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

RELIABILITY IS KEY FOR ANT DECISIONS


Siggi Bolek

Life is precarious for *Cataglyphis fortis* ants in the baking Tunisian desert. Preyed on by large insects and lizards, the ants are also at risk from the searing midday heat, but none of this deters them from foraging. Harald Wolf from the University of Ulm, Germany, explains that having successfully located fertile foraging ground, the venturers find their way home by taking the most direct path back, regardless of how circuitous the outbound journey was. But how do they assess whether it is worth returning to a location, or whether it is more productive to strike out in a fresh direction? Travelling to Maharès, the Tunisian village that he has been returning to for 16 years, Wolf, Siegfried Bolek and Matthias Wittlinger prepared to find out which factors the ants consider when coming to a decision (p. 3218).

Attaching two parallel channels to an ants' nest with a Y-shaped gate, the team placed a single cookie crumb 10 m along the first channel and waited for an ant to find it and return home. Then, when the ant re-emerged from the nest, the team closed the entrance to the training channel, directing it along the second channel. 'The animal runs 10 m along the channel and says, "Food was here last time but it is not now, so let's look"', explains Wolf. Monitoring the ant as it searched to and fro, the team recorded the locations where the ant switched direction and took the median of the turning points as the site where the ant expected to find another crumb. Ants that were sure of the location would concentrate their searches over a small range while ants that were less certain would search over much wider ranges.

Repeating the test on many more ants to determine how certain they were about finding more food, the team then tested other foragers with piles of five or 25 crumbs and eventually a mountain of over 800 crumbs. Then, the team gave the ants longer to become familiar with the location of the food, allowing them to visit the crumb piles five or more times before directing them to the test channel.

After 3 months of painstakingly recording the ants' movements, the team plotted the range over which the ants searched and the position where they expected to find the crumb stashes. 'In the worst case (one crumb and one visit) then the animals go way past, the point is well past 10 m, and they have a large spread of points', says Wolf. And the ants that had visited the small piles of five and 25 crumbs were also equally vague about the pile's location. 'On the other hand, if you have 800 crumbs, then it really concentrates their search almost exactly on 10 m and the spread is really small', recalls Wolf.

Next, the team compared the ants' behaviour after one training run with their behaviour after five or more training runs, and were amazed to see that the ants that had been provided with a single crumb on five repeat visits were as certain about its location as the ants that had hit the jackpot and located 800 crumbs on one occasion: 'If the animal has visited the feeding site at least five times, they regard it as very reliable and concentrate their search', says Wolf.

Finally, the team tested how the insects reacted when they were presented with a densely packed pile and a loose pile of 25 crumbs and found that the ants that had been presented with the densely packed pile searched with more precision. So the ants seem to value sites where they are certain that they are going to find food – and lots of it – but a reliable site is as good as a well-stocked one.

10.1242/jeb.078642

Bolek, S., Wittlinger M. and Wolf, H. (2012). What counts for ants? How return behaviour and food search of *Cataglyphis* ants are modified by variations in food quantity and experience. *J. Exp. Biol.* **215**, 3218-3222.

Kathryn Knight

OPTIC FLOW GIVES STINGLESS BEES IMPRESSIVE VERTICAL ACCURACY

It's easy to measure the distance you have travelled if you walk, but how do flying insects gauge their progress without the aerodynamic equivalent of a stride? According to Megan Eckles from the University of California San Diego, USA, 'the honeybee odometer relies on optic flow, the perceived movement of images across the retina.' In other words, they keep track of time and the speed of images moving across the retina to tell them how far they have gone and to control manoeuvres such as landing. However, Eckles explains that optic flow appears to offer honeybees less precise control during ascent and descent, which might pose a challenge for the honeybee's distant relatives, the so-called ‘stingless bees’ that frequent tropical rainforests. ‘These bees live in a complicated forest environment, and routinely search for food at various heights in the canopy’, says Eckles. Teaming up with David Roubik and James Nieh, Eckles wondered whether stingless bees might share the honeybee’s navigational strategy for judging how far and high they fly (p. 3155).

Travelling to the Smithsonian Tropical Research Institute’s Barro Colorado Island field station in the Republic of Panama, the trio trained *Melipona panamica* stingless bees to forage from a well-stocked feeder located 1.25 m along a 2-m-long horizontal tunnel lined with 8-cm-wide black and white stripes. Eckels admits that getting the bees to cooperate was the hardest part of this study. ‘There were plenty of days when the rains came early and stayed late, and the bees were understandably reticent about leaving the warmth of their nest to come explore one of our tunnels’, she recalls.

However, once the bees were content to forage, the team took away the feeder and watched the returning insects make repeated 180 deg turns as they tried to locate the missing feeder. Converting the average distance travelled by each insect into the amount that the tunnel image moved across the insect’s eye, Eckles and her colleagues found that on average the bees began searching for the feeder roughly 1.29 m along the tunnel. Next the team began playing with the insect’s view of the tunnel by making it narrower – which would make the image of the tunnel move faster across the bee’s eye, convincing it that it had arrived at its destination earlier – and wider – slowing the image’s movement and duping the bee into flying further if it was judging distance by optic flow.

As the team predicted, the bees in the narrower tube stopped short at approximately 0.9 m, whereas the foragers in the wider tube continued on to approximately 1.75 m. The stingless bees, just like their temperate cousins, were using optic flow to judge the horizontal distance that they had travelled, but how were they judging vertical distance?

This time the team turned the tunnel on its end, suspended the feeder 0.75 m from the top and encouraged the bees to ascend to the feeder from an entrance at the bottom. However, when the team removed the feeder on this occasion, they were amazed by the precision of the insects’ vertical odometer. The bees repeatedly began searching at a height of 1.2 m in the standard width tunnel, while cutting their search distance by a half in the narrow tunnel and extending it to over 160 cm in the wide tunnel.

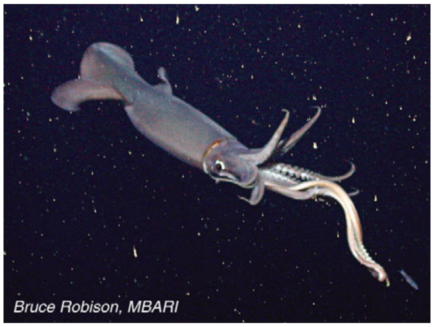
Eckles admits that she was surprised by the improvement in the bees’ vertical accuracy, saying, ‘We did not expect there to be much difference in the precision of distance measurement *versus* height’, adding that she is keen to understand more about how stingless bees cope with their visually complex tropical environment.

10.1242/jeb.078683

Eckles, M. A., Roubik, D. W. and Nieh, J. C. (2012). A stingless bee can use visual odometry to estimate both height and distance. *J. Exp. Biol.* **215**, 3155-3160.

Kathryn Knight

LAID-BACK SQUID SLOW DOWN WHEN OXYGEN LEVELS DROP



Bruce Robison, MBARI

After a decade of studying Humboldt squid in the Gulf of California, William Gilly was puzzled. Working at the Hopkins Marine Station of Stanford University, Gilly had established that Humboldt squid spend significant amounts of time in the oxygen minimum zone, a region of the water column in the eastern Pacific Ocean with a very low dissolved oxygen concentration. The squid still seemed able to make a living in these cold, oxygen-starved waters, and Gilly discovered that they did so by lowering their metabolism. But when Gilly started using electronic tags to monitor their movements, he was surprised to find that squid moved around just as much – and just as fast – in the oxygen minimum zone as they did in near-surface waters, which have much higher oxygen levels. ‘This was odd’, says Gilly. ‘On the one hand, we know that squid lower their metabolism in low oxygen conditions, but on the other hand we weren’t seeing any effect on their behaviour.’ To solve this conundrum, Gilly and his colleagues decided to take another look at Humboldt squid swimming behaviour at different depths (p. 3175).

Fortunately, the team had access to a squid fishery in the Gulf of California, and easily caught some squid. Under the fin of each squid they tucked an electronic tag measuring depth, temperature and light once per second – a much better resolution than previous tags – and set the squid free again. After recovering nine tags, the team set about analysing the data. Sure enough, they found that the squid generally moved more slowly in the oxygen minimum zone than in the water layer just above the oxygen minimum zone, which has a higher oxygen level. When depth measurements indicated that squid were in the oxygen minimum zone, the team saw that the time squid spent moving at intermediate vertical speeds (0.3–1.0 m s^{-1}) was reduced by about half, and the time spent travelling at higher velocities was even more drastically reduced. ‘This solved our puzzle’, says Gilly. ‘This is entirely consistent with the lower metabolism that we see in low oxygen conditions.’ The measurements from the previous tags simply weren’t sensitive enough to detect the lower activity levels in oxygen-starved conditions.

But what were squid doing in the inhospitable oxygen minimum zone? ‘Their favourite prey is concentrated there, and given that they are voracious predators, it seems inconceivable that they’re not eating’, says Gilly. To capture what the squid were doing at these depths, Gilly dressed squid in a ‘bathing suit’ holding a video and data-logging device. Unfortunately, they didn’t dive deeply enough to provide footage of their antics in the oxygen minimum zone, but the accelerometer in the device did help Gilly’s team build a more accurate picture of how Humboldt squid move. ‘They jet upwards at an angle of about 65 deg and then gently glide downwards at a much shallower angle’, explains Gilly. In fact, they spend the vast majority of time gliding, an efficient form of locomotion for the large creatures, which can weigh up to 20 kg.

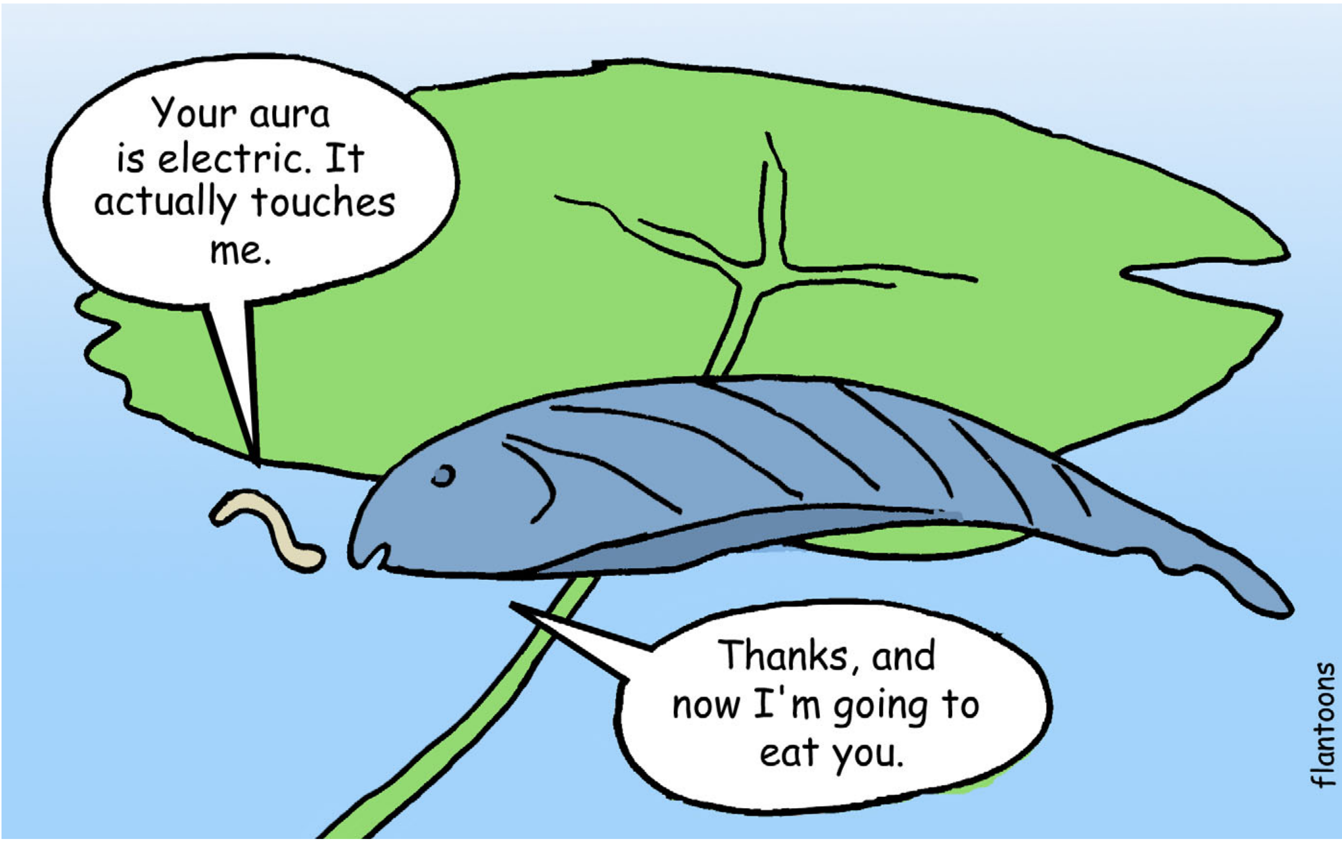
Despite the lack of video evidence, Gilly believes that Humboldt squid eat all the time – at the surface at night, and near the oxygen minimum zone during the day. ‘Everything we saw in this study is consistent with that hypothesis,’ says Gilly, ‘and the next step is to test it more critically.’

10.1242/jeb.078667

Gilly, W. F., Zeidberg, L. D., Booth, J. A. T., Stewart, J. S., Marshall, G., Abernathy, K. and Bell, L. E. (2012). Locomotion and behavior of Humboldt squid, *Dosidicus gigas*, in relation to natural hypoxia in the Gulf of California, Mexico. *J. Exp. Biol.* **215**, 3175-3190.

Yfke Hager

ELECTROREPTION AKIN TO TOUCH



Sheltering under rafts of camalote leaves floating along South American rivers, *Gymnotus omarorum* fish hunt their prey amongst the lilies' roots. However, these predators do not rely on vision when trapping their victims. *Gymnotus omarorum* sense the natural weak electric field produced by other creatures, in addition to distortions in their own pulsed electric field, to locate lunch. But how far-reaching is the fish's electric sense? Is it analogous to vision or more akin to touch? Explaining that electric images become blurrier as objects become more remote, and that electric fields weaken rapidly away from the source while the electric image of an object expands with distance, Carolina Pereira, Pedro Aguilera and Angel Caputi, from the IIBCE, Uruguay, add that long-range electric field image interpretation is challenging. 'The detection range of edible prey using electrolocation appears to be very short. Moreover, theoretical predictions suggest that the range for prey location is even shorter', the team explains. Intrigued by the exotic sense, the trio decided to find out just how extensive the fish's electric sense is (p. 3266).

Measuring the strength of a fish's personal electric field close to the its skin while moving steel and glass spheres of different diameters through the electric field, the team mapped the impact that each sphere had on the field at the fish's surface. Then they placed a cylinder in the fish's electric field, suddenly lowered the object's resistance from 2.5 MΩ to 1 kΩ and monitored the fish's reaction to the change by recording how rapidly the fish pulsed its electric field. The team also measured the limit of the fish's ability to electrolocate by measuring their responses to objects placed at various locations along five lines that extended through its electric field.

Having discovered that objects located near the fish dramatically distorted the distribution of the electric field across the fish's surface, the team was also surprised to see that much of the electric field images varied depending on the size and shape of the object: small objects produced ovoid-shaped fields, while larger objects increased the field volume. In addition, Caputi says, 'We found an electroreception range smaller than predicted.' Each fish's personal electric field was only effective over a range of about 10 mm.

'Electroreception was traditionally compared with vision', Caputi explains. However, he is now reconsidering this perspective. 'In this paper we show that active electroreception is a short-range modality, which fits with our hypothesis that this sensory modality is part of a haptic sense, more similar to active touch than vision in humans', he concludes.

10.1242/jeb.078659

Pereira, A. C., Aguilera, P. and Caputi, A. A. (2012). The active electrosensory range of *Gymnotus omarorum*. *J. Exp. Biol.* **215**, 3266-3280.

Kathryn Knight
kathryn@biologists.com