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.

LONG MEMORIES


Picture provided by Ken Lukowiak

It's an undignified way to go: ending your days as another animal's dinner. Rather than risk being found by or trying to escape from a crayfish predator, pond snails (*Lymnaea stagnalis*) take evasive action. They respond to a crayfish's smell by crawling above the waterline to escape their shell-crushing claws. But since most anti-predator responses have been tested in wild-caught snails, researchers didn't know if the snails' predator response is innate or learned. Using snails that have been bred as a lab colony since the 1950s, Ken Lukowiak and his colleagues at the University of Calgary, Canada, investigated whether snails that have never encountered a crayfish still have anti-predator responses (p. 4150).

The team exposed snails to pond water, pond water that had contained crayfish, and boiled crayfish water. Testing two of the snails' vigilance behaviours after exposure, they found that snails exposed to crayfish water righted themselves more quickly when they were placed on their backs. These snails also took longer to emerge from their shells and start exploring their environment. When a shadow passes over a snail's breathing tube, indicating danger, they withdraw the tube into their shell until it is safe to emerge again. The snails exposed to crayfish water were more likely to pull in their breathing tube when exposed to a shadow, indicating that crayfish water made the snails more vigilant to the presence of a predator than pond water or boiled crayfish water.

Because snails escaping crayfish are known to slither above the water's surface, the team wanted to know if exposure to crayfish water changed their breathing behaviour, since snails near the surface rely less on respiring through the skin and more on breathing through their breathing tube. They found that crayfish water caused snails to open their breathing tube more frequently, meaning that they breathed for longer, consistent with how they would behave when a real predator is about.

Having shown the behavioural effects of crayfish water, the team then moved on to the physiological effects. They found that crayfish water didn't increase the heart rate in the snails; 'we expected it to go up', Lukowiak says, 'it's possible that the snails don't want to expend energy keeping the heart rate up'. Although there was no difference in the overall oxygen consumption in snails exposed to pond water and crayfish water, in the first 8 min of the experiment the crayfish water snails consumed oxygen more slowly than the others in pond water. This suggests that the snails go into an energy saving mode when a predator is nearby.

Finally the team focussed on the nervous system, to see if there was a neuronal anti-predator response. They recorded the electrical activity of a neuron called RPeD1 using microelectrodes. This neuron initiates the rhythmic activity that drives breathing behaviour and is also 'absolutely necessary for memory formation', says Lukowiak. In crayfish-water exposed snails, spontaneous firing activity, the number of spike bursts and number of spikes in each burst all went down, showing that predator detection has a direct influence on the neuron. Although the team still have to work out the link between the neuron's activity and the behavioural and physiological changes they saw, 'the most important implication is that the snails have maintained a knowledge of who's the predator', Lukowiak says, 'there is a genetic memory'.

10.1242/jeb.014274

Orr, M. V., El-Bekai, M., Lui, M., Watson, K. and Lukowiak, K. (2007). Predator detection in *Lymnaea stagnalis*. *J. Exp. Biol.* **210,** 4150-4158.

Laura Blackburn

FLY WITH THE WIND

To get to where they need to go without crashing, fruit flies (*Drosophila melanogaster*) turn away from so-called visual expansion, caused by the image of a looming object expanding on the retina. But the fly's world is complex, and 'any insect flying forwards is going to experience a certain degree of visual expansion', says Seth Budick of the California Institute of Technology. If flies always turned away from this visual expansion, then they would never get anywhere. The question is, what keeps flies flying in a straight line?

Budick and his colleagues Michael Reiser and Michael Dickinson used a simple magnetic tether to find out what keeps flies on the straight and narrow (p. 4092). Each fly had a steel pin attached to its back, and the pin's end sat in a small depression in a minute sapphire block attached to a magnet fixed directly above the fly. This set-up allowed the flies to swivel on the spot and orientate themselves in different directions.

The team knew that some flying insects tend to orientate themselves so that the wind is blowing in their faces, so first they investigated how flies orientated at different wind speeds. By blowing winds of 0–1 m s^{-1} over the flies, they found that at all wind velocities, the flies turned themselves around so that they faced into the wind. However it was not clear how much the flies were blown about by the wind, and how much they were actively orientating. To find out, the team tethered both dead and live flies and repeated their experiment, finding that although dead flies were blown to face into the wind, the live flies still orientated more accurately into the wind, especially at lower wind speeds.

Having shown that flies respond to wind stimuli and turn into the wind, the team wondered which of the flies' sense organs were sensing the wind and helping them fly straight. Results from other insects indicate that the Johnston's organs, sense organs near the base of the antennae that respond to antennal movements, could play a role. The team glued segments on one or both of the antennae together, which removes feedback to the Johnston's organs. The team found that flies needed both antennae intact to orientate properly into the wind, especially at lower wind speeds. This indicates that feedback from the Johnston's organs, caused by wind movements, might help flies to fly in a straight line.

But what about visual stimuli? In the final part of the experiment, the team exposed the flies to different wind speeds and to a pattern representing the visual expansion that a fly would experience during flight. They did this using a cylinder lined with light emitting diodes surrounding the tether, with gaps in front of and behind the fly to let the wind pass through. When the team presented the visually expanding stimulus from the downwind direction, the flies flew very reliably into the wind, turning away from the 'looming' object. When they presented the expanding stimulus from the upwind direction, however, the flies still generally orientated into the wind, and didn't turn away from it. They mostly turned away only when the pattern expanded very quickly. This shows that there is a trade-off between flying into the wind, and avoiding expanding visual stimuli. By using feedback from the antennae, this trade-off makes sure that flies don't always turn away from visual expansion, and reach their destination while still avoiding crashes.

10.1242/jeb.014258

Budick, S. A., Reiser, M. B. and Dickinson, M. H. (2007). The role of visual and mechanosensory cues in structuring forward flight in *Drosophila melanogaster*. *J. Exp. Biol.* **210,** 4092-4103.

Laura Blackburn

EAGLE WINGS DEPLOY LEADING EDGE FLAPS

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When Graham Taylor and Adrian Thomas from the University of Oxford were asked to consult for a BBC programme fitting minute cameras to wild animals, they knew they were in for a treat. Taylor recalls that when he saw the eagle footage, he was struck by a flap of covert feathers from the lower surface of the eagle's wings that flipped out as the bird came in to land; 'the feathers looked strikingly like the leading edge flaps used on high performance aeroplanes', he says. According to Taylor hydraulically driven flaps prevent these aircraft from stalling as they come in to land or perform steep manoeuvres; 'they extend the wing's usual range of performance', he explains. Could the eagle's covert feathers perform the same function? Having teamed up with Anna Carruthers, Taylor and Thomas decided to film the wings of a free flying bird to find how the covert feathers function in free flight (p. 4136).

But finding the right bird to study proved tricky. Taylor explains that most falconers train their birds for short flights. Fortunately Thomas knew the World Champion Danish paraglider pilot Louise Crandal who had a steppe eagle, called Cossack, trained to soar next to her as she glided. Better still, the eagle was trained to fly wearing a camera. The team travelled to Cossack's Danish home in spring 2006, strapped a tiny wireless spy camera to the eagle and let him glide in sea cliff updrafts. Taylor remembers that 'it was bitter, the sea was frozen', but it was well worth the discomfort. The team could clearly see the wing's leading edge feathers flip out for less than a second when Cossack encountered the cliff top updraft, perched and, most surprisingly, also at the end of every wing beat.

Realising that it took less than 60 ms to deploy the leading edge flap, the team switched to tripod-mounted high-speed cameras to capture the movement in fine detail. The precise high resolution films of the wings' activity allowed the team to analyse the flap's deployment quantitatively. They saw that the under wing covert feathers flip out passively; instead of being moved by erector muscles at the base, the feathers were moved by the air 'like a Mexican wave moving along the wing until all were deployed to form a continuous flap-like structure', says Taylor.

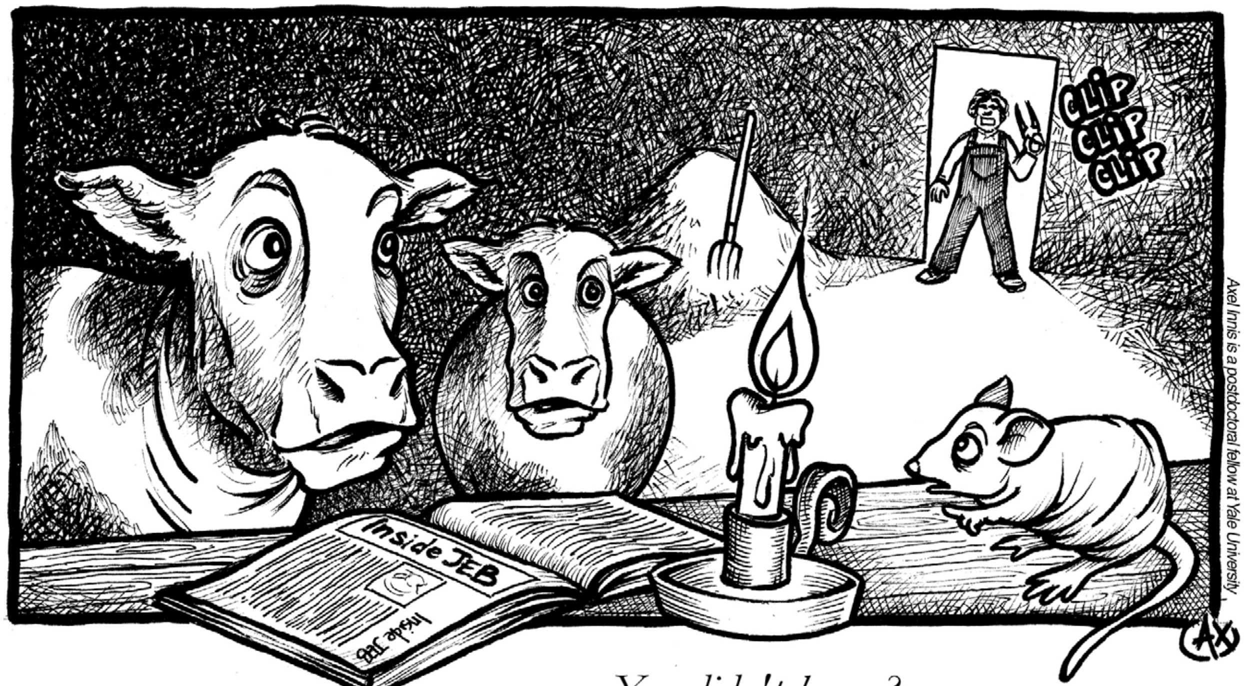
Looking for other wing structures deployed during manoeuvres, the team noticed that the alula also swept out from the wing as Cossack perched. Taylor explains that the alula is a group of feathers at the front of the wing which are attached to a moveable joint (the remnants of the bird's thumb). The feathers were thought to be actively deployed during manoeuvres, but when the team scrutinised Cossack's landing sequence they realised that instead of moving from the base, the feathers were initially lifted by the airflow. Like the covert feathers, the alula was initially moved passively. The team speculate that sensors in the alula detect the feather's passive movement before triggering the alula joint to move, only deploying the alula when the wing is in danger of stalling.

10.1242/jeb.014241

Carruthers, A. C., Thomas, A. L. R. and Taylor, G. K. (2007). Automatic aeroelastic devices in the wings of a steppe eagle *Aquila nipalensis*. *J. Exp. Biol.* **210,** 4136-4149.

Kathryn Phillips

LIMITS ON LACTATION



Axel Innis is a postdoctoral fellow at Yale University

You didn't know?
They say shaving can really boost your milk production...

Nursing mouse mothers must be hungry all the time. Feeding multiple greedy mouths takes a lot out of a girl. So what limits the amount of energy a nursing mother can supply her litter? According to John Speakman, a mother is limited by the amount of energy she can take in, but the aspect of her physiology that imposes the limit wasn't clear. Having previously found that the gut and mammary gland did not restrict energy intake, Speakman, Elżbieta Król and Michelle Murphy decided to test whether lactating mice are constrained by the amount of waste heat generated by digestion and milk production (p. 4233). The team shaved some nursing mice to see if removing their insulation allowed them to cool off, and increase their energy intake and milk output. The team monitored the mothers' milk production and found that it was 15.2% more than unshaved mums, and the shaved mums' youngsters were 15.4% bigger too. So the amount of heat that a mammal can dispose of seems to limit the amount of energy they can take in, which could have far reaching consequences for evolution, not least in our warming climate.

10.1242/jeb.014266

Król, E., Murphy, M. and Speakman, J. R. (2007). Limits to sustained energy intake. X. Effects of fur removal on reproductive performance in laboratory mice. *J. Exp. Biol.* **207,** 4233-4243.

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