

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.

HEARING ABOVE THE DIN OF A KATYDID'S COCKTAIL PARTY



As darkness descends upon the tropical rainforests of Malaysia, male chirping katydids of the *Mecopoda* complex are just getting warmed up for their usual nightly concerts to woo the females. These nocturnal suitors are favoured for chirping in synchrony as a chorus; however, singing in time with one another is no easy task as they have to co-ordinate in the presence of the noisy serenades from a very closely related katydid species. This is particularly difficult, as Manfred Hartbauer from Karl-Franzens University, Austria, explains: 'This species uses almost the same frequency spectrum [2–80 kHz] in their acoustic signal [as the chirping katydid species], but produces this signal in an ongoing train of syllables, so it's a trill, and we wondered how the chirping species could establish chorus synchrony in the presence of such a noisy masker.' Hartbauer decided to find out with the help of PhD student Marian Siegert and colleague Heiner Römer (p. 4656).

First the team wanted to check that 'chirper' katydids could indeed synchronize chirps in the presence of a masking trill. To do this, they recorded chirps from a 'chirper' katydid and played it back to isolated males. Once the male had joined in and synchronized with the periodic signal, Hartbauer and Siegert then introduced the trill soundtrack, gradually increasing its loudness until the 'chirper' could no longer synchronize with the playback. 'It turns out that the chirpers are able to tolerate a high noise level', says Hartbauer. 'All tested males were able to entrain their chirps to a conspecific pacer in the presence of a trill broadcast 8 dB louder than the conspecific signal.'

But how exactly can they do this? When the team compared the chirps and trills, they noticed something rather unusual, as Hartbauer recalls: 'Chirps had a rather strong frequency component at 2 kHz that the trills didn't have. This seemed very unusual because we knew that all auditory neurons known so far in most katydids are tuned to 10 kHz and ultrasonic frequencies.' So could the chirpers even detect this 2 kHz component? Sure enough, when the duo made this frequency component undetectable, the male 'chirpers' could no

longer synchronize their chirps, a good sign that males could detect this low-frequency component.

Next, the duo moved on to seeing whether an auditory neuron with T-shaped morphology (TN1) was involved in detecting the chirps in the presence of background noise. To test this, Hartbauer and Siegert first carefully inserted tiny hook electrodes into the katydid's neck and saw neuronal activity from the TN1 neuron during chirp presentations. They then wanted to see whether the TN1 neuron could detect the low-frequency component, and so exposed the katydids to 2 kHz pure tones. To their surprise, however, the threshold of detection was very high, meaning the pure tone had to be quite loud to elicit a response in the TN1 neuron. 'But as soon as we turned on the masking noise, this threshold decreased by about 10 dB. This is surprising because normally if you turn on a noise source, you have to increase the intensity of the signal in order to elicit a response in the neuron, but in this katydid it was the opposite way around', says Hartbauer. 'This is really exciting news, because it means that if there is a heterospecific male around it helps [the chirpers] detect the species-specific signal at 2 kHz somehow.' So, all in all, it seems that the cocktail party environment of the nocturnal jungle actually aids communication in chirping katydids rather than hindering it.

10.1242/jeb.097972

Siegert, M. E., Römer, H. and Hartbauer, M. (2013). Maintaining acoustic communication at a cocktail party: heterospecific masking noise improves signal detection through frequency separation. *J. Exp. Biol.* **216**, 4655-4665.

Nicola Stead

ANTENNAE'S MECHANICAL ROLE IN ESCAPING

Love them or hate them, cockroaches are notoriously good escape artists and can flee at astonishing speeds. However, this speed can make it difficult to sense the world around them: 'When animals move slowly they rely mostly on their nervous system for accomplishing tasks, but as the animals are pushed to more extreme performances they face potential constraints in their nervous system, for example sensory conduction delays', explains Jean-Michel Mongeau, a researcher from the University of California, Berkeley, USA. Mongeau goes on to suggest that in the face of these problems, using a system reliant on mechanical changes that can occur rapidly, rather than relying solely on the nervous system, might be advantageous during high-speed manoeuvres. With the help of his advisor, Robert Full, Mongeau decided to investigate potential mechanical systems (p. 4530).

Jean-Michel Mongeau



Mongeau began by placing blind cockroaches into an arena under the watchful lens of two high-speed cameras. With a gentle prod, the cockroaches were then sent scurrying along a wall with a 30–60 deg bend mid-way. On a smooth acrylic wall the cockroaches' antennae often projected straight out in front of them as they tracked the wall, but this changed on a wooden wall: 'When the wall becomes rougher, which you could think of as more ecologically relevant for this animal, the antenna would bend backwards almost all of the time, in a sort of inverted J-shape', recalls Mongeau. But how does this benefit the cockroaches in their high-speed dashes? Measuring the body-to-wall distance, Mongeau found that bending the tip of the antenna caused the cockroaches to orientate themselves further away from the wall, preventing them from crashing into it, unlike their friends with straight antennae.

'After these findings, we became interested in understanding the mechanism behind the antenna changing shape', says Mongeau. 'We hypothesised that very tiny tactile hairs on the antenna would potentially be able to engage with, and stick to, [a rough] surface, and when that is coupled with forward motion this would be sufficient to make the antenna flip.' To test this, the team decided to remove these little hairs; however, it turned out that giving the antennae a haircut was more difficult than they first thought: 'The first thing I tried to do was use tiny forceps to pluck the hairs out, but that turned out to be impossible because these hairs are very robust and they're embedded within the exoskeleton.' But eventually Mongeau's perseverance paid off: 'After going through several rounds of trial and error, or mostly error, I decided to try a laser system that burns these little hairs at the tip.' And sure enough, without their hairs the antennae rarely bent backwards, even as they were dragged along a wall.

The ultimate aim of Mongeau's study was to help design better robots, as currently most robots also have difficulties processing information at high speeds, so he turned to an artificial antenna created by their collaborator Alican Demir, in Noah Cowan's lab at Johns Hopkins University, USA. By mimicking the cockroach's hairs, the team could get the robotic antenna to bend in a similar manner. However, it turns out that if you even slightly change the orientation of the hairs, so they are facing opposite directions on either side of the

antenna, it can cause the antenna to fully curl over to form an inverted C, meaning that the antenna is no longer projecting in front of the robot, which isn't much use. So it seems that cockroaches have already worked out a good design for an antenna, and studies such as Mongeau's might help us make better high-speed robots.

10.1242/jeb.097873

Mongeau, J.-M., Demir, A., Lee, J., Cowan, N. J. and Full, R. J. (2013). Locomotion and mechanics mediated tactile sensing: antenna reconfiguration simplifies control during high-speed navigation in cockroaches. *J. Exp. Biol.* **216**, 4530–4541.

Nicola Stead

THE LIFE ACIDIC: TUBEWORMS' SURVIVAL IN FUTURE OCEANS



Ackley Lane

In tropical coastal cities and ports around the world, the tiny tubeworm has garnered quite a bad rep. As minuscule larvae, these tubeworms make it undetected into seawater-based cooling systems, and once inside, they settle down and metamorphose into their adult forms, with their characteristic calcium carbonate shells causing costly blockages. But their way of life is under threat as a result of our oceans absorbing excess man-made carbon dioxide, as Vengatesen Thiyagarajan, a researcher from the Swire Institute of Marine Science and School of Biological Sciences, Hong Kong, explains: 'Human carbon dioxide is affecting calcifying animals in two ways. Firstly, the acidification is decreasing the carbonate ion concentration in the seawater, so building the calcium carbonate structure is difficult; and secondly, the decreased pH in the [sea] environment means the animal has to spend more energy maintaining their internal pH.' As they are troublemakers, many would welcome the demise of tubeworms, but Thiyagarajan points out that these marine animals are also ecologically important, forming coral-reef-like structures that promote biodiversity, as well as cleaning up the water in their role as filter feeders. As their loss would be significant, Thiyagarajan decided to find out just how susceptible these tubeworms are to ocean acidification (p. 4580).

Thiyagarajan and his team focused on what effect ocean acidification would have on the

ability of larval tubeworms to transition into the adult form, as metamorphosis at normal ambient pH already uses up 50% of the body's energy and is associated with a high mortality rate of 80–90%. With acidification depleting carbonate ions and larvae having to expend more energy on maintaining internal pH, could some larvae still metamorphose in acidic conditions? To test this, Thiyagarajan's team placed larvae into seawater with a pH of 7.6 and then measured how many made it through metamorphosis. Sure enough, compared with their larval friends kept in seawater with a normal and milder pH of 8.1, significantly fewer larvae made it through to adulthood.

However, Thiyagarajan points out: 'In the future oceans it's not just acidification [that's going to be happening], it's going to be combined with hypoxia, global warming and pollution; there are going to be multiple stressors on these animals.' To test the effects of acidification in a more realistic setting, the team measured metamorphosis success in larvae also subjected to low-oxygen (hypoxic) conditions. However, to their surprise, instead of faring even worse, these doubly stressed larvae seemed to metamorphose at normal levels and the hypoxia seemed to rescue the larvae from the negative effects of ocean acidification.

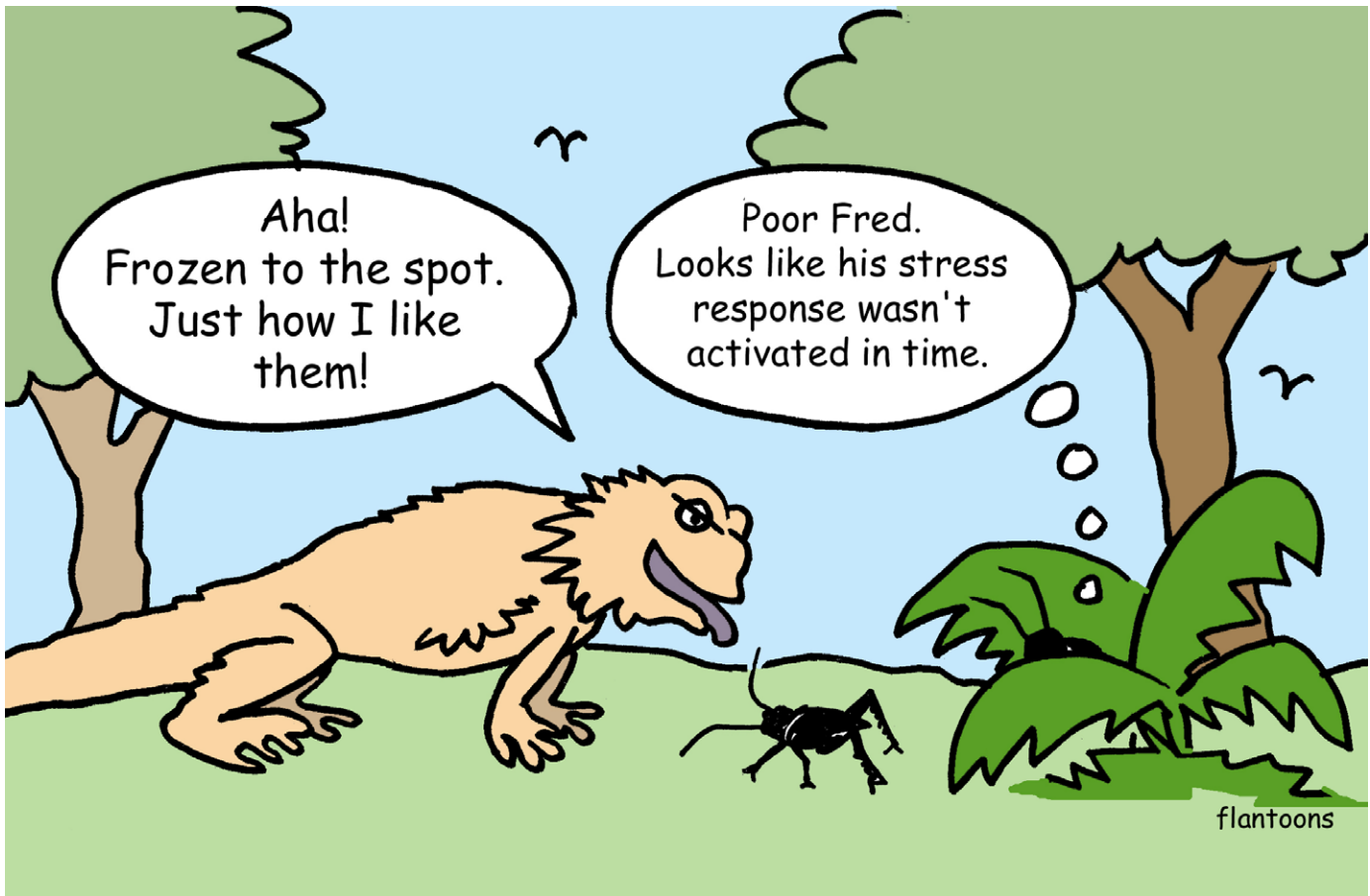
But how exactly was acidification hindering metamorphosis and hypoxia rescuing these larvae from the negative effects? Unfortunately, without the tubeworm genome sequence, working this out is a little hard. However, undeterred, the team decided to measure changes in levels of proteins using a technique called two-dimensional gel electrophoresis. Overall, they found larvae that had been subjected to acidic conditions reduced the number of proteins they expressed. They then found that many of these proteins were very similar to proteins in other marine species that were responsible for stress responses and for controlling the calcification process. In larvae treated with both acidification and hypoxia, they didn't see this decrease in protein expression. Although hypoxia rescued the larvae from the negative effects of ocean acidification, the team still don't know what the long-term effects will be for these doubly stressed worms, but the study highlights the importance of studying ocean acidification in combination with other potential future stressors.

10.1242/jeb.097980

Mukherjee, J., Wong, K. K. W., Chandramouli, K. H., Qian, P.-Y., Leung, P. T. Y., Wu, R. S. S. and Thiyagarajan, V. (2013). Proteomic response of marine invertebrate larvae to ocean acidification and hypoxia during metamorphosis and calcification. *J. Exp. Biol.* **216**, 4580–4589.

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SURVIVAL OF THE STRESSED



A nearby predator eyeing you up for their next meal is undoubtedly enough to kick-start a stress response in all but the very coolest of us – after all, who wants to be eaten? And although stress can bring with it many disadvantages, in the face of a hungry predator it could mean the difference between life and death, and is thought to cause the famous fight-or-flight response. However, in recent years it has proved difficult to directly link the stress response with a change in behaviour, and in some animals the stress response seems out of sync with the behavioural response. As stress responses in animals can be quite complex, Shelley Adamo, from Dalhousie University, Canada, decided to turn to the simpler cricket to see whether their stress response caused a change in behaviour (p. 4608).

To begin with, Adamo, along with the help of undergraduate students Ilya Kovalko and

Brianna Mosher, allowed crickets to wander around a cross-shaped maze free from any threats. Two of the arms were covered in black board to provide shelter, and the team then recorded how long the crickets spent in both the open and sheltered areas.

Next, the team wanted to induce a stress response in their crickets. To do this, the trio exposed some of their crickets to a moving robotic toy hamster that mimicked a potential predator. They also injected some of their crickets with octopamine, a stress response chemical very similar to noradrenaline. After placing the crickets back in the cross-shaped maze, the team found that crickets that had been previously stressed by the moving robotic hamster or those that had been injected with octopamine spent more time hidden in the sheltered areas than before their stress treatment.

To test how the stress response may help in a real-life predator–prey situation, the team next placed their crickets into an open maze setup alongside an additional participant – a bearded dragon with a taste for crickets. They found that crickets that had been previously stressed were much less likely to be eaten than their unstressed friends, who often froze in the open, making them an easy target for the hungry bearded dragon. So being stressed does help sometimes!

10.1242/jeb.097857

Adamo, S. A., Kovalko, I. and Mosher, B. (2013). The behavioural effects of predator-induced stress responses in the cricket (*Gryllus texensis*): the upside of the stress response. *J. Exp. Biol.* 216, 4608–4614.

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