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

PENGUINS PLAN DIVES

Cassondra Williams

Diving seems effortless for penguins. Plunging beneath the surface, emperor penguins regularly remain submerged for up to 12 min by carefully managing their oxygen reserves. Paul Ponganis from the Scripps Institution of Oceanography explains that emperors diving from isolated ice holes fuel the dive aerobically for the first 5.6 min and supplement the remainder of the dive with anaerobic metabolism. However, when Ponganis compared the aerobic dive limit for ice hole diving penguins with estimates of the aerobic dive limit for freely foraging animals, it appeared that the free ranging birds were able to sustain the aerobic portion of a dive for up to 8 min. What were the free ranging birds doing to eke out their oxygen supply for an additional 2.4 min? Ponganis and an international team of collaborators travelled to the Antarctic to find out how the birds extend their aerobic dive limit (p. 2854).

Attaching swim speed/acceleration data loggers to penguins diving in open water and through an isolated ice hole, Katsufumi Sato, Greg Marshall, Gerald Kooyman and Ponganis allowed the free ranging birds to venture off foraging for a couple of weeks while the ice hole divers dipped in and out of the water. 'From the acceleration data you can see a surge every time the animal strokes with its wings, so you can count the number of peaks per dive to get the stroke rate pattern,' explains Ponganis. He adds, 'We expected that stroke rate would be lower in dives at sea and because of that there would be less muscle work and less oxygen consumption and that would explain how these birds dive as long and as frequently as they do.'

However, the freely diving birds were stroking faster. The birds were not extending their aerobic dive limit by beating their wings more slowly to conserve oxygen. And when the team compared the length of time spent by birds at the surface recovering from dives, the free divers spent no more time at the surface than the ice-hole divers. 'Then we became interested in looking at the diving air volume, how much air they take down with them, because it is a significant proportion of the oxygen store,' explains Ponganis.

'Knowing the swim speed, depth and body angle during a penguin's passive glide to the surface at the end of a dive, we can make calculations – based on a buoyancy model developed by Katsu Sato – as to how much air is in the respiratory system,' says Ponganis. Assuming that the penguins did not exhale while submerged, the team found that the penguins carried more air as they extended their dives down to 300 m. The penguins seemed to anticipate how deep they would dive and adjusted the amount of air they carried down accordingly.

However, penguins that dived between 400 and 500 m appeared to be carrying less air than the birds that only dived to 300 m. 'They probably exhaled prior to the final segment of the dive and that is why we were getting the low volumes, and we are trying to pursue that,' Pongains says.

Most amazingly, the team recorded one dive where an emperor penguin remained submerged for a record breaking 27.6 m. According to Ponganis, the accelerometery data show that after it emerged from the water the penguin just lay on the ice for 6 min before it stood, took another 20 min before it started walking and then waited a further 8.4 h before it ventured back into the water. 'This animal was exhausted,' says Ponganis, who suspects that the dive was extended when the pack ice shifted above the penguin's head, blocking its escape route.

10.1242/jeb.063255

Sato, K., Shiomi, K., Marshall, G., Kooyman, G. L. and Ponganis, P. J. (2011). Stroke rates and diving air volumes of emperor penguins: implications for dive performance. *J. Exp. Biol.* **214**, 2854-2863.

Kathryn Knight

BOX JELLY'S SIMPLE EYES CONTROL MOTION

Cluttered mangrove swamps may not seem to be the best locations to set up home if you're a delicate jellyfish, but this is exactly where you'll find tiny *Tripedalia cystophora* box jellyfish. Guided by their visual system of 24 simple eyes, the animals successfully avoid contact with damaging mangrove roots and assemble in shafts of light where their favourite copepod meals congregate. Ronald Petie from Dan Nilsson's group in Lund University, Sweden, explains that Nilsson's team has studied the jellyfish's vision extensively, but little was known about how

they use vision to control their movements. Petie says, 'I thought of combining vision and biomechanics to see how these eyes control the animal's steering'. Explaining that box jellyfish control the direction of their propulsive jet by asymmetrically contracting the bell and a membrane ring around the bell's lower edge, known as the velarium, Petie, Nilsson and Anders Garm decided to find out how different lighting patterns affect the way the jellyfish contracts its bell (p. 2809).

Explaining that the jellyfish's eyes are arranged in four clusters called rhopalia, Petie says, 'I wanted to be able to film the jellies from underneath because the rhopalia are quite dark and I could use automatic tracking of the rhopalia to analyse their movements'. Designing a temperature-controlled box where he could tether the jellies by the top of their bell, Petie placed four blue–green LED panels around the box to produce different light stimuli. Then he gently placed a jellyfish in the box, so that each rhopalium looked square onto one of the green LED panels and allowed the jellyfish to become acquainted with its setting. Finally, he turned off one of the panels – to simulate the jellyfish approaching a dark object – and filmed the animal's responses in infrared light.

After switching off each panel in turn and analysing the movements of the dark rhopalia that track each side's contraction, Petie realised that the contraction in the side of the jellyfish closest to the dark panel was delayed relative to that in the other three sides, which continued contracting in synch. And when he looked at the velarium, he realised that the side closest to the dark panel remained relaxed while the other three sides contracted, probably directing the pulsatile jet towards the dark panel to propel a free jellyfish toward the light.

So how do the jellyfish's eyes control this behaviour? Petie explains that instead of looking outward, each of the jelly's four rhopalia are directed inward, looking through the animal's transparent body. This means that the rhopalium closest to the dark panel is facing toward the illuminated panels, while the other three rhopalia are directed – to a greater to lesser degree – toward the dark panel. He also explains that each rhopalium houses a visually controlled pacemaker; they interact together to control contraction of the jellyfish's entire bell and motion. Somehow the contraction due to the pacemaker adjacent to the light becomes delayed relative to the other three, allowing the jelly to orient its propulsive jet to swim away from looming dark objects and home in on light beams packed with tasty copepods.

10.1242/jeb.063271

Petie, R., Garm, A. and Nilsson, D.-E. (2011). Visual control of steering in the box jellyfish *Tripedalia cystophora*. *J. Exp. Biol.* **214**, 2809-2815.

Kathryn Knight

Ltor PROCESSES MALE TÚNGARA MATING CALLS

It's a warm Panamanian evening and male Physalaemus frogs are out crooning to their females. But with many other species serenading in the night's air, how do túngara females pick out their mates from the rest of the hullabaloo? Lisa Mangiamele and Sabrina Burmeister from the University of North Carolina at Chapel Hill explain that, 'Sensory systems respond selectively

to information in the environment – extracting some stimulus features while discarding others.' According to Burmeister, females respond to the drop in frequency as the male's whine glissandos from 900 to 400 Hz. They also respond equally well to a synthesised two-tone call that drops from 800 Hz to 500 Hz tone; the underlying two-tone signature is all that a túngara female needs to correctly select a mate of her own species. Knowing that a transcription factor, egr-1, is produced in brain tissue in response to stimulation, the duo decided to identify the regions of the female brain that are involved in processing the males' serenades by looking for evidence that the *egr-1* gene had been activated in the brain after listening to natural and simulated mating calls (p. 2911).

The duo found that one tiny region of the female's brain, the laminar nucleus of the torus semicircularis (Ltor), responded to both the males' whining glissando and the signature two-tone simulation, suggesting that Ltor is the 'neural analyser for call recognition'. Other regions of the auditory brainstem and thalamus also responded to the males' full-spectrum call, but they failed to activate *egr-1* in response to the two-tone signature, leading the duo to conclude, 'Ltor activation is sufficient to explain species recognition decisions for female túngara frogs.'

10.1242/jeb.063263

Mangiamele, L. A. and Burmeister, S. S. (2011). Auditory selectivity for acoustic features that confer species recognition in the túngara frog. *J. Exp. Biol.* **214**, 2911-2918.

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