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

LIZARDS PULL A WHEELIE

Picture by Christofer Clemente

Why bother running on hind legs when the four you've been given work perfectly well? This is the question that puzzles Christofer Clemente. For birds and primates, there's a perfectly good answer: birds have converted their forelimbs into wings, and primates have better things to do with their hands. But why have some lizards gone bipedal? Have they evolved to trot on two feet, or is their upright posture simply a fluke of physics? Curious to find the answer, Clemente and his colleagues Philip Withers, Graham Thompson and David Lloyd decided to test how dragon lizards run on two legs (p. 2058).

But first Clemente had to catch his lizards. Fortunately Thompson was a lizard-tracking master. Driving all over the Australian outback, Clemente and Thompson eventually collected 16 dragon lizard species, ranging from frilled neck lizards to the incredibly rare *C. rubens,* found only on one remote Western Australian cattle station. Returning to the Perth lab, Clemente and Withers set the lizards running on a treadmill, filming the reptiles until they were all run-out.

Clemente admits that when he started, he thought that the lizards would fall into one of two groups; lizards that mostly ran on two legs, occasionally resorting to four, and lizards that never reared up. Not so. Even the lizards that he'd never seen on two legs in the wild managed an occasional few steps on their hind legs. In fact, the lizards' propensity for running on two legs seemed to be a continuum; *C. rubens* and *P. minor* spent only 5% of the time on their hind legs while *L. gilberti* spent 95% up on two.

Curious to know whether or not bipedalism has evolved, Clemente drew up the lizards' family tree and plotted on the percentage of time each species spent on their rear legs, but there was no correlation. The reptiles had not evolved to move on two feet. Something else was driving them off their front legs; but what?

According to Clemente, other teams had already suggested reasons for the lizards rearing up; maybe running on two legs was faster or more economical than running on all four. But when Clemente analysed the lizard running footage he realised that running on hind legs was more energetically costly, and the bipedal runners were no faster than the quadrupeds. Knowing that Peter Aerts had suggested that lizards improved their manoeuvrability by moving their centre of mass back towards the hips, Clemente wondered whether the lizards' front legs were leaving the ground because of the position of their centre of mass. Maybe they were 'pulling a wheelie'.

Teaming up with David Lloyd and modelling the running lizards' movements as the lizards accelerated, they realised that there was a strong correlation between the lizards' acceleration and their front legs pulling off the ground. Clemente explains that by moving their centre of mass back, a turning force acts on the lizards' torso; lifting it off the ground making them run upright.

So running on two legs is a natural consequence of the lizards' acceleration. Clemente adds that 'some dragon lizards have exploited the consequence and chosen to go bipedal because it gives them some advantage, but we have no idea what that advantage is'.

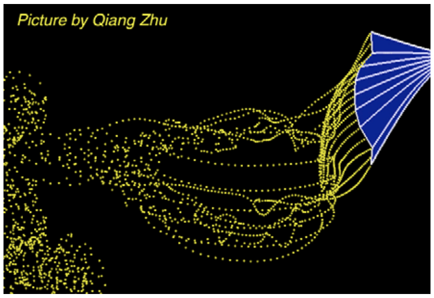
10.1242/jeb.020875

Clemente, C. J., Withers, P. C., Thompson, G. and Lloyd, D. (2008). Why go bipedal? Locomotion and morphology in Australian agamid lizards. *J. Exp. Biol.* **211**, 2058-2065.

FLEXIBLE FINS BEAT RIGID FINS

Humans are pretty good problem solvers, but we've still got a long way to go before we better evolution's ingenuity; which is why engineers turn to biology for inspiration. Self-cleaning glass and gecko sticky tape are just two examples of biologically inspired inventions. When it comes to moving under water, fish and cetaceans have a lot to teach us. Which is why Qiang Zhu and Kourosh Shoele have been investigating the propulsive properties of fish fins. Far from being rigid like the fins on submersible vehicles, most fish fins are flexible skeleton-strengthened membranes. Curious to know how fish fins function, Zhu decided to mathematically model a simulated fish tail (p. 2087).

Developing the algorithm to simulate fish tail function was a lengthy process. Zhu had to integrate fluid dynamics simulations while modelling the fin's strengthening rays as beams that could be stretched, twisted and bent. Modelling the tail as a membrane with nine embedded skeletal rays, he



simulated the membrane in two ways: as springs connecting adjacent rays and as panels that push against the water. Having built his computational tail, Zhu was able to run thousands of simulations where he controlled the movements of all nine tail rays independently, just like the muscles that control fin movements, computationally reproducing real tail movements and calculating the tail forces and efficiency as it wove from side to side.

According to Zhu, many of the simulations weren't very fish-like, but after months of calculation he had collected several dozen simulations that reproduced realistic tail beats. One of the first things that Zhu noticed was the flexible fin's efficiency; it was 20–30% more efficient than a rigid fin. 'More importantly,' says Zhu 'the performance is not sensitive to kinematic parameters': the tail does not have to be controlled as precisely as a rigid fin to produce the same performance. The flexible fin also wastes less energy, by generating sideways force, than a rigid fin, and reduces the waste even more when the top half of the tail beats out of synch with the bottom half. Zhu's calculations also showed that flexible tail fins generate some lift as the fish swims forward, as well as reproducing many of the fluid flow features that experimental biomechanists have seen when visualising the flows around swimming fish tails.

Zhu admits that he was surprised that the mechanical performance of flexible tails is so much less sensitive to the way they move than rigid tails, and suspects that this could be an important discovery for engineers designing propeller systems; 'it simplifies the control system' he explains. What is more, flexible fins are easily folded, doing away with bulky fins on modern submersible vehicles.

Having modelled how flexible tails propel fish through water, Zhu is keen to model how fish actively control the curvature of reinforcing fin rays to produce more complex fin shapes and movements.

10.1242/jeb.020867

Zhu, Q. and Shoele, K. (2008). Propulsion performance of a skeleton-strengthened fin. *J. Exp. Biol.* **211**, 2087-2100.

ELKS SCALE VOCAL HEIGHTS

We all know that hoarse feeling after a night in a noisy bar, but imagine how elk and European red deer stags feel building up to their annual recital? According to Tobias Riede, stags put on a performance of operatic proportions during the mating season, and all with virtually no preparation; we'd rip our vocal folds to shreds if we tried the same. What is more, Rocky Mountain elk stags hit high notes that should be out of their range. Their vocal folds should be much too long to produce such high-pitched calls. Curious to know how the elk's vocal folds perform these extreme feats, Tobias Riede and Ingo Titze, from the National Centre for Voice and Speech in Denver Colorado, decided to take a closer look inside the elk's voice box (p. 2144).

Fortunately for Riede, there is a ready supply of elk vocal folds in Colorado; hunters have to turn in the beasts' necks and heads so that the authorities can track the development of chronic wasting disease. Dissecting the tissue to see if the vocal fold structure accounted for the elk's high pitch and remarkable resilience, Riede soon realised that there were no unusual features that could account for the vocal folds' extreme performance. The elk's vocal folds were composed of a muscle, covered in a flexible epithelium linked by a ligament, much like other animals'.

However, it was clear that the elk vocal folds were a much closer approximation to human vocal folds than other animals. Riede explains that the ligament in dog vocal folds tends to be quite small, but the elks' were relatively thick and long; just like the ligament in human vocal folds. Which makes elk vocal folds a good model for human vocal folds, despite being three times the size.

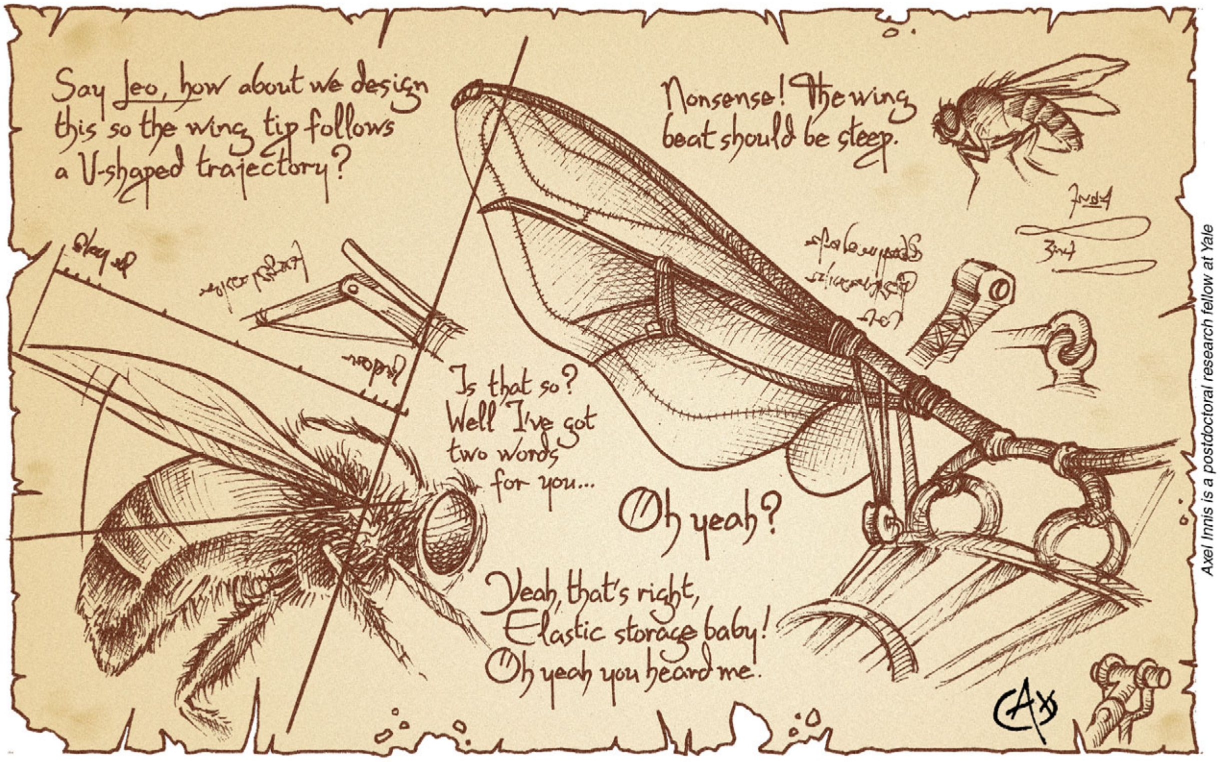
Having found that the elk's vocal folds look much like ours, Riede decided to test the tissue's material properties to see if they accounted for the animals' high-pitched voices. According to Riede, one of the ways for animals to hit the high notes is to stretch the vocal folds, but elks would have to apply 9 times as much tension as humans for their long vocal folds to hit the same notes. Had elk evolved a stronger ligament and epithelium to allow them to scale the vocal heights? Slowly stretching the vocal fold epithelium and measuring the force applied, it was clear that the tissue was as floppy as other creatures'. And although the ligament was slightly stronger than human vocal fold ligaments, it wasn't 9 times stronger. So neither the vocal fold's structure or its material properties can account for the animal's high pitch.

Riede suspects that there is something else going on, but he's not sure what. He suggests that the vocal folds may not vibrate along their full length, either because a muscle protrusion, part way along the fold, effectively shortens the vibrating tissue's length, or the tissue's flexibility varies, shortening the vibrating section of the vocal fold and allowing elk stags to hit the high notes.

10.1242/jeb.020883

Riede, T. and Titze, I. R. (2008). Vocal fold elasticity of the Rocky Mountain elk (*Cervus elaphus nelsoni*) – producing high fundamental frequency vocalization with a very long vocal fold. *J. Exp. Biol.* **211**, 2144-2154.

INSECT FLIGHT: THE DRONE FLY PERSPECTIVE



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Rare example of Leonardo da Vinci's somewhat unusual brainstorming style.

At first glance, the humble fruit fly doesn't have much in common with the rat. However, take a closer look at the literature on insect flight, and it's clear the fruit fly is a very popular organism. However, there are some drawbacks to working with fruit flies; their size for a start. Which is one of the reasons that Yanpeng Liu and Mao Sun have turned their attention to the yellow and black drone fly (p. 2014); it's bigger and it's happy to hover in a brightly lit lab. Filming the hovering insects with three cameras at 5000 frames s^{-1} and comparing the insect's performance with that of the fruit fly (Fry et al., 2005, *The Journal of Experimental Biology*, **208**, 2303-2318), Liu and Sun were able to see that the insects' flight patterns are rather different. The drone fly moves its wings in a shallow U shape while the fruit fly's wing beats were much steeper. Reconstructing the drone fly's flapping movements in a computer simulation and calculating the miniscule forces that keep it aloft, the team found that instead of relying on drag, the drone fly relies entirely on lift forces to remain airborne and elastic energy storage may supply 40% of the power for hovering flight.

10.1242/jeb.020859

Liu, Y. and Sun, M. (2008). Wing kinematics measurement and aerodynamics of hovering droneflies. *J. Exp. Biol.* **211**, 2014-2025.

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