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

COLD SCALLOPS RELY ON RUBBER

Picture by Luke Miller

Scallops are one of the few bivalve molluscs that can swim. They are not graceful and they are not fast, but they can move when threatened. While temperate and tropical scallops are only just able to swim in warm waters, it is remarkable that Antarctic scallops manage at all in Antarctica's exceedingly cold and viscous environment; yet they have somehow overcome this challenge. However, Mark Denny and Luke Miller were quite surprised that the only evolutionary adaptation to the cold they could find was in the properties of the rubber hinge that holds the shell together (p. 4503).

Scallops swim using jet propulsion. The two halves of the shell – the valves – quickly clamp together when the muscle connecting them contracts and the water trapped inside is squirted out. When the muscle relaxes, the properties of the rubber hinge cause the valves to spring open. But having to move a large flat shell through water and having to expel the trapped water is a huge strain on the scallops. 'It's my impression that they are hanging on to their swimming ability by the tips of their toes', remarks Denny, a biomechanist who studied these scallops while on a trip to the Antarctic.

Denny and Miller started checking for adaptations that would help these cold-water scallops to swim. The most obvious change is that the shell is much lighter and easier to lift off the seabed. This may be an adaptation for swimming, or it may be down to the fact that there are far fewer predators in the Antarctic. While the thin shell will help, Denny expected to find that the muscle that closes the shell would be larger, so that the shell can clap open and closed at the same rate as the temperate species. However, the Antarctic muscle was only half the size of temperate scallops', which makes sense as the lighter shell is fragile and a large muscle might pull away from the shell or even break it when snapping shut. Unfortunately, these two adaptations cancel each other out and fail to explain how the Antarctic scallops swim in freezing conditions.

The only other explanation for the Antarctic scallop's mobility was the mechanism that springs the shell open again – the hinge. Made of a protein called abductin, this biorubber has several properties that could make a difference. Denny explains that abductin is an entropic elastomer; as the hinge is stretched the tangled protein chains rearrange and become more ordered, but quickly spring back into their original disordered state when the hinge is released. Unfortunately, entropic elastomers become less stiff and more viscous when cooled, making abductin a strange choice for a scallop that lives in the cold.

However, when Denny and Miller measured the hinge's resilience – the property that returns the rubber back to the original state – they found that it was slightly higher than temperate abductin's resilience, giving the cold-adapted molluscs the extra edge they need to keep moving in icy waters. Denny comments, 'It is one of the intriguing things about evolution – it can be a minor something that it comes down to'. In this case, that minor something appears to be enough to keep these scallops swimming.

10.1242/jeb.02604

Denny, M. and Miller, L. (2006). Jet propulsion in the cold: mechanics of swimming in the Antarctic scallop *Adamussium colbecki*. *J. Exp. Biol.* **209**, 4503-4514

Sarah Clare

EAVESDROPPING TO STAY ALIVE

Luke Remage-Healey still recalls the day he first suspected that gulf toadfish can listen in on hungry dolphins' calls. Floating above toadfish nests in a research boat, he was recording the mating calls of male toadfish when, 'suddenly, they all went quiet.' Puzzled, he realised that he was now recording dolphin calls instead; peering over the side of the boat, his field assistant spotted dolphins hovering over the toadfish nests. Wondering if these two events were linked, Remage-Healey and Andrew Bass set out to see if toadfish can eavesdrop on dolphins (p. 4444).

They called in the assistance of Douglas Nowacek, a marine mammal expert at Florida State University. From previous work, Nowacek knew that dolphins pay attention to the sounds of their prey. But is the reverse also true: are toadfish aware of their predators? To find out, Remage-Healey decided to play dolphin sounds to toadfish and see if the fish became stressed and stopped calling. Nowacek had recordings of the high frequency 'whistles' that dolphins use to communicate with each other, as well as the low frequency 'pops' that dolphins probably use to locate their lunch, because these sounds can penetrate sandbeds and sea grass, where toadfish like to breed. 'Toadfish are low frequency specialists,' Remage-Healey says. 'They hear best below 1 kHz, so we suspected that they would be able to hear the dolphins' low frequency pops but not the high frequency whistles.'

Conveniently, toadfish breed in the bay just outside Florida State University's marine lab. Coaxing toadfish out of their nests proved difficult, but Remage-Healey soon discovered that he could catch fish by collecting the shells they nest under. 'They defend their nest aggressively, so they hang onto the shell even when it's moving,' he says. Taking his research boat to the toadfish breeding site, Remage-Healey placed each captured toadfish in its own cage and nestled the cages on the seabed in the breeding patch. He then lowered a speaker into the water and played one of four recordings: dolphin pops, dolphin whistles, dolphin pops and whistles or snapping shrimp pops, a common background noise in the bay that shouldn't alarm the toadfish. He recorded each toadfish's calls before, during and after the playback. To see how stressed the fish were after listening to each recording, he took blood samples to measure levels of the stress hormone cortisol.

Remage-Healey was delighted to have his suspicions confirmed. He found that toadfish listening to snapping shrimp pops or dolphin whistles happily kept on calling, but fish that heard dolphin pops or a combination of pops and whistles drastically reduced their calling rates. 'This suggests that toadfish can perceive dolphin foraging sounds and respond behaviourally to reduce the chance of being overheard,' he says. But he was really convinced when he saw that the cortisol levels of toadfish that had listened to dolphin pops had shot up compared with those of fish that had listened to shrimp pops; toadfish clearly find dolphin pops more stressful to listen to. 'This really cemented the idea that something was happening,' he says.

Remage-Healey is intrigued by this evidence for a co-evolutionary game between a fish and a mammal. For toadfish, there is a clear trade-off between calling to attract a mate and keeping quiet to avoid being eaten, while dolphins face a trade-off between the need to use low frequency pops to locate their dinner and the risk of being overheard by their prey.

10.1242/jeb.02605

Remage-Healey, L., Nowacek, D. P. and Bass, A. H. (2006). Dolphin foraging sounds suppress calling and elevate stress hormone levels in a prey species, the Gulf toadfish. *J. Exp. Biol.* **209**, 4444-4451.

Yfke Hager

HONEYBEES MAKE PLANS

Picture by Mario Pahl

Honeybees drink nectar from flowers. This, on first sight, seems a simple task: find flower, drink nectar, and return to nest. In reality the task is more complicated. Each flower species has different amounts of nectar, and they bloom at different times of day. To make the most of a foraging trip, honeybees need to make a series of complex decisions. Shaowu Zhang and his German colleague Juergen Tautz have demonstrated for the first time that honeybees can make two choices simultaneously, which greatly improves their chances of foraging successfully (p. 4420).

But before Zhang could begin offering the insects interesting choices, he taught them to perform a simple decision-making operation. Training the insects to follow a defined path through a maze to the feeder and allowing them to return to their hive through a specific entrance, both entrances having been marked with a distinctive visual cue, Zhang tested to see if bees would choose cues they had been trained to recognise when they were offered a variety of routes to both the maze and hive. They did. Having established the basic technique, Zhang set about using different factors to influence the insects' decisions about which routes to take.

First the team decided to test whether the bees could make decisions based on the time of day that they were foraging. By rewarding the bees with access to food and the hive, Zhang trained the bees to recognise one pattern in the morning, with another pattern used in the afternoon. When the bees were tested by offering them the choice of both patterns throughout the day, the honeybees clearly preferred the pattern they had been trained to recognise early in the day when tested in the morning and switched to the other pattern in the afternoon, demonstrating that they chose according to the time of day.

In their second test, the honeybees had to choose between visual cues depending on whether they had learned to recognise the cue when they were foraging or returning to the hive. Zhang marked the path to the feeder with a yellow cue so the honeybees associated this colour with foraging, while the unrewarded maze entrance was marked with a blue cue. At the hive these colours were reversed, so the open entrance had a blue cue to signify a return trip. When tested the honeybees continued to choose the cues they associated with rewards, showing that they made one choice to get to the feeder, but the opposite choice to get to the hive.

Neither of these results were a surprise to Zhang and his colleagues, who have studied honeybee cognition for many years. But both tests were designed to lead up to something far more complicated: whether honeybees can make two decisions simultaneously. In this case, can they choose cues depending on whether they were foraging or heading for the hive, as well as making those choices according to the time of day? This time access to the feeder was marked in the morning with one pattern that the insects should associate with foraging at the maze, and a different pattern at the hive entrance associated with homing. In the afternoon, these patterns swapped over. Impressively, during the test when the honeybees were offered a variety of routes through maze and home, the honeybees continued to choose the patterns that led to rewards during training, and definitely switched their preference between morning and afternoon. 'We're seeing a time schedule', explains Zhang, 'honeybees plan their activities in time and space'.

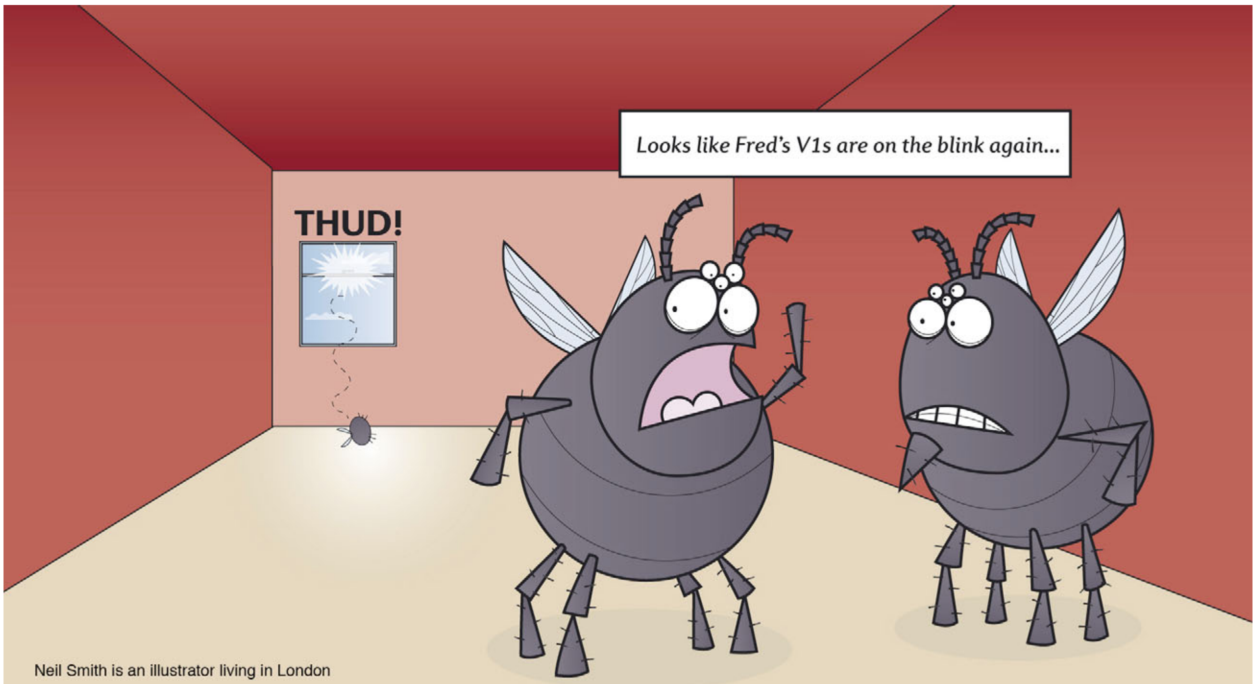
Honeybees may be small, but these results could have a big impact. 'Honeybees perform many cognitive tasks similar to bigger animals and humans', says Zhang. This makes the simpler honeybee brain a good model for cognitive processes in general. Understanding this model may have implications for technology too. Robots can see, hear and touch, but making decisions based on these sensations is far more difficult to engineer. The next generation of robots may learn a lot from the simple honeybee.

10.1242/jeb.02602

Zhang, S., Schwarz, S., Pahl, M., Zhu, H. and Tautz, J. (2006). Honeybee memory: a honeybee knows what to do and when. *J. Exp. Biol.* **209**, 4420-4428.

Sarah Clare

FLIES MAINTAIN A STRAIGHT FLIGHT PATH



How a fly avoids going into a tailspin while buzzing around intrigues Matthew Parsons and his colleagues at Cambridge University. They want to know how nerve cells in a fly's brain use information sent from its three one-lens eyes, called ocelli, and combine it with information from its pair of compound eyes to achieve this feat. A nerve cell in the fly's brain, known as V1, responds to light flickering on the compound eyes, but does the cell also respond to light flickering on the ocelli? To test this the team mimicked rotations of the fly's head by shining a pattern of flickering light on the ocelli, similar to what an airborne fly would see if it was rolling around. They recorded V1's response: the cell responded to clockwise rolls, but not to anticlockwise ones, and had a stronger response to brighter lights (p. 4464). V1 can respond to signals from compound eyes and ocelli, making it a key player in fly visual processing.

10.1242/jeb.02603

Parsons, M. M., Krapp, H. G. and Laughlin, S. B. (2006). A motion-sensitive neurone responds to signals from the two visual systems of the blowfly, the compound eyes and ocelli. *J. Exp. Biol.* **209**, 4464-4474.

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