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.

FINDING THE PERFECT ROOST

Having studied roost selection by bats for his PhD, Ireneusz Ruczyński was struck by the fact that researchers knew a great deal about how bats find prey using echolocation, but no-one knew how they actually find somewhere to roost after a night's hunting. Teaming up with sensory ecologists Elisabeth Kalko and Björn Siemers, Ruczyński took on the challenge of designing a lab-based experiment to find out how noctule bats (*Nyctalus noctula*) from the Białowieża forest in Poland find their ideal tree roost (p. 3607).

Bats change roosts frequently, probably to reduce predation risk and exposure to parasites. As Ruczyński explains, one of the problems of investigating roost finding is the assumption that a bat's echolocation is good enough: 'Finding prey in a forest isn't easy', he says, so it is likely that roost finding is also challenging for the bats. The team suspected that the bats would probably use a combination of cues, such as echolocation, vision and smell to help them find a cavity.

First the team trained the bats to find roosting cavities drilled into larger alder logs placed upright in a lit flight room. Each log had 8 cavities carved into it, which were a similar size to the cavities that the bats use in nature. At first, the bats would land on the log and find one of the entrances by chance, but once they had crawled inside an experimenter rewarded them with a tasty mealworm. The bats quickly learned to associate the mealworm treat with finding a cavity, so as their performance improved the team progressively blocked up each of the entrances until only one cavity was left open.

Once each of the bats could find most of the entrances within 5 minutes, using just their echolocation and vision, the team started experiments to find out which cues improved the bats' ability to find an entrance. They found that it took the bats around 40 s searching to find an entrance, and that they would either find entrances in flight, landing very close to the entrance and crawling in, or they would land on the log and find the entrance by crawling around on it. The team expected that low light levels, similar to those experienced in the early evening when the bats are active, would help them find the entrance, however, their performance didn't improve over echolocation alone. Putting cloths smelling of other bats in the holes didn't improve performance either, while heating up the inside of the cavities only helped the bats find the entrances a little quicker when they were crawling around on the log. When the team played echolocating calls recorded from roosting bats out of a speaker in the cavity, though, the bats found the entrances quicker, in around 20 s. They were also more likely to find the entrance from flight, and spent less time finding the entrance by crawling.

This shows that finding a roost from a distance is difficult and that social cues are important for helping bats to find a roosting site. 'It means that sensory constraints may promote sociality', Ruczyński says. He suspects that when bats find good tree holes they remember where they are, as they are known to use the same cavities again and again.

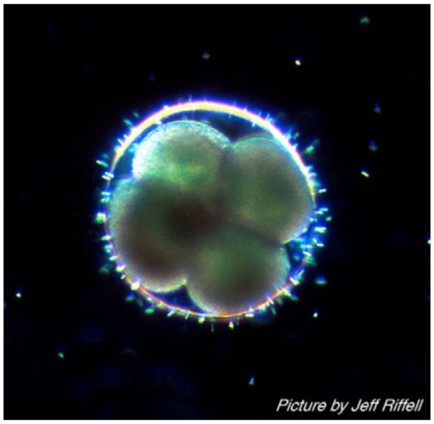
10.1242/jeb.012500

Ruczyński, I., Kalko, E. K. V. and Siemers, B. M. (2007). The sensory basis of roost finding in a forest bat, *Nyctalus noctula*. *J. Exp. Biol.* **210**, 3607-3615.

GO WITH THE FLOW

Red abalone (*Haliotis rufescens*) live deep in the cracks and crevices in rocky reefs, and have probably retreated there because of predation pressure from sea otters, who like how they taste almost as much as humans do. Abalone are external fertilisers, releasing eggs and sperm into the water, which flows at speeds 2–3 times slower than the exposed sea above. But how do the sperm find eggs? Because the gametes are so small, they live in a microscopic world of viscous forces, dominated by laminar shear flow. This is where layers of fluid slide past each other and don't mix, and looks like 'stirring honey in a pot', says Jeff Riffell. With his colleague Richard Zimmer, Riffell investigated how shear, the linear change in water velocity with distance, affects sperm-egg interactions, and hence fertilisation success (p. 3644).

Having measured water flows in the field, the team created shear flow conditions in



the lab, using an apparatus consisting of a smaller cylinder placed inside a larger one, with a layer of water in the gap in between them. By turning the two cylinders in opposite directions, the water layers turn in the direction of each cylinder. To find out how shear flow affected fertilisation success, the team filled the gap with seawater and sperm at different concentrations. They rotated the cylinders at different speeds to create different shear flows, and then added the eggs, taking a water sample 15 s later and filtering out the eggs. They found that the percentage of fertilised eggs at each of the sperm concentrations peaked at the low shear of 0.1 s^{-1} and then declined as shear increased up to 10.0 s^{-1}.

To find out how shear affects sperm behaviour and gamete interactions, the team added eggs and sperm to the apparatus at the same time. To monitor these encounters, the team relied on the fact that there is a predictable cross-over point between the two water flows created by the cylinders, where the two shear flows travelling in opposite directions effectively cancel each other out. The gametes get stuck in this cross-over point for up to 30 s at a time, experiencing shear on both sides in equal but opposite directions. Using a laser sheet to illuminate the stationary gametes, they recorded their interactions onto video and used tracking software on a computer to plot the movements, taking into account the flow of the water. The sperm swam fastest and were most likely to encounter eggs and fertilise them at 0.1 s^{-1} shear; they were less successful at higher shears. This is because as shear increases, so does egg rotation, which decreases fertilisation success as the sperm are more likely to slip around the egg's surface. At low water speeds, sperm swam faster than water flow, so they could overcome the effects of rotation.

'The fluid environment is playing a very important role in the evolution of gamete morphology and behaviour', says Riffell. This explains why the greatest fertilisation success occurred in conditions closest to the natural environment, suggesting that the abalone gametes have evolved to make the most of where they live. This could also have conservation implications for the endangered abalone, allowing scientists to recommend where it is best to transplant them based on an environment's shear flow, which would maximise fertilisation success and therefore survival.

10.1242/jeb.012518

Riffell, J. A. and Zimmer, R. K. (2007). Sex and flow: the consequences of fluid shear for sperm–egg interactions. *J. Exp. Biol.* **210**, 3644-3660.

STICK-SLIP ACOUSTICS

California spiny lobster (*Panulirus interruptus*), and their relatives have been tormenting fishermen for centuries with their anti-predator rasp; according to Sheila Patek from the University of California, Berkeley, it's an 'abrasive, obnoxious, squawking noise'. Despite this, Patek and her colleague Joe Baio have characterised for the first time the unusual mechanism – stick-slip friction – that spiny lobsters use to make sounds (p. 3538).

Other noisy creatures such as crickets generate sounds by rubbing a cuticular 'scraper' over a toothed 'file'. In katydids, the scraper can get stuck behind the teeth in the file and suddenly release, moving over many teeth at once and generating higher-frequency sounds. Lobsters, however, rely on the same mechanisms that underlie the earthquakes and the excitation of bowed stringed instruments: stick-slip friction. In a stick-slip system, the friction and elastic energy storage between the two surfaces opposing each other means that one surface becomes 'stuck' to the other, before the pressure builds up and it slips across the other surface, creating a sound.

The team's microscopy images showed that lobsters have a soft-tissue ridged 'plectrum', a small extension at the base of their antennae, which they rub against a hard 'file' covered in knobbly 'shingles' under each eye. The shingles, around 12.3 µm long and 7.3 µm wide, oppose the movement of the plectrum ridges, which are around 2.3 mm long and 0.1 mm wide. As the plectrum sticks and slips over the file, it rubs over thousands of shingles.

To test whether plectrum movements correlate to sound production, Patek and Baio filmed rasping lobsters at 3000 frames per second while simultaneously recording the generated sounds. Comparing the timing of the plectrum movements with the sounds, they found that the physical movements, lasting around 3.6 ms, were shorter than the recorded sounds at 7.9 ms. This difference was caused by the microphones picking up acoustic reverberations in the tank. They also found that as plectrum speed increased, the rate of pulses in each rasp and the volume of the rasps also increased.

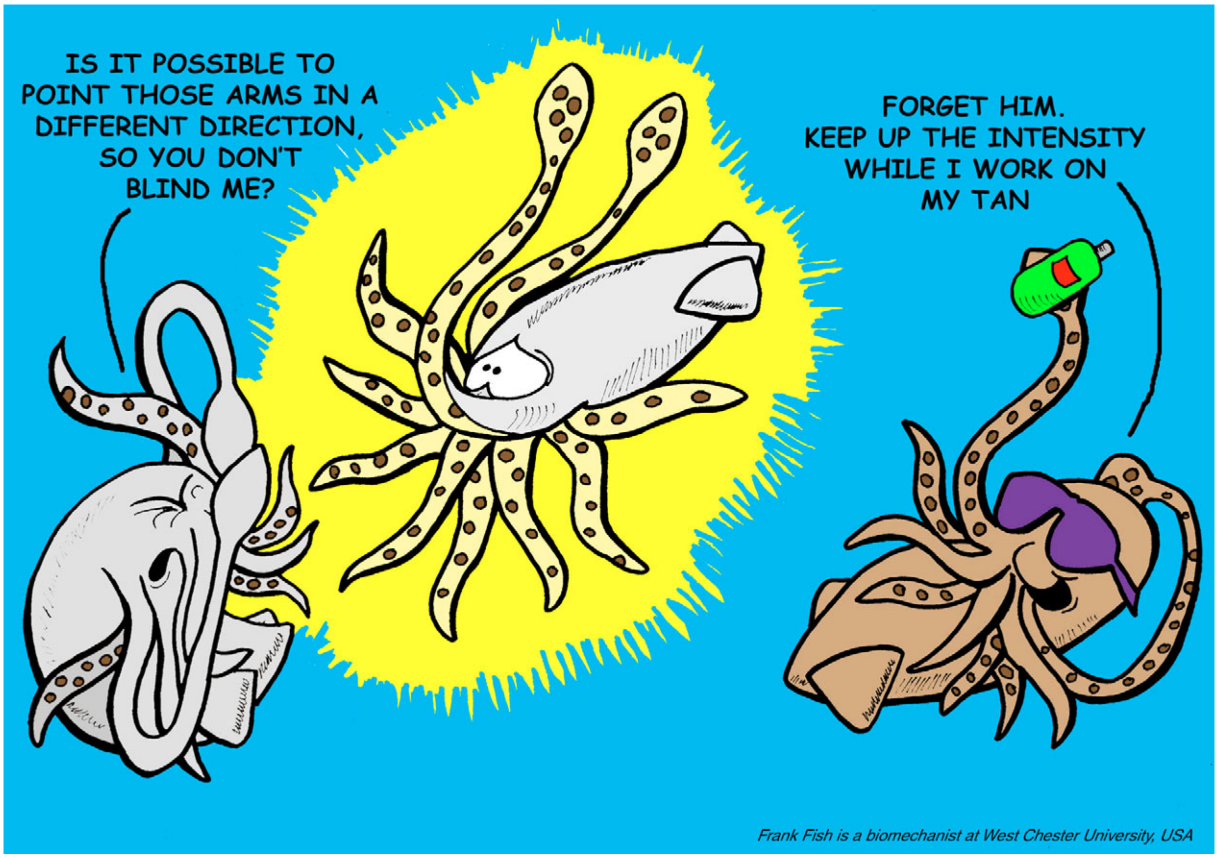
Their results led Patek and Baio to expect that by moving the plectrum at different speeds, they would be able to make louder or quieter noises. So to investigate further they extracted the plectrums and files from a group of lobsters and glued them to separate force transducers that measured the frictional forces generated as they moved the plectrum over the file. What they found was unexpected. Despite moving the plectrum at a constant 10 cm s^{-1}, the actual plectrum speed during slip varied between 7 and 76 cm s^{-1}. This suggested that the lobsters don't have much control over rasp volume. The coefficient of friction – the frictional force between the plectrum and the file relative to the downwards forces between the two surfaces – decreased greatly when the plectrum started to move. On the whole, the faster the plectrum moved, the bigger the change in the frictional forces, and the louder the sound.

Patek suspects that the lobsters should be able to control their rasping, and thinks that they could do this by pushing the plectrum and file together harder, so that more force is needed to push the plectrum across the file. This is like someone pushing a pencil eraser into a table, making it much harder to push it forwards than if it was just resting on the table. Working out how much control the lobsters do have, though, will keep the researchers busy for a while yet.

10.1242/jeb.012526

Patek, S. N. and Baio, J. E. (2007). The acoustic mechanics of stick–slip friction in the California spiny lobster (*Panulirus interruptus*). *J. Exp. Biol.* **210**, 3538-3546.

CONSTANT REFLECTIONS



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Despite being colour-blind, squid and cuttlefish live in a visually complex world, using polarised light reflected from their mirror-like iridophores to communicate with each other. A stripe of high-reflectance iridophores on their arms reflects the most highly polarised light. But how do the reflections change as the animals move their super-bendy arms? To find out, Tsyr-Huei Chiou and colleagues took samples of squid and cuttlefish arms and examined reflections from the stripe under a microscope as they rotated and tilted the samples through different angles while shining light on them (p. 3624).

They found that the posture of the arm had little or no effect on the *E*-vector of the reflected light, which describes the plane of orientation of a polarised light wave perpendicular to the direction the light wave is travelling. Arm orientation also didn't affect the partial polarisation, which is how much the light was polarised, and the spectral reflectance, which is the ratio of the light reflected back from the surface compared to the amount of light hitting the surface.

When they changed the angle of the light hitting the arm, however, the partial polarisation and the spectral reflectance changed, making the reflected colour appear less saturated. Interested to know how the reflections were staying relatively constant, the team examined the arms under an electron microscope, finding that the arm stripes are made up of several groups of multi-layer platelets within the iridophores, which are all oriented at different angles. This produces a constant reflection of polarised light over a range of viewing angles, and suggests that cuttlefish and squid can send out reliable polarisation signals to each other regardless of the orientation of their arms.

10.1242/jeb.012492

Chiou, T.-H., Mäthger, L. M., Hanlon, R. T. and Cronin, T. W. (2007). Spectral and spatial properties of polarized light reflections from the arms of squid (*Loligo pealeii*) and cuttlefish (*Sepia officinalis* L.). *J. Exp. Biol.* **210**, 3624-3635.

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