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.

Inside JEB

FOOD COLOURING FOR MOTHS

Colour is something we take for granted. But while it is useful during the day, in dim light our colour vision fails because of the low levels reaching our eyes' colour receptors. It was generally assumed, therefore, that nocturnal creatures would not have colour vision, so it was a surprise when Almut Kelber and colleagues discovered that it exists in a nocturnal hawkmoth. Hawkmoths forage for nectar using their colour vision to find the best flowers. Most hawkmoths, whether diurnal or nocturnal, are active at dawn and dusk, but at this time of day the light levels change drastically. This makes finding the right coloured flower difficult, but both types of insect seem to be up to the challenge. This ability to constantly recognise colour regardless of the colour of the illumination is called colour constancy. If we look at a blue flower on a sunny day, our eyes register a specific spectrum of light that is reflected back from the flower. But if a cloud passes over the sun, the surrounding light changes; 'if you look at the spectrum that reaches the eyes, it is very different,' explains Anna Balkenius from Lund University in Sweden. Despite this we still know that the flower is blue. Colour constancy has only been found in a few species so far, but all have colour vision, and it would clearly be an advantage for hawkmoths. But whether a nocturnal hawkmoth would still have this ability was a question that Balkenius set about testing with Kelber (p. 3307). 'Colour constancy appealed to me because it has a philosophical dimension and isn't easy to understand. I thought it would be fun to test it in hawkmoths,' enthuses Balkenius.

First, the team trained moths to associate a sugary treat with a specifically coloured paper 'flower' under white light. Balkenius then removed the tasty reward and tested the moths' colour preferences by offering them the choice of identical colours viewed under different coloured lights to see which colour they chose. Even though one of the test colours had a similar spectrum under coloured light to the rewarded colour under white light, the moths seemed able to discriminate between the colours, and preferred visiting the coloured flower that had provided food during training.

But Balkenius needed convincing that the moths hadn't chosen this colour for other reasons; shuffling the flowers prevented the hawkmoths from associating the position of a flower with food, but this did not eliminate the possibility that they were learning which colour provided food relative to the other colours available. So, in another experiment, Balkenius trained the moths to choose the bluest of two colours. Then they were tested with two colours, one the previously rewarded colour and the other even bluer. 'I tried to trick them,' laughs Balkenius. But the hawkmoths were not so easily fooled and went for the colour that they associated with food.

So what's next? Balkenius has some big ideas – relative colour learning has been studied in very few animals and she would like to investigate if dogs use it, especially as they have a more limited range of colour vision. But for now she is sticking with her hawkmoths and is currently investigating whether they use other senses alongside vision to guide them to their dinner.

10.1242/jeb.01216

Balkenius, A. and Kelber, A. (2004). Colour constancy in diurnal and nocturnal hawkmoths. *J. Exp. Biol.* **207**, 3307-3316.

Sarah Tilley, London

THE SWEET CHALLENGE

The sugar found in floral nectars may be sweet, but it comes at a price. Birds that feed on nectar can consume a huge amount of fluid compared to their body weight. And the more dilute the nectar, the higher the volumes ingested. Although the birds derive nutrients and energy from nectar, they have to get rid of the large amounts of water taken in. Failing to do so can have devastating consequences. Palestine sunbirds have somehow overcome the problems of life on liquid diet, so Todd McWhorter and an international team of collaborators decided to examine how they dispose of their excessive water intake (p. 3391).

In the kidney, water is filtered out of blood by specialized structures called glomeruli, and some of the eliminated water is later reabsorbed in the nephron and collecting duct. The researchers set out to test how these processes respond to water intake in Palestine sunbirds. Although following the birds around and measuring their nectar intake is difficult, McWhorter and his colleagues came up with an ingenious solution to the problem. They discovered that the birds adjust the amount they consume according to the concentration of sucrose solutions they are fed: the more dilute the solution, the higher the volumes ingested. In this way, the team could vary the bird's water intake and measure the rates of renal filtration and reabsorption.

McWhorter explains that when the team began investigating this nectarivorous bird's approach to fluid management, it was thought that renal filtration changes according to water status; decreasing in response to water shortage, but increasing only moderately as the birds take on water. But this was based on ideas developed for birds that do not regularly cope with a large intake of water. McWhorter and his team also knew that when the birds are on dilute diets, water is shunted through the gut without being absorbed. So, how would Palestine sunbirds' kidneys cope?

The team found that renal filtration is not exceptionally sensitive to water loading in sunbirds; it increased only slightly in response to a dramatic decrease in sucrose concentration. On the other hand, the fractional water reabsorption – a measure of the proportion of the eliminated water that is reabsorbed by the kidney – dropped significantly when the birds were on the most dilute diet. The sunbirds' kidney responds to the elevated water levels by decreasing reabsorption, rather than by raising the filtration rate.

The team also found that the glucose and osmotic concentrations in the final excreted fluids were significantly lower than those in the ureteral fluids released by the kidney. Because the gut and urinary tracts of birds join at the cloaca, the researchers conjecture that the dietary water that shunts through the gut might have diluted the ureteral fluids. They conclude that Palestine sunbirds deal with large amounts of water intake by not absorbing it in the first place.

From an economical standpoint this makes sense, as eliminating water by increasing renal filtration rate can be energetically costly for birds. Sugar and other metabolites lost during filtration may only be retained by reabsorption, possibly overwhelming the kidney's ability to prevent solute loss. But how the gut could absorb nutrients without taking in dietary water is still a mystery, as the two processes normally come hand in hand.

10.1242/jeb.01217

McWhorter, T. J., Martínez del Rio, C., Pinshow, B. and Roxburgh, L. (2004). Renal function in Palestine sunbirds: elimination of excess water does not constrain energy intake. *J. Exp. Biol.* **207**, 3391-3398.

Jane Qiu,
London

ANTS' HOME APPROACHES DIFFER


Picture provided by Tsukasa Fukushi

If you've ever watched a lone ant scurrying across your floor, you'll know that once its located a juicy snack, the tiny forager somehow recalls where home is and finds the most direct return route, regardless of the circuitous path it took. Intrigued by the navigational strategies ants use to negotiate their way through the world, Rüdiger Wehner has spent much of his career investigating foraging ant's navigational strategies. One species he focused on in Africa, *Cataglyphis*, relies on polarised light cues from the sky to orient themselves. But Wehner was curious whether a close relative, the wood ant, would also use the same strategy. Wehner knew that the tiny explorers are capable of detecting polarised light, but would they use these cues to find their way home? Teaming up with Tsukasa Fukushi in Miyagi University of Education, Japan, they began testing the ants' navigational responses, to see which strategy the Japanese ants used to find their way home (p. 3431).

Fukushi explains that by intercepting ants as they return from a foraging trip, and watching their chosen path when released a short distance away, it's possible to discover which cues the insects use to get their bearings. Ants that rely on polarised light from the sky aren't able to adjust to their new orientation, so they continue following their original course, missing the nest entirely. But ants that rely on local cues are wise to the shift, and adjust their homeward journey to compensate for the inconvenience. Luring the ants with tempting honey water to an abandoned terrace on the campus, Fukushi intercepted the insects and released them a short distance from the feeder, tracking their return journeys to see how they responded. The displaced ants instantly set off in the direction where the nest lay, regardless of where they were released. They weren't relying on a celestial compass. But which landmarks were the insects fixing on to direct them home?

At this point, Fukushi explains, winter set in and he was forced to retreat to the comfort of his laboratory. Plotting the ants' return journeys relative to landmarks visible from the deserted terrace, Fukushi realised that the ants weren't aiming directly at the nest site, but another landmark; a point visible on the ants' skyline that lay between two large chestnut trees. Instead of turning to the sky for guidance, the ants were navigating relative to fixed local landmarks to find their way home.

Having discovered that the wood ants and their African cousins use completely different strategies, Wehner and Fukushi were curious to know which landmarks the wood ants use to orient themselves at different stages during the round trip. Intercepting the ants as they embarked from either the nest or feeder, Fukushi found that the ants set off resolutely towards their goal, no matter where they were released. But when he intercepted the ants that had arrived at the nest or feeder and displaced them, they became disoriented. 'They staggered with frequent turns' says Fukushi, but then they slowly began moving in the direction of their goal. Surprisingly, the insects seemed to use different navigational strategies depending on which leg of the journey they were on.

10.1242/jeb.01215

Fukushi, T. and Wehner, R. (2004). Navigation in wood ants *Formica japonica*: context dependent use of landmarks. *J. Exp. Biol.* **207**, 3431-3439.

SYNCHRONISING SWIMMING AND FLOW

Pete Jeffs is an illustrator living in Paris, France

Although a great deal is known about the synchronised movements fish use to propel themselves through water, and new techniques have recently allowed us to visualise the complex fluid flows that drive them, no studies had linked the two until Eric Tytell decided to put American eels through their paces. By filming eels as they swam over a range of steady speeds at Harvard University, Tytell was able to capture their undulating movements while also viewing the propulsive jets they generated with a sheet of laser light. Correlating the two, Tytell found that although the wake's flow increased as the fish swam at higher speeds, the structure of the wake changed little, even at the highest speeds tested (p. 3265). This is in stark contrast to the wake structures of other fish, which reorient significantly as the fish speed up.

Having visualised the fish's hydrodynamics, Tytell was able to estimate both the power shed into the wake and the change of momentum, as the fish moved through the water, and to compare his measurements with values derived from earlier theories. Surprisingly, the calculated theoretical change in lateral momentum was half the value measured by the hydrodynamic visualisation, while the power predicted by theory agreed well with Tytell's measurements. And when Tytell calculated the wake's cost, he realised that as eels speed up they 'squander less power producing their wakes', although he adds that 'they still waste more power at higher speeds, even if it's a smaller fraction than the amount wasted at lower speeds'.

10.1242/jeb.01218

Tytell, E. D. (2004). The hydrodynamics of eel swimming. II. Effect of swimming speed. *J. Exp. Biol.* **207**, 3265-3279.

Kathryn Phillips
kathryn@biologists.com