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

DOLPHINS MAINTAIN ROUND THE CLOCK VIGILANCE

Everyone knows how difficult it is to function after a few missed nights' sleep: ask any new parent. However, it seems that dolphins have a clever trick for overcoming sleep deprivation. Sam Ridgway from the US Navy Marine Mammal Program explains that they are able to send half of their brains to sleep while the other half remains conscious. What is more, the mammals seem to be able to remain continually vigilant for sounds for days on end. All of this made Ridgway and his colleagues from San Diego and Tel Aviv wonder whether the dolphins' unrelenting auditory vigilance tired them and took a toll on the animals' other senses? Ridgway and his team set about testing two dolphins' acoustic and visual vigilance over a 5 day period to find out how well they functioned after days without a break (p. 1519).

First Ridgway and his colleagues, Mandy Keogh, Mark Todd and Tricia Kamolnick, trained two dolphins to respond to a 1.5 s beep sounded randomly against a background of 0.5 s beeps every 30 s. Ridgway explains that the sounds were low enough for the dolphins to barely notice them as they swam through their enclosure, but the animals sprung into action every time they heard the 1.5 s tone, even after listening to the sounds for 5 days without a break. Their auditory vigilance remained as sharp as it had been 5 days earlier.

Next Allen Goldblatt and Don Carder designed a visual stimulus to test the dolphins' vigilance while they continued listening to the repetitive beeps. Knowing that the dolphins' binocular vision is limited because their eyes are situated on opposite sides of their heads, Kamolnick trained one of the dolphins, SAY, to recognise two shapes (either three horizontal red bars or one vertical green bar) with her right eye before training her to recognise the same shapes with the left eye, reasoning that if half of her brain was asleep during testing, the dolphin would only see the shapes through the eye connected to the conscious half of the brain. But the team were in for a surprise when they began training SAY's left eye. She already recognised the shapes, even though her left eye had not seen them previously. Ridgway explains that the information must be transferred between the two brain hemispheres and suspects that the dolphin's inter-hemispheric commissures, which connects the two halves, may transfer the visual information.

Having trained both dolphins to recognise the shapes, the hard part began: monitoring and rewarding the dolphins continually over a 5 day period while the team tested the animals' responses to both the sound and visual stimuli. Amazingly, even after 5 days of listening out for 1.5 s beeps amongst the 0.5 s beep background, the dolphins were still responding as accurately as they had done at the beginning of the experiment. The team also enticed the dolphins into a bay at night where they could be shown the horizontal and vertical bar shapes, and found that the dolphins were as sharp at the end of the 120 h experiment as they had been at the beginning. And when the team checked the dolphins' blood for physical signs of sleep deprivation, they couldn't find any. After 5 days of unbroken vigilance the dolphins were in much better shape than the scientists.

10.1242/jeb.032524

Ridgway, S., Keogh, M., Carder, D., Finneran, J., Kamolnick, T., Todd, M. and Goldblatt, A. (2009). Dolphins maintain cognitive performance during 72 to 120 hours of continuous auditory vigilance. *J. Exp. Biol.* **212**, 1519-1527.

WOLBACHIA PARASITE COULD LIMIT DENGUE FEVER

Dengue fever is a terrible viral disease blighting many of the world's tropical regions. Carried by mosquitoes, such as *Aedes aegypti*, 40% of the world's population is believed to be at risk from the infection. What is more, previous exposure to other strains of the fever does not confer protection. In fact, subsequent infections are significantly worse, and can result in fatal dengue haemorrhagic fever. The lack of a fuctioning vaccine forced Scott O'Neill and Elizabeth McGraw to look for a more creative form of defence. Knowing that a parasite, *Wolbachia pipientis*, shortens the lifespan of host insects and could restrict dengue fever transmission by killing the insects before they can pass the infection on, O'Neill and his team successfully infected *Ae. aegypti* with a strain of the *Wolbachia* bacterium and shortened the mosquitoes' lifespan. But before insects carrying the bacterium can be released into the environment, the O'Neill and McGraw teams have to convince international governments that mosquitoes carrying the *Wolbachia* parasite could successfully limit transmission of the virus. McGraw and O'Neill had to find out how the bacterium affects the mosquito's physiology and behaviour (p. 1436).

Knowing that *Wolbachia* slows down some insects' activity and speeds up others, the team decided to test how the parasite affects *Ae. aegypti* as they age and the infection takes hold. Working with uninfected and infected mosquitoes produced by Conor McMeniman, Oliver Evans and Eric Caragata used a system designed by Craig Williams to film the activities of male and female mosquitoes as they aged to find how the bacteria affected the insects' activity levels. According to McGraw, the experiments generated a huge amount of video data, so Evans teamed up with Megan Woolfit and David Green to pipe the data to a cluster of workstations to track the insects' movements and analyse their activity levels.

After a year of experimental design, data collection and analysis, it was clear that the infected mosquitoes were more active than the uninfected insects. Most surprisingly, as the mosquitoes aged and the infection took hold, it did not increase their activity levels further.

Having found that the insects became more active in response to their bacterial lodgers, Craig Franklin joined the team to help measure the insects' CO_2 production to find how their metabolic rates respond to the parasite. Again, the insects' metabolic rates were higher than those of the uninfected mosquitoes.

So why are the infected insects more active than the uninfected insects? McGraw says there are three possible explanations; the insects are living fast and dying young; the insects are hungrier and consume more energy in their constant search for food; or the bacteria somehow affect the insects' tissues to change their behaviour and increase their metabolic rate. McGraw suspects that the last explanation is the most likely.

Having shown that the activity levels of *Wolbachia* infected mosquitoes respond to the bacterium, McGraw and O'Neill are continuing to test how the infection affects the insects' biting behaviour and whether a *Wolbachia* infection can become established in *Ae. aegypti* populations to limit their lifespans. Ultimately, McGraw and O'Neill hope to release infected mosquitoes into afflicted regions of the world to limit dengue fever transmission, but only once they are sure that the insects will do no harm to the environment.

10.1242/jeb.032516

Evans, O., Caragata, E. P., McMeniman, C. J., Woolfit, M., Green, D. C., Williams, C. R., Franklin, C. E., O'Neill, S. L. and McGraw, E. A. (2009). Increased locomotor activity and metabolism of *Aedes aegypti* infected with a life-shortening strain of *Wolbachia pipientis J. Exp. Biol.* **212**, 1436-1441.

TOADFISH PROCESS BINAURAL SIGNALS EARLIER THAN THOUGHT

We take it for granted that we can pinpoint the direction that a noise comes from. Our brains rapidly calculate the difference between a sound arriving at both our ears to locate its source; but fish have a much bigger problem. With their ears close together deep in their heads and sound travelling 5 times faster in water than air, placing a sound must be much harder; yet fish manage. As toadfish are very vocal, and the females locate the positions of courting males by following their serenade, Peggy Edds-Walton and Richard Fay, from Loyola University Chicago, were curious to find out if the fish use information from both ears in the neural circuit that codes the direction of the sounds (p. 1483).

Knowing that most vertebrates, humans included, process auditory information from one ear before combining the information from both ears at a second site in the brain circuit, Edds-Walton and Fay decided to investigate the sites where auditory inputs from the left and right ears are combined by the toadfish's brain. But to find out, the team needed a way to alter the auditory input from one ear to cells in specific regions of the brain and measure the effect of the change on cells in the same brain region. For example, if the pair could change the 'directional response' of a cell in the left descending octaval nucleus (DON: the first auditory region of the brain) by manipulating the right ear, this would suggest that sound information from both ears is brought together and processed in the DON.

Deciding to anaesthetise the auditory nerve from the saccule (one of the fish's hearing organs) in one side of a fish's head to alter its input to the brain, Edds-Walton tried injecting lidocaine into the saccule and was surprised when the electrical spike activity that she and Fay were recording in the DON disappeared. At first the pair thought that the saccule had been damaged, but as Edds-Walton removed the needle, the signal returned. Edds-Walton had inadvertently tipped the large calcareous otolith, to which the sound sensitive saccule is attached, and changed the strength of the saccule's directional response to sound. 'This was one of those moments of serendipity in science,' says Edds-Walton. She and Fay had found a way of reversibly altering a saccule's input to the brain.

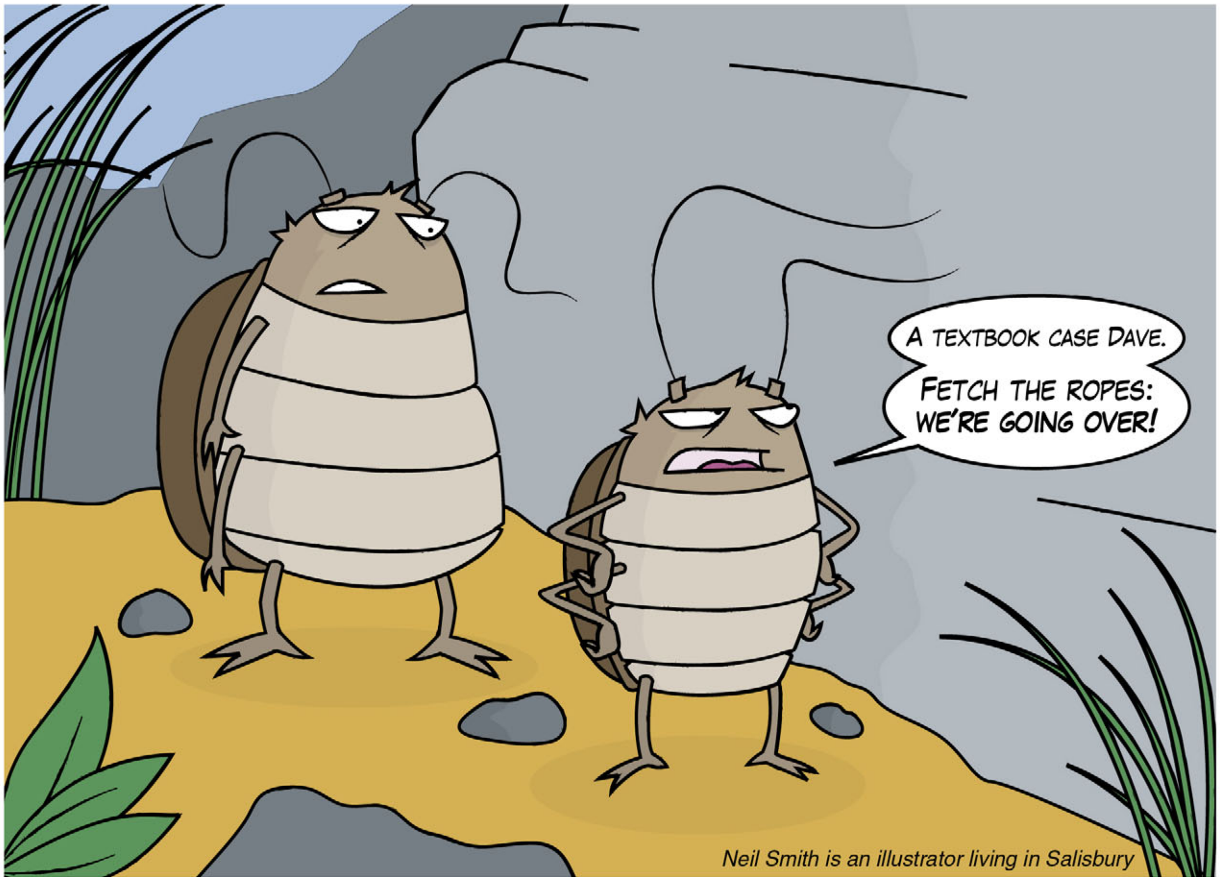
Having discovered this new method to test the fish's hearing, the duo played vibrations to toadfish over frequencies ranging from 50 to 300 Hz from different directions as they recorded the directional response patterns from cells in the midbrain and the DON while the otolith and saccule were tipped. The pair then repeated the experiments when the hearing structures were in their original orientations.

After 3 years of meticulous experimentation and analysis, it was clear that cells in the midbrain were processing sounds picked up by both ears, just like vertebrates. But so were cells in the DON. This means that toadfish begin combining auditory inputs from both saccules at an earlier stage in the auditory system than had been thought. The only other vertebrates that combine auditory inputs from both ears at the first auditory site in the brain are frogs and toads. 'Maybe toadfish have more in common with toads than just being unattractive,' laughs Edds-Walton.

10.1242/jeb.032508

Edds-Walton, P. L. and Fay, R. R. (2009). Physiological evidence for binaural directional computations in the brainstem of the oyster toadfish, *Opsanus tau* (L.). *J. Exp. Biol.* **212**, 1483-1493.

COCKROACH ANTENNAE CRITICAL FOR OBSTACLE NEGOTIATION



Not much stops a cockroach in its tracks. They determinedly negotiate most obstacles they encounter. But how do cockroaches sense their surroundings? This is the question that puzzled Cynthia Harley, Brittany English and Roy Ritzmann from Case Western Reserve University. Knowing that many insects use their antennae and eyes to help them navigate obstacles, the team focused on the cockroach antennae to find out how they use them when negotiating vertical obstacles. Filming cockroaches with full-length, shortened and removed antennae as they encountered either an 11.7 mm high block or a glass shelf at heights ranging from 8.9 to14 mm, the team painstakingly analysed the insects' approaches and strategies for negotiating the obstacles when they could see under various lighting conditions and when they were wearing eye patches (p. 1463).

Watching the insects with full-length antennae, the team saw that the cockroaches almost always mounted the block successfully in a single step when they were within 11 mm of the block. The insects could estimate their distance from, and the height of, the obstacle using their antennae, allowing them to lift their front legs high enough to climb onto the obstacle. However, when the cockroaches' antennae were removed, the animals resorted to brute force, either ramming themselves into the block until they forced themselves up and over, or waving their front legs around until they encountered the top of the block, confirming that sensory information from the antennae is essential for cockroaches to overcome obstacles.

Analysing the insects' approaches to the glass shelf, it became clear that sensory inputs from the antennae were critical in the insect's decision to climb over or under the shelf. However, the lighting conditions also had a big effect on the way the cockroach dealt with the obstacle. The insects preferred to tunnel under the shelf in the light, 'suggesting that the light created a context around this behaviour,' says Harley and the team.

So sensory inputs from the antennae provide vital information that helps cockroaches successfully negotiate obstacles.

10.1242/jeb.032490

Harley, C. M., English, B. A. and Ritzmann, R. E. (2009). Characterization of obstacle negotiation behaviors in the cockroach, *Blaberus discoidalis. J. Exp. Biol.* **212**, 1463-1476.

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