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Inside JEB

OCEAN ACIDIFICATION SERIOUSLY IMPACTS MUSSEL LARVAE

JL Sones

Since the birth of the industrial revolution, ocean pH has dropped by 0.1 units. That might not sound like much until you realise that a 0.1 unit fall is a 30% increase in acidity. And, with predictions that ocean pH will continue plummeting, ecologists are becoming increasingly concerned about the impact of ocean acidification on marine populations. Brian Gaylord and his colleagues from the University of California at Davis explain that the open-coast mussel, *Mytilus californianus*, is a foundation species for many coastal ecosystems on the exposed northwestern coasts of North America, yet no one knew how ocean acidification might affect this keystone organism, so the team decided to find out how a fall in pH might impinge on the earliest settlers to colonise an exposed rocky outcrop: *M. californianus* larvae (p. 2586).

Growing freshly fertilized *M. californianus* larvae in seawater laced with carbon dioxide ranging from the modern level of 380 p.p.m. CO_2 up to a 'fossil-fuel intensive' scenario of 970 p.p.m. CO_2, the team allowed the larvae to develop for 8 days (p. 2586). Then they analysed the strength, size and thickness of the larvae's shells and found that acidification of the mollusc's seawater has a strong impact on shell strength. Shockingly, the shells of 5 day old larvae raised in 970 p.p.m. CO_2 were 20% weaker than those of larvae reared at the current CO_2 level, while the shells of larvae reared at 540 p.p.m. CO_2 were only 13% weaker. The team also found that after 8 days at 970 p.p.m. CO_2 the shells were up to 15% thinner and 5% smaller, and the body masses of the molluscs within the shell were as much as 33% smaller than those of mussels grown at modern CO_2 levels.

'The observed ocean acidification-induced decrease in shell integrity in *M. californianus* represents a clear decline in function,' say Gaylord and his colleagues, who also warn that, 'Such reductions may in fact be common in bivalves.' Outlining the potential ecological consequences of ocean acidification, the team suspects that larvae weakened by rising CO_2 levels could develop more slowly or, alternatively, they could be more vulnerable to predation, more susceptible to stress and at greater risk of desiccation. Ultimately these factors could conspire to reduce the mussel's survival and destroy the delicate balance that exists in today's coastal ecosystems.

10.1242/jeb.062125

Gaylord, B., Hill, T. M., Sanford, E., Lenz, E. A., Jacobs, L. A., Sato, K. N., Russell, A. D. and Hettinger, A. (2011). Functional impacts of ocean acidification in an ecologically critical foundation species. *J. Exp. Biol.* **214**, 2586-2594.

Kathryn Knight

AFRICAN PENGUINS FOLLOW DMS TRAIL TO TRACK SNACKS

Peter Ryan

With hungry chicks to feed, the pressure is on for African penguin parents to find food. But how do they locate sparsely distributed shoals of their preferred fish, anchovies and pilchards, when they hunt predominately by vision? Lorien Pichegru and her colleagues Kyran Wright and Peter Ryan from the University of Cape Town, South Africa, explain that the penguin's close relatives – petrels – track tasty shoals by sniffing out odours such as dimethyl sulphide (DMS) – released as the fish feast on zooplankton – and fish oil – produced by other predators devouring the fish. The team realised that penguins would benefit enormously if they could follow tell-tale DMS trails at sea. Knowing that African penguins are able to detect DMS odours on land, Pichegru and her colleagues decided to spike vegetable oil slicks in the sea with either DMS or cod liver oil, to find out whether African penguins follow their nostrils to locate lunch (p. 2509).

Releasing small vegetable oil slicks just off the shore of St Croix and Bird Islands in Nelson Mandela Bay, South Africa, while the birds foraged to feed their young, the team counted the number of penguins that visited each slick and the duration of their stay. Comparing the number of penguin visits to the DMS-scented slick with the number of penguins visiting an odour-free slick, the team found that the scented slick attracted three times as many penguins as the unscented slick and the individuals spent longer in the vicinity. The scientists also calculated that the penguins could travel as far as 2 km to locate a promising DMS slick, 'Which is particularly important given their slow commuting speed relative to flying seabirds,' they add.

So, African penguins appear to be guided, at least in part, by the odour of DMS and they probably use it to locate shoals of fish when foraging. The team also showed that the penguins pay no heed to fishoil-scented slicks; which isn't too surprising as penguins swallow their prey whole without releasing oil, unlike petrels, which are content to scavenge dead and damaged fish.

10.1242/jeb.062133

Wright, K. L. B., Pichegru, L. and Ryan, P. G. (2011). Penguins are attracted to dimethyl sulphide at sea. *J. Exp. Biol.* **214**, 2509-2511.

Kathryn Knight

TREE CRICKET FEMALES LISTEN TO EVERYTHING

Natasha Mhatre

It's a noisy world when you're trying to find a mate and every crooning male around is doing his best to attract the ladies. So how do female crickets successfully select their own species' serenades against the background of everyone else's clamour? Natasha Mhatre from the University of Bristol, UK, explains that most cricket females only hear their own males' calls. Their ears are cleverly tuned to the pitch of their males' chirrups. But insects' body temperatures are not constant, so what happens when the temperature rises? According to Mhatre, most crickets chirrup faster but at the same pitch. However, tiny tree crickets (*Oecanthus henryi*) raise the pitch of their song, leaving their mates with a problem: how to match their hearing to the male's constantly shifting stridulation. According to Mhatre, tree cricket females could use one of two approaches. They could either adjust their hearing as the temperature changes so that they selectively pick out their own males' chirrups at any pitch, or they could listen to every lothario simultaneously and identify their own species' calls by listening out for their own unique song motifs. So which strategy do they opt for?

Mhatre and her colleagues Rohini Balakrishnan from the Indian Institute of Science and Daniel Robert from the University of Bristol, decided to take a look at the female's ears (p. 2569). Scanning a tiny beam of laser light across the insect's tympanum to measure its vibration, Mhatre played a tone rising from 0.5 kHz to 20 kHz and expected to see the delicate tympanum vibrate strongly like a drum skin at the frequency to which it was tuned. However, only a minute 200 μm long sliver of the tympanum vibrated and, instead of vibrating in response to a subset of frequencies, it responded almost equally to every frequency in the sound test. Wondering if there was a problem with the cricket's hearing, Mhatre tested another cricket's ear, but it was the same. After months of painstaking testing, the team finally accepted that instead of tuning their ears to track chirrups at any pitch, the females' ears appeared to be listening indiscriminately to everything.

But even if the female's tympanum could vibrate in response to every frequency from 0.5 to 20 kHz, that doesn't necessarily mean that she can respond to real male chirrups over that range of pitches. 'We decided we needed to do the behaviour if we were going to round the story off,' says Mhatre.

Back in Balakrishnan's Bangalore lab, Monisha Bhattacharya picked up the project to find out whether the females respond to chirrups across the entire pitch range. Synthesising male chirrups from a deep 1.5 kHz up to a high-pitched 8.5 kHz, Bhattacharya filmed female tree crickets' responses as she played the synthesised songs from one of two loud speakers, and found that the females only responded to chirrups between 2.5 and 4.5 kHz, which closely matches the natural range – 2.4–3.3 kHz – over which the males chirrup as temperatures increase from 18°C to 28°C.

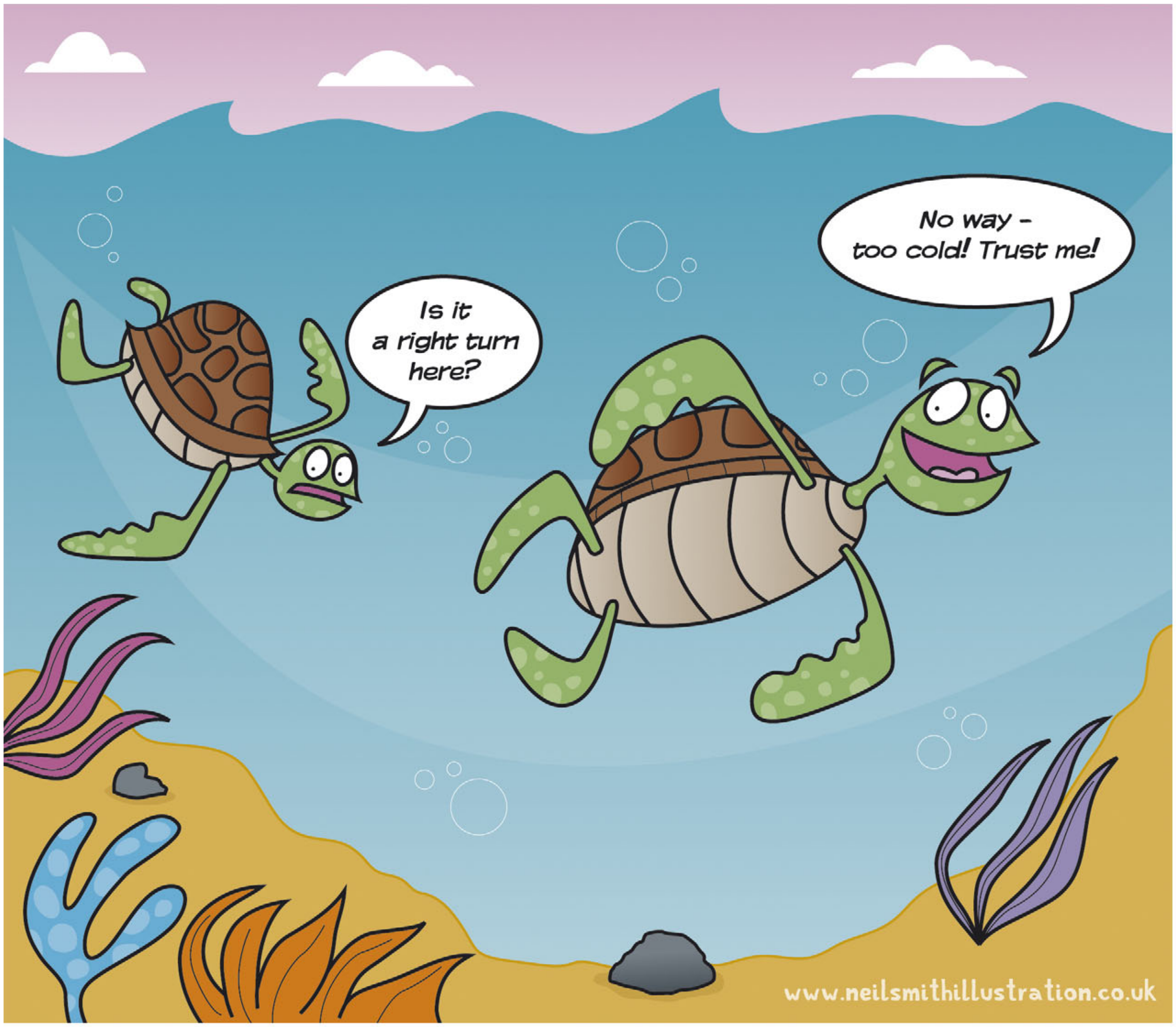
So, instead of tracking the males' serenades as their pitch varies with temperature, female tree crickets listen out for every male, whether he's growling at 2.4 kHz or piping high at 3.3 kHz. However, this means that they must also be picking up background noise from every other amorous species in the neighbourhood, and the team is keen to find out how the females discriminate between their own species' songs and those of interlopers.

10.1242/jeb.062109

Mhatre, N., Bhattacharya, M., Robert, D. and Balakrishnan, R. (2011). Matching sender and receiver: poikilothermy and frequency tuning in a tree cricket. *J. Exp. Biol.* **214**, 2569-2578.

Kathryn Knight

HATCHLING TURTLES NAVIGATE BY GYRE MAGNETIC FIELDS



When hatchling loggerhead turtles embark on their maiden voyage, they join a well-swum route through the warm circulating current of the North Atlantic gyre. However, navigation errors could prove fatal if the novices lose their bearings and head into the colder waters further north. Yet little is known about the navigation mechanisms that keep the novices on course. In 2001, Ken Lohmann from the University of North Carolina at Chapel Hill, USA, measured the directions that newly hatched loggerheads took as they swam through three magnetic fields that occur at locations in the boundary of the north Atlantic gyre where the current shifts direction and could sweep the turtles out into the cold north Atlantic if they were unable to follow the magnetic field and change to course. He found that the turtles' always took bearings that positioned them safely in the gyre. But it wasn't clear if the young voyagers are programmed only to respond to magnetic fields at specific staging posts on the migration route, or whether they respond to all fields within the gyre. Matthew Fuxjager, Brian Eastwood and Lohmann collected newly emerged hatchlings from beaches in Florida and tested the animals' responses to two magnetic fields found at intermediate points in the gyre, one at the gyre boundary and another located 2000 km north of the gyre, to find out whether the hatchlings respond to a few fields in the gyre or, a wider range of fields within and beyond the circulating current (p. 2504).

Measuring the turtles' orientations as they swam in the magnetic fields found in the north and east of the gyre, the team saw that the hatchlings took the best bearing to keep them on track in the warm waters. However, when the youngsters swam in the magnetic field north of the gyre, they headed off in random directions. 'This result is consistent with the hypothesis that hatchling loggerheads are not programmed to respond to regional fields that exist outside of the normal migratory pathway,' say Lohmann and his colleagues, although they point out that the location of the northern field is quite remote from the turtle's natural migration route and the loggerheads may be able to orient in fields that are closer to their usual migration route. The team also adds that turtles that lose their way are unlikely to survive the cold waters, naturally selecting turtles whose sense of direction steers them safely through the gyre and allowing subsequent generations to stay on course as the Earth's magnetic field slowly shifts.

10.1242/jeb.062141

Fuxjager, M. J., Eastwood, B. S. and Lohmann, K. J. (2011). Orientation of hatchling loggerhead sea turtles to regional magnetic fields along a transoceanic migratory pathway. *J. Exp. Biol.* **214**, 2504-2508.

Kathryn Knight
kathryn@biologists.com