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.

FLYING CRICKETS HEAR ULTRASOUND BETTER


Photo by Gerald Pollack

When a cricket is airborne, it is on the alert for the ultrasonic calls of predatory bats. However many species of insects, including crickets, have both flying long-winged forms and flightless short-winged forms. Insects that are preyed on by bats are more likely to hear ultrasound, but since short-winged crickets can't fly, would their ability to hear ultrasound be affected because they are no longer preyed on by bats? Gerald Pollack and Ruben Martins, McGill University Canada studied the behaviour and the nervous system of long-winged and short-winged crickets (*Gryllus texensis*) to find out (p. 3160).

To measure the crickets' behavioural responses to cricket song and ultrasound, the team attached crickets to a stick with wax and put them in an air stream to induce flight. They played sounds of different intensities that mimicked a cricket's song or ultrasonic pulses out of one of two speakers either side of each cricket. As a cricket turns towards or away from a sound, it moves its abdomen and the team monitored these movements by measuring the abdomen's shadow cast on a photocell.

They found that all of the crickets tried to steer away from the ultrasound pulses and towards the cricket song, regardless of whether they were short-winged or long-winged. The threshold for the response to cricket song was the same in both types; however, the long-winged crickets had a threshold 8 dB lower to the ultrasound than the short-winged. This showed that long-winged crickets are more sensitive to ultrasound.

The team then made recordings from the nervous system, to find out how the auditory neurons responded to sound signals. As crickets age, their flight muscles degrade, in a process called histolysis. So they divided their crickets into three groups: short-winged, long-winged with intact muscles and long-winged with histolysed muscles. They recorded from a neuron called ON1, which is sensitive to a wide range of frequencies and receives inputs from one ear while inhibiting inputs from neurons transmitting signals from the other ear. They found that the threshold for ON1's response was similar in all the groups at 5.2 kHz, the frequency of cricket song. At ultrasonic frequencies, though, the response threshold of ON1 was lower in all long-winged crickets than in short-winged ones. This shows that ON1's response depends on the crickets' wing types: long *versus* short.

The response of a second neuron, AN2, which responds better to higher frequencies and triggers steering away from ultrasonic sounds, was also different between the groups. The sensitivity of AN2, however, depended on flight ability. While the threshold for the steering response was similar for cricket song, the thresholds for ultrasonic frequencies were higher for short-winged and long-winged histolysed muscle groups, neither of which can fly. This implies that the sensitivity of AN2 changes as the muscles break down.

Although the team's results clearly show that flightless crickets are less sensitive to ultrasound, the mechanism is unclear. They suspect that rather than short-winged crickets losing the ability to hear ultrasound, long-winged crickets are gaining increased ultrasound sensitivity as part of the suite of physiological changes that occur in preparation for flight, bringing with it an increased likelihood of being preyed on by ultrasonic-clicking bats.

10.1242/jeb.011775

Pollack, G. S. and Martins, R. (2007). Flight and hearing: ultrasound sensitivity differs between flight-capable and flight-incapable morphs of a wing-dimorphic cricket species. *J. Exp. Biol.* **210**, 3160-3164.

VISUAL MAGNETISM

According to biologist Sönke Johnsen, understanding magnetoreception is 'the last holy grail of sensory biology'. Despite years of experiments, scientists still aren't sure exactly how it works. There are two alternative theories for how animals, such as birds and turtles, detect magnetic fields. The first is that migrating animals have tiny particles of magnetite in their heads, which effectively act as 'mini compasses' in response to the magnetic field. The second is that light-sensitive molecules in the eyes – photopigments – could play a role in detecting magnetic fields. As a vision biologist, Johnsen is interested in the second theory, so he teamed up with physicists Erin Mattern and Thorsten Ritz to find out if light absorption by certain molecules is associated with migratory birds being able to detect magnetic fields (p. 3171).

The team went back to the literature and collected the results from 62 experiments on light-dependent magnetoreception in songbirds that migrate at twilight, or at night. They grouped the experiments into categories depending on how the birds behaved: whether they oriented correctly in their migration direction, indicating that they were detecting a magnetic field, or incorrectly, indicating that they probably weren't.

To unravel light-dependent magnetoreception, they team needed to take into account the light entering the birds' eyes in each experiment, and what happens to it when it gets there. First they needed to calculate what the birds' photopigments are sensitive to. They calculated the quantum catch of 7 of the birds' photopigments; 'this is how many photons of light are collected by a photopigment over a set amount of time,' Johnsen explains.

Having calculated how much light the birds' photopigments could pick up, the team then calculated which photopigments were stimulated in each of the experiments, which were carried out under different light conditions. They calculated the quantum catch of the light used in the experiments hitting the photopigments, and also calculated the opponency. This is where the stimulation of one photopigment is subtracted from the effect of another. They then related photopigment stimulation to the behavioural results, to see if there was a link between one photopigment, and a magnetoreceptive behaviour.

'We really wanted to find the smoking gun', says Johnsen. However, while the team's 'smoking gun' remains elusive, for now, they did find that there were experimental situations that inhibited magnetoreception, where the birds oriented incorrectly. First they found that experiments with bright light levels, with a high quantum catch, inhibited magnetoreception. The boundary where this effect stopped was at light levels very similar to sunset. They also found that there was inhibition of orienting behaviour where there was long wavelength (reddish) light present, with the cut-off for this effect in the yellow/green part of the spectrum. So for these birds to detect magnetic fields, the results suggest that 'it needs to be blue, and dim', says Johnsen. The photopigments that might be causing this effect are a long wavelength red cone, and the pigment semiquinone, which is a breakdown product of another photopigment, cryptochrome.

The results also highlighted that there are big gaps in the light spectrum that haven't been investigated yet, which will help others design future experiments, but Johnsen explains that more research is needed to understand if light levels really are influencing magnetoreception, or if this effect is due to the birds' motivation to migrate.

10.1242/jeb.011767

Johnsen, S., Mattern, E. and Ritz, T. (2007). Light-dependent magnetoreception: quantum catches and opponency mechanisms of possible photosensitive molecules. *J. Exp. Biol.* **210**, 3171-3178.

DESPERATE TO SETTLE

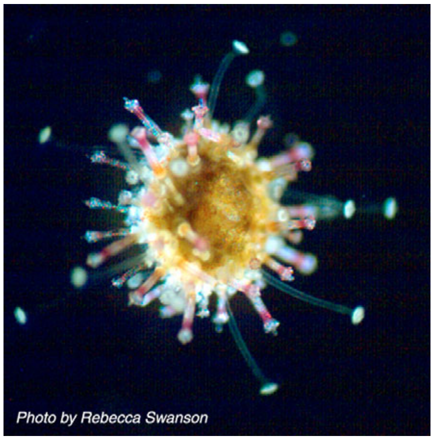
Photo by Rebecca Swanson

Floating around in their ocean home, Australian sea urchin (*Holopneustes purpurascens*) larvae are in a race against the clock to settle on sub-tidal algae and metamorphose into their adult form before they use up their precious internal food supplies or are eaten themselves. About 5-7 days after fertilisation, the larvae become 'competent': they develop tiny tube feet for attachment and they are able to detect histamine. This chemical is a settlement cue, much like a 'homing' signal, released by the preferred host alga that they will dine and hide on. A previous study by Jane Williamson and Peter Steinberg found that younger larvae metamorphosed in response to red algae only, while older larvae metamorphosed not only in response to red, but also to brown algae, which contains lower levels of histamine than reds. Because the older larvae may be responding to lower histamine levels, or another compound altogether, Rebecca Swanson from the University of New South Wales, Australia, and her colleagues Dustin Marshall and Steinberg, tested if older Australian sea urchin larvae would metamorphose in response to lower concentrations of histamine than younger larvae (p. 3228).

The team fertilised sea urchin eggs and allowed them to develop in large beakers in the lab. Once they were competent, after 5-7 days, the team let groups of larvae develop for different lengths of time – 7, 14, 21 or 28 days – before testing their responses to histamine.

To find out how larvae of different ages responded to histamine, the team added histamine of different concentrations to small test dishes containing seawater before adding larvae of different ages and measuring if they settled at the bottom of the dish and metamorphosed or not. They found that the percentage of larvae that responded to lower concentrations of histamine increased as the larvae got older. For example, at 10 nmol l^{-1} histamine after 72 h exposure, ~45% of 28 day-old larvae metamorphosed compared to only 5% of 7 day-old larvae. 'The increased sensitivity of older larvae to histamine occurred gradually with age,' says Swanson.

The team also found that the amount of time that larvae of different ages were exposed to histamine affected their transition to metamorphosis. When exposed to 10 μmol l^{-1} histamine, 60% of newly competent (7 day-old) larvae settled after 20 min exposure. However most of these larvae started swimming again when placed in histamine-free seawater. The young larvae needed at least 3 hours of continuous histamine exposure to induce metamorphosis in all of them. But, older larvae only needed 30 min histamine exposure for all of the settled larvae to metamorphose. This suggests that younger larvae are more flexible when they settle, and can resume swimming if conditions change. Older larvae, however, are committed to metamorphose, even if they no longer detect histamine.

By becoming more sensitive to ever decreasing concentrations of histamine as they develop, the sea urchin larvae are potentially able to detect a wider range of host algal species, over greater distances, meaning that they are more likely to find a suitable place to settle, increasing their chances of survival. 'What we really need to do next is work out the mechanism', Swanson says.

10.1242/jeb.011759

Swanson, R. L., Marshall, D. J. and Steinberg, P. D. (2007). Larval desperation and histamine: how simple responses can lead to complex changes in larval behaviour. *J. Exp. Biol.* **210**, 3228-3235.

YOUNG CRICKETS' SUPERIOR ESCAPE RESPONSE

Sure, leaving Grandpa Jiminy behind wasn't something that they were proud of, but deep inside Donny and Oswald knew that he would work his way out of this one...
...just like he always did.

Axel Innis is a postdoctoral fellow at Yale University

A cricket's mechanosensory hairs, which cover its cerci at the end of its abdomen, are literally lifesavers, picking up the telltale vibrations of a predator making its deadly approach. Since small crickets are more likely to become a predator's snack than larger ones, Olivier Dangles, Jérôme Casas and their colleagues measured the escape performance of small and medium sized juvenile and adult wood crickets (*Nemobius sylvestris*) for the first time in their natural environment (p. 3165). To take their experiment out of the lab and into the field, the team built a portable actuator connected to a piston, which they programmed to release a flow of air directly at the cerci that mimicked the approach of an attacking wolf spider. Filming the crickets' escape responses at 1000 frames per second to the air flow, they found that both groups of juveniles were more likely to respond than adults, and also much more likely to respond by jumping. Measuring the distance the crickets travelled in response to the air flow or to being touched by the piston, they found that adults moved a relatively smaller distance than the juveniles when escaping, and that juveniles responded faster. The team suspect that the juveniles' superior escape performance is to make up for the increased likelihood of them being preyed on, and also that many crickets wait until the last possible minute – when they are touched by the piston – before using their powerful back legs to escape by jumping.

10.1242/jeb.011742

Dangles, O., Pierre, D., Christides, J. P. and Casas, J. (2007). Escape performance decreases during ontogeny in wild crickets. *J. Exp. Biol.* **210**, 3165-3170.