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.

BEES USE MOTION SNAPSHOTS TO PICK OUT INCONSPICUOUS LANDMARKS

Laura Dittmar

Bees are remarkable navigators. Flitting around the environment, they match snapshot memories of landmarks surrounding luscious flowers with their current view to successfully direct themselves back to blooms: and they do all this with a brain the size of a microdot.

Laura Dittmar and her colleagues from Bielefeld University, Germany, explain that this strategy works fine when landmarks stand out well from the background, but what happens when the landmarks blend in with the surroundings? Dittmar, Martin Egelhaaf and Norbert Boeddeker decided to find out how bees locate a transparent feeder guided only by landmarks that blend in (p. 2912). But first the team decided to check that their bees used snapshot memories of conspicuous landmarks to locate goals.

Building a 1.95 m diameter flight arena covered with blotchy red paper, Dittmar and Emily Baird trained bees to fly into the arena and locate an almost invisible acrylic glass feeder surrounded by three conspicuous red pillars (landmarks). Then the duo began filming the insects with high-speed video as they altered the landscape. They removed one of the red pillars and filmed the bee as it tried to locate the Perspex feeder with only two pillars for guidance. Then they replaced the cylinder and removed another to see how the bees coped using a different pair of landmarks.

Dittmar saw that the bees initially memorised the location of the entrance to the arena before exploring the pillar landmarks by flying in straight lines, making sharp turns and flying sideways. Dittmar admits that many of these manoeuvres were so fast that they were only visible in the high-speed movies. However, when Dittmar and Baird removed a pillar, the bees' search strategy changed completely. This time the bees focused their search on the remaining pillars and spent longer searching.

After analysing the bee's flight paths, Wolfgang Stürzl calculated stationary bee's eye views of the arena to find out how the insects navigated and saw that the bees try to match their current view of two pillars with the snapshot memory of the three pillars. The team realised that the bees were able to match up their view of the two remaining pillars with their snapshot memory at several locations in the arena, so the insects spent extra time searching these locations until they correctly matched the two remaining pillars with their memory and located the feeder.

Having confirmed that the bees used snapshot memories when navigating with conspicuous landmarks, the duo covered all of the cylinders in the blotchy red paper that covered the flight arena and filmed the bees to see how they fared when their landmarks blended in with the background. Amazingly, they had no problem. 'I was really surprised to see the bees finding the nearly invisible food source when the landmarks were hardly detectable,' says Dittmar.

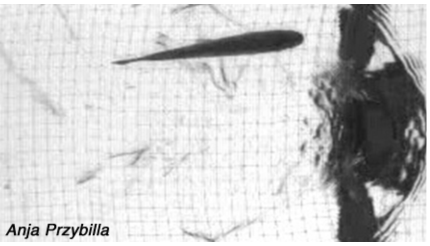
So how did the bees do it? Calculating the stationary bee's view of the blotchy pillars, Stürzl could see that the pillars were almost invisible as they blended in perfectly with the background. However, when he calculated the way that the pillars moved across the insect's eye at different locations in the arena, and compared it with the way that the image of the pillars moves over the eye when the insect is in its final approach to the feeder, Stürzl found a good match. Not only do the bees match static snapshot memories to locate conspicuous landmarks but also they memorise motion snapshots, that include information about the relative movement of objects against the background, to pick out navigation landmarks that would otherwise blend in.

10.1242/jeb.050229

Dittmar, L., Stürzl, W., Baird, E., Boeddeker, N. and Egelhaaf, M. (2010). Goal seeking in honeybees: matching of optic flow snapshots? *J. Exp. Biol.* **213**, 2912-2923.

TURBULENCE GIVES TROUT AN ALMOST FREE RIDE

If you choose to live in fast water, you have to get used to being buffeted about, and that is exactly what stream dwelling trout have done. They appear unaffected by turbulence that would disturb fish used to more tranquil waters. So what adaptations have stream dwelling species made to their turbulent life styles? Anja Przybilla from the University of Bonn explains that trout seem to be able to hold their position just to the side of and behind obstacles in rivers using only a gentle swimming action and this behaviour is known as entraining. Knowing that some


Anja Przybilla

fish take advantage of turbulence generated immediately behind rocks to save energy, Przybilla and her colleagues Horst Bleckmann and Christoph Brücker decided to find out how trout apparently defy their turbulent environment and hold a steady station when entraining (p. 2976).

Placing a 5 cm diameter semicircular cylinder in a flow tank with water flowing at 42 cm s^{-1}, Przybilla allowed individual trout to find a location where they were happy to hold station near the D-shaped obstacle and filmed them swimming with high speed video. Reviewing the movies, Przybilla saw that the fish spent almost 30% of their time swimming in the entraining positions, either to the left or to the right of the D-shaped cylinder's corners. She was also struck that instead of swimming continually, the trout interspersed periods of undulating swimming with brief periods, lasting less than a second, of inactivity. Przybilla explained that during the period when the fish was inactive it drifted back slightly, recovering its position quickly when it restarted swimming. The fluid dynamic forces acting on the fish must have been almost perfectly balanced while the fish was almost stationary.

Having measured the trout's position, body angle relative to the flow direction and other movement parameters, Przybilla described her discovery that the fish stopped swimming while entraining to Brücker and Alexander Rudert from TU Bergakademie Freiberg. They used computational fluid dynamics to build a mathematical model to explain the unexpected behaviour. Analysing the model, the team could see that the angled fish's body essentially behaved like an aerofoil, with the forces generated by the fast flowing water between the fish's body and the D-shaped obstacle cancelling out the lift and drag forces exerted on the body by the water flow. 'The calculations pointed out that this is an energetically beneficial way of swimming because it is low cost,' says Przybilla.

Having shown that entraining fish take advantage of the fluid dynamics for an almost free ride, Brücker suggested replacing the D-shaped cylinder in the flow tank with a long thin D-shaped plate as his calculations had shown that this should improve the trout's stability. Trying the trout out in the flow tank with the D-shaped plate, Przybilla found that the fish used their pectoral fins less for stability than they had with the D-shaped cylinder, so entraining next to a long obstacle is even more energetically efficient than entraining by small rocks.

Finally, the team decided to directly visualise the fluid flows around the fish, but as the trout would not swim in the thin plane of laser light that the team needed to reveal the fluid motion, Sebastian Kunze from Brücker's lab built a model of a fish's body and positioned it in the water like an entraining trout. The flows behaved exactly as Rudert and Brücker had predicted. So trout that live in fast flowing water take advantage of the turbulence to save energy while entraining.

10.1242/jeb.050237

Przybilla, A., Kunze, S., Rudert, A., Bleckmann, H. and Brücker, C. (2010). Entraining in trout: a behavioural and hydrodynamic analysis. *J. Exp. Biol.* **213**, 2976-2986.

PROS AND CONS OF DLW METHOD


Elin Noreen

Knowing how much energy an animal uses is essential for ecologists to understand how ecosystems function. One technique that physiologists use to measure energy expenditure in the field is the doubly labelled water (DLW) method. By injecting water enriched with heavy oxygen (^{18}O) and deuterium (^{2}H) into an animal, physiologists can measure the change in body water ^{18}O:^{16}O (lost as CO_2 and H_2O) and ^{2}H:^{1}H (lost only as H_2O) ratios to calculate the amount of carbon dioxide produced and energy consumed by an animal.

Jannik Schultner from the Norwegian Polar Institute and University of Tromsø explains that there are two widely used methods for taking DLW measurements: one where the birds are released immediately after the injection and a second where the birds are held for an hour after injection to allow the heavy water to become evenly distributed throughout the bird's body fluids before a blood sample is taken to establish the initial ^{18}O:^{16}O and ^{2}H:^{1}H ratios. But the metabolic measurements are only reliable if the animals continue behaving normally during the course of the experiment. Schultner explains that Jorg Welcker had noticed that kittiwakes that had been detained after their injection spent more time away from the nest after release than birds that had been released straight away. Joining Geir Gabrielsen's lab, Schultner, Erling Nordøy and their colleagues decided to investigate what effect the two DLW methods had on kittiwakes' behaviour and energy expenditure to find out how reliable DLW metabolic measurements are (p. 2958).

Travelling to Svalbard, Norway, the team tagged and weighed pairs of nesting birds and injected them with DLW. Releasing some birds immediately after the injection, the team held others for an hour before taking the initial blood sample and releasing the birds. Then the team monitored the injected birds, recording how often they returned to their nests and collected additional blood samples 24 h and 72 h after the injection. Returning to the lab, Schultner sent the blood samples to John Speakman's lab at the University of Aberdeen to measure the ^{18}O:^{16}O and ^{2}H:^{1}H ratios and estimate the birds' metabolic rates.

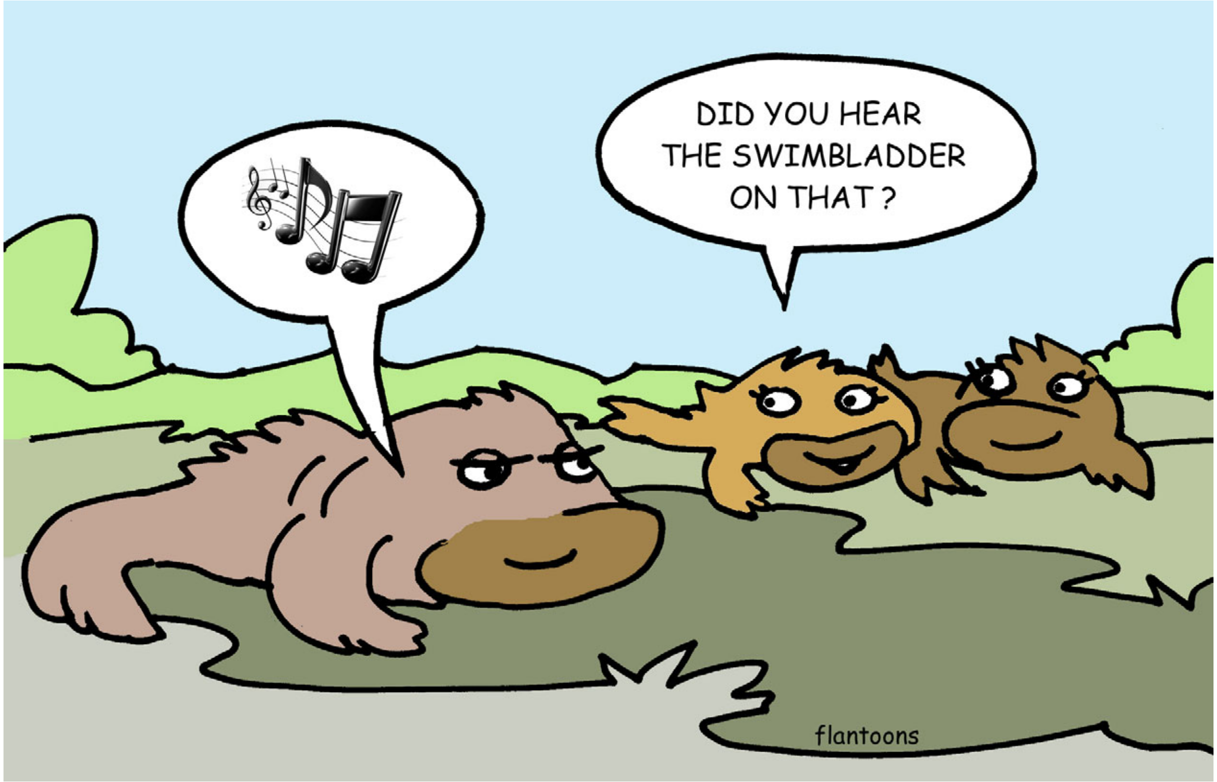
Comparing the behaviour of the detained and undetained birds, the team were surprised to see that the two groups behaved differently. The detained birds stayed away from their nests for about 4 h, while the undetained birds returned within about 10 min. And, when the team recaptured the birds and took later blood samples, the detained birds stayed away from their nests longer than the undetained birds. Finally, when the team compared the metabolic rate estimates obtained from the ^{18}O:^{16}O and ^{2}H:^{1}H ratio measurements, the detained birds' metabolic rates were 15% lower than those of the undetained birds.

So it seems that kittiwake's behaviour is more adversely affected by the second DLW method than had been previously thought, significantly reducing energy expenditure estimates. Schultner adds that the second method was perceived to be more accurate than the first – because researchers measure the initial ^{18}O:^{16}O and ^{2}H:^{1}H ratios rather than estimating them – but this may not be the case. 'I guess when applying the DLW method it is important to weigh the advantages and disadvantages of the different protocols against each other, and then to observe closely what happens to the animals during the study to confirm that the data are as strong as assumed,' says Schultner.

10.1242/jeb.050302

Schultner, J., Welcker, J., Speakman, J. R., Nordøy, E. S. and Gabrielsen, G. W. (2010). Application of the two-sample doubly labelled water method alters behaviour and affects estimates of energy expenditure in black-legged kittiwakes. *J. Exp. Biol.* **213**, 2958-2966.

TOADFISH DADS ARE HONEST ABOUT BEING THE BEST



Eligible Lusitanian toadfish females are always looking out for the best fathers as toadfish dads are actively engaged in their youngsters' future. Standing guard over their nests for 30 days, they protect their eggs and fan them to keep them ventilated. During their long vigil, the males never leave the nest; so prospective fathers have to be fit and toadfish mums want to pick the strongest partners to give their young the best start in life. Clara Amorim and her colleagues from Lisbon, Portugal, wondered how toadfish males advertise their fitness, so they focused on the fish's mating call (p. 2997). Recording males' mating chirrups and checking their physical condition, the team found that the fittest males called more frequently and longer than their weaker counterparts. The fittest males also had larger sonic muscles and gonads and produced shorter chirrup pulses. The team suspects that males that call more often and can contract their sonic muscle fast to generate short chirrup pulses are not just bragging: they're simply being honest about being the best.

10.1242/jeb.050245

Amorim, M. C. P., Simões, J. M., Mendonça, N., Bandarra, N. M., Almada, V. C. and Fonseca, P. J. (2010). Lusitanian toadfish song reflects male quality. *J. Exp. Biol.* **213**, 2997-3004.

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