthly feature, which 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

THE GREAT ESCAPE



Picture by David D. Yager

Praying mantids are large and juicy, so it's little wonder that bats find them appetising. But mantids perform a cunning trick to stay out of a predator's clutches; their single ear is tuned to bats' ultrasonic calls, and when they hear a bat sneaking up on them, they plunge into a speedy nosedive. Exactly which characteristic of a bat's echolocation call triggers the escape artists' dramatic dive wasn't clear, until Jeffrey Triplehorn and David Yager timed exactly when praying mantids plummeted in response to different bat attack calls (p. 1867).

Bats emit pulses of echolocation calls during their nightly hunt. Triplehorn explains that they start calling at a low rate, but as they home in on a hapless insect, they switch to a higher calling rate to get more frequent updates on their prey's location. 'Sometimes this transition from a low to a high calling rate is gradual, but sometimes it's very fast,' Triplehorn says. He wondered if mantids use the timing of a bat's transition pattern to decide exactly when to take the plunge.

To discover what triggers a mantid's power dive, Triplehorn took a close look at mantids' responses to bat calls. He tethered mantids in a sound chamber and set up a gentle breeze to encourage the insects to fly. He then played the last 1.2 seconds of five bat attack sequences, some with gradual and some with rapid transitions in calling rates, and waited for the insects to dive. To mark the millisecond timing of the mantids' escape response, he projected a laser light beam from the top of the sound chamber, which passed just in front of the tethered insect and contacted a light-detecting photocell on the chamber floor. Mantids' forelegs are neatly tucked away during flight, but when ultrasound calls trigger their escape manoeuvre, their legs

shoot forwards and break the light beam, providing Triplehorn with the dive's exact timing.

But there's a problem when you're working on a millisecond scale: there is a time delay between the moment that a mantid's nervous system triggers the escape response and the moment that you record the insect actually performing the dive, called the response latency. Luckily, Triplehorn already knew the duration of the response latency between the trigger point and the mantids' dive. He knew that a particular artificial call rate definitely evokes a dive, and had recorded when mantids performed their dive after the onset of this particular call, giving him the mantids' response latency. Now, he could identify the exact point in the five bat attack calls that triggered the mantids' nervous system, by subtracting this known response latency from the timing of the dives that he had recorded for the mantids listening to these five calls. He found that all the mantids' dives were triggered when the bats called at 20-40 pulses per second, and concluded that this specific calling rate triggers the mantids' decision to dive.

But Triplehorn discovered that mantids' survival chances really depend on *when* bats hit this calling rate; the timing of bats' calling rate transitions is crucial. When bat calls switch rapidly from low to high calling rates, the mantids' alarm bells only start ringing very late in the call sequence, when the bat's attack is imminent. But a gradual transition appears to provide mantids with a 'tip-off', because they perform their life-saving dive much earlier during these attack calls. Clearly, the odds that a bat will catch its dinner improve dramatically with a hasty increase of its pulse repetition rates.

10.1242/jeb.01643

Triplehorn, J. D. and Yager, D. D. (2005). Timing of praying mantis evasive responses during simulated bat attack sequences. *J. Exp. Biol.* **208**, 1867-1876.

SNAKES TAKE FLIGHT

Most flying or gliding animals rely on a symmetrical pair of wing-like structures to generate lift, the force that opposes gravity and keeps the flier aloft. But 'flying' tree snakes have no wings or any other obvious structures that might help them fly, explains Jake Socha, a biologist at Argonne National Laboratory, Illinois. Little was known about these enigmatic creatures until Socha, then a graduate student at the University of Chicago, set out for Singapore in search of the elusive paradise

tree snake (p. 1817 and p. 1835). Aside from a desire to see up close the marvel of a flying snake in action, he was compelled by the question: How do they do it?

To answer this, Socha needed to describe the kinematics of snake flight. Luckily, with the help of local volunteers, catching paradise tree snakes wasn't too hard. But capturing their flights on videotape 'was a nontrivial process,' says Socha. He coaxed the stubborn snakes to jump from 10 m high towers set up in the Singapore Zoological Gardens. Tony O'Dempsey, an expert on photogrammetric techniques, helped Socha extract 3-D flight information from the synchronized recordings of two video cameras. 'Finding Tony was a stroke of luck', says Socha; the 3-D information was crucial in reconstructing the flying snakes' aerial trajectories, speed and body postures.

Socha found that paradise tree snakes are true gliders, and pretty good ones at that. Rather than simply parachuting to the ground, these cylindrical-bodied snakes somehow generate enough lift to carry them across a substantial horizontal distance. Socha suspected that the unusually dynamic flight behavior of the snakes might be responsible; while flying, the snakes create distinctive S-shaped aerial waves that travel from head to tail. To test this, he correlated the snakes' wave amplitude and frequency with flight performance variables. He found that snakes with the greatest combination of body length and wave amplitude (relative to body size) travelled fastest; but the largest snakes were not necessarily the ones making the biggest waves. While wave amplitude is important, Socha found that the frequency of these waves appears to play little or no role in producing aerodynamic forces during flight. So why do snakes undulate so frequently? Socha suggests that it may provide stability, keeping the snakes from spinning out of control.

Given that body size influences flight performance in other animals, Socha correlated snake body size with flight parameters and found that smaller snakes are generally better gliders. He also found that the paradise tree snake is a better glider than its larger, stockier cousin, the golden tree snake. But Socha noticed that paradise tree snakes tend to flatten their body more during flight, suggesting that body shape may also be a key factor in snake flight aerodynamics.

Socha has only begun to unravel the

mysteries of snake flight. He is now working on physical and computational models to test more specifically how a snake's shape, size, and behavior influence flight dynamics. Ultimately, he hopes to understand how differences in morphology and flight performance might influence ecological differences between flying snake species. This will require more field studies, but luckily for Socha, 'the thrill of watching snakes fly is something that never gets old.'

10.1242/jeb.01644

Socha, J. J., O'Dempsey, T. and LaBarbera, M. (2005). A 3-D kinematic analysis of gliding in a 'flying' snake, *Chrysopelea paradisi*. *J. Exp. Biol.* **208**, 1817-1833.

Socha, J. J. and LaBarbera, M. (2005). Effects of size and behavior on aerial performance of two species of 'flying' snakes (*Chrysopelea*). *J. Exp. Biol.* **208**, 1835-1847.

Cynthia Wei, Chicago

SURVIVAL OF THE FITTEST



When rainbow trout started dying mysteriously at Joël Aubin's fish farm, he called in fish physiologists Guy Claireaux and Tony Farrell to investigate. They discovered that some of Aubin's fish had oddly shaped hearts. 'These fish may appear to be healthy when young, but then suffer heart failure in later life,' Claireaux explains, 'so investing in these fish is a costly business for the fish farming industry.' He figured that if frail fish could be identified when they're young, fish farmers could weed them out to make sure that they only rear healthy fish. Searching for a suitable way to screen juvenile fish, Claireaux and Farrell devised a simple fitness workout that allows farmers to pick out the most athletic fish (p. 1775).

Pondering how to develop an early warning system for potential future health problems, Farrell reasoned that the answer might lie in the heart's ability to deliver oxygen to active muscles in swimming fish. In other words, if cardiac and swimming

performance are closely linked, the swimming ability of young fish might predict which fish have the weakest hearts. To test their idea, Claireaux and Farrell loaded equipment into a van and drove to Aubin's fish farm in Brittany, where David McKenzie, Gaylene Genge and Aurélien Chatelier joined the team. 'Doing physiology in the field was a real challenge,' Claireaux says. 'Workers at the fish farm watched us set up our equipment and thought we were very strange,' he recalls.

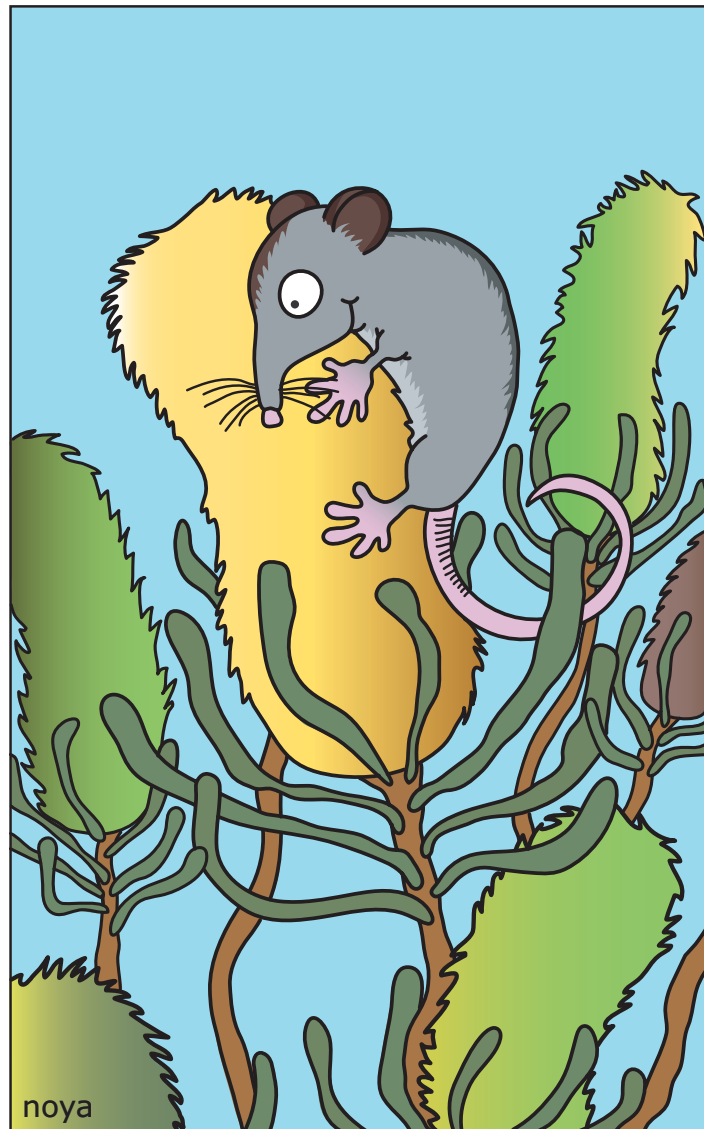
Finally, the team were ready to give Aubin's fish a cardiovascular workout and find out if poor swimmers have weaker hearts than good swimmers. They began by testing the swimming ability of 600 young rainbow trout weighing in at around 100 g. The tiny fish swam against a current until they were exhausted. The team picked out the first 60 fish to tire and labelled them as poor swimmers. They labelled the last 60 fish to tire, which were still going strong almost an hour later, as good swimmers. Nine months later, when the fish weighed a hefty 1 kg, the team placed the fish in the swim-tunnel for a second workout. They compared poor swimmers' oxygen consumption and arterial blood pressure and flow with that of good swimmers. As the team had suspected, cardiac and swimming performance are clearly linked; poor swimmers not only swim slower than good swimmers, they also have lower maximum metabolic rates and their hearts pump blood at a lower maximal rate. Since fish that were poor swimmers when they were young were still poor swimmers nine months later, their cardiac deficiencies are clearly detectable at an early age.

But the poor swimmers' misfortune didn't end there; the team found that they are also fatter than the good swimmers, and their hearts are abnormally rounded, whereas healthy fish have pyramid-shaped hearts. Claireaux explains that breeders select fish by placing them on a grid and keeping the plump fish that don't fall through the holes. So all this time they've been rearing obese fish with abnormal hearts rather than sporty streamlined fish! The team hopes that its results will convince fish farmers that a simple swim test, and not a grid, truly identifies the fittest fish.

10.1242/jeb.01645

Claireaux, G., McKenzie, D. J., Genge, A. G., Chatelier, A., Aubin, J. and Farrell, A. P. (2005). Linking swimming performance, cardiac pumping ability and cardiac anatomy in rainbow trout. *J. Exp. Biol.* **208**, 1775-1784.

THE COLOUR OF DINNER



Noya Miller is an artist living in London

Honey possums are unassuming little creatures. But their reputation for being rather boring changed when Catherine Arrese at the University of Western Australia reported that the tiny marsupials have three cone visual pigments instead of the more common two; their colour vision is better than that of most mammals. Honey possums dine on the nectar of bright *Banksia* flowers, so Arrese suggested that their enhanced colour vision might come in handy when they locate their meals. Petroc Sumner at Imperial College realised that he could easily test her prediction with the methods he was using to analyse primate colour vision. Julian Partridge, reading Arrese’s paper in his office at Bristol University, was thinking exactly the same thing. Sumner and Partridge both contacted Arrese, and soon

found themselves on a plane headed for the Australian bush to test her idea (p. 1803).

In Mount Lesueur National Park, Sumner and Partridge measured the light spectrum reflected from flowers and leaves using a teleradiometer nicknamed the “possum’s-eye-view” because it was perched on a tiny tripod at honey possum eye level. Then they modelled possum cones’ responses to these light spectra, and how easy it would be for possums to discriminate between flowers and neighbouring leaves. They found that honey possums’ ability to detect flowers against their natural background was better than the ability of other local marsupials. But the possums’ discrimination ability would be even better if they shifted their cones’ sensitivity to longer wavelengths.

So why haven’t the honey possums’ cones tuned in to longer wavelengths? Sumner and Partridge suggest a possible ecological explanation: the honey possums’ cones are in fact tuned to the best possible wavelength to detect the all-important subtle shift from an unripe green *Banksia* flower to a ripe yellow flower. If they adjusted their cones’ sensitivity, possums might lose the ability to discriminate between an inedible flower and one that will provide dinner.

10.1242/jeb.01646

Sumner, P., Arrese, C. A. and Partridge, J. C. (2005). The ecology of visual pigment tuning in an Australian marsupial: the honey possum *Tarsipes rostratus*. *J. Exp. Biol.* **208**, 1803-1815.

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