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

SENSATIONAL SPONGES

Picture by Sally Leys

Sponges don't deserve their reputation as amorphous, uniform creatures, unable to show any coordinated behaviours. For Sally Leys from the University of Alberta, there is a lot more to sponges: 'they are multi-cellular animals', she says, 'and all multi-cellular animals must be able to coordinate behaviour'. When Leys and her colleague Glen Elliott looked at sponges expelling waste, they found that they coordinated contractions in their bodies to achieve this (p. 3736). 'The intriguing thing is that they can do this without a nervous system', says Leys.

The team collected samples of the freshwater sponge *Ephydatia muelleri* and removed the asexual cysts, called gemmules, from their samples. They then placed the gemmules in growth medium so that they could grow small sponges for their experiments. Juvenile *E. muelleri* are small and see-through, so it is relatively easy to see what is going on. The small sponges 'look like a garden tent, with a chimney coming out of the middle,' Leys explains. The 'garden tent' contains a series of canals, tubes and bulges that all converge on a central chimney, which has an opening at the top called the osculum that lets waste out. The team grew the sponges either in the middle of a coverslip, so that they could see their overall movements, or sandwiched between two coverslips, which made it easier to measure how the different parts of the sponge moved to expel waste.

Using time-lapse imaging under the microscope the team stimulated sponges either with a drop of water soluble ink, or by shaking, and measured the changes in the diameter of the canals and pores as the sponges responded to the unpleasant stimuli. During the initial 'inflation' phase of the response the canals inside the tent got bigger as they filled up with water, and the osculum at the top of the chimney was very small. During the next 'plateau' phase the channels got bigger still, and this process lasted longer in bigger animals as there is more space to expand. During the final 'contraction' phase the pores that let water into the sponge closed and the channels in the tent started to contract slowly from the outside in, the contractions increasing in rate towards the centre, filling the base of the chimney with water. For the final contraction, the canals and the osculum contracted, the tent lowered and all the water was quickly forced up the chimney as a package and out of the osculum at the top.

Examination of sponge samples under a fluorescence microscope showed that contractile actin filaments connected cells, which would allow waves of contraction to travel through the sponge. Because sponges don't have nerves, finding out what causes these coordinated contractions to happen is 'the holy grail', says Leys. The team think that the most likely explanation is a wave of calcium ions travelling through the sponge, acting as a signalling molecule. Despite the many mysteries remaining, the team's results means that there is more to sponges than meets the eye; 'we need to think about sponges differently', Leys says, 'because they are animals, they act like animals, and have more animal characteristics than previously thought'.

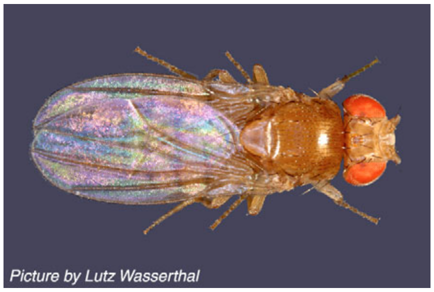
10.1242/jeb.013342

Elliott, G. R. D. and Leys, S. P. (2007). Coordinated contractions effectively expel water from the aquiferous system of a freshwater sponge. *J. Exp. Biol.* **210**, 3736-3748.

HOW FLY HEARTS BEAT BOTH WAYS

Many insect hearts have a property unheard of in most other animals: they can beat backwards as well as forwards. But in the tiny fruit fly *Drosophila melanogaster*, not enough was known about heartbeat reversals in adults or the structure of the heart, which would give more clues as to why reversals might happen. According to Lutz Wasserthal from the University of Erlangen Nuernberg, Germany, heartbeat reversals could help with gas exchange. As non-oxygen carrying insect blood, called haemolymph, is shifted between the front and the back of the body, it could act as a hydraulic fluid, expanding the fly's 'lungs', the tracheal air sacs. To shed some light on backwards beating in adult flies, Wasserthal measured the heartbeat in adults, and scrutinised the heart's anatomy (p. 3707).

The fly's heart is a 1 mm long muscular tube that runs along the dorsal side of the



abdomen, and contains a number of intake valves. At the anterior end of the abdomen, nearest the fly's waist, the heart narrows and becomes the aorta, which travels through the fly's thorax and opens up in the head. Haemolymph is pumped out of this opening into the body cavity, where it travels backwards through the fly's body and is taken up into the heart again via the intake valves.

To record the heartbeat, Wasserthal delicately attached flies to his apparatus by their wings, ensuring that they were completely undamaged. He projected an infrared light through the abdomen of the flies that was picked up by a modified sensor chip with 5 mini-sensors similar to those used in bar code readers. As the heart relaxes, it fills with haemolymph, meaning that more light gets through to the sensor. The changes in light levels recorded by the chip's sensors corresponded to the contracting and relaxing of the heart, and the relative timing of the waves of contraction told Wasserthal whether the heart was beating forwards or backwards.

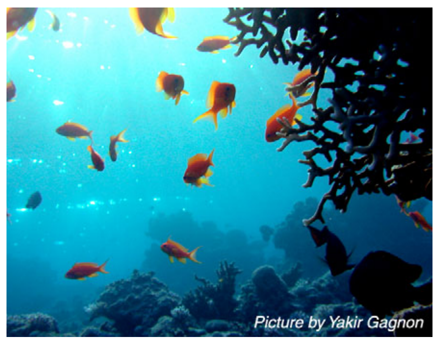
He found that when beating forwards, the heart beats at slower rate, around 4 Hz, and for longer periods of time, around 14 s. When the direction reverses the heart beats faster, around 5 Hz, and for a shorter time, around 5 s. The heartbeat switched from forwards to backwards beating and then back again once every 20 to 25 s.

What was currently known about the anatomy of the fly's heart, though, couldn't explain where the haemolymph would flow during reversed heartbeat. By carefully preparing his samples for scanning electron microscopy and analysing the tissues, Wasserthal found another pair of input valves at the end of the heart near the waist, which would allow haemolymph to get into the heart from the thorax nearby. These input valves are fed by a pair of newly discovered channels that allow haemolymph to flow from the thoracic cavity to the heart. He also found an opening at the posterior end of the heart, allowing haemolymph to flow out in the opposite direction. These results made it clearer how and why the heart beats both ways: as heartbeat reversals shift haemolymph out of the front half or the back half of the fly's body, the tracheal sacs compensate for the change in haemolymph volume, emptying or filling with air.

10.1242/jeb.013334

Wasserthal, L. T. (2007). *Drosophila* flies combine periodic heartbeat reversal with a circulation in the anterior body mediated by a newly discovered anterior pair of ostial valves and 'venous' channels. *J. Exp. Biol.* **210**, 3707-3719.

LIGHT SCATTERING BY ZOOPLANKTON



In the open sea, there is nowhere to hide. Predators scanning the depths can spot potential victims by how they scatter the light shining through the water. However the different shapes, sizes and transparencies of the creatures swimming around in the ocean affects how easy they are to see. So Yakir Gagnon, Nadav Shashar and their colleagues measured how light-scattering by zooplankton, a common prey, affects their visibility in the Gulf of Aqaba (p. 3728).

The team collected a variety of shrimp-like crustaceans, marine worms and acorn worm larvae, mostly 1–3 mm long, using light traps or very fine mesh nets. Gagnon delicately glued individual zooplankton with a tiny amount of superglue to a very fine glass needle before re-submerging them in seawater. To measure scattered light, the team shone white light directly downwards onto the back of each animal. A semi-circle of fibre optic cables placed at different angles relative to the light source and linked up to spectrophotometers measured the spectra of the light scattered off the animals at each of the different angles. They could also calculate how much light passed through the creatures, and therefore how transparent they were, finding that they ranged in transparencies from 1.5% to 75%.

As light travels through the water column, it is scattered or absorbed: red wavelengths are filtered out first, and blue light travels the furthest. Light intensity decreases logarithmically with depth, such that differences in light intensity with depth are much greater at shallower depths than at deeper ones. So the depth of the water influences which wavelengths of light are present, and therefore which wavelengths are scattered.

With this in mind, the team wanted to know how visible each of the species were at different depths and viewing angles. To do this they combined the information they had collected about the unique light scattering patterns of the different zooplankton species with previously developed mathematical models that calculated how light intensity changes in the sea according to the viewing angle of an observer, the angle of the light travelling through the water, and also the depth. Using these models, the team calculated how depth affected the sighting distance, which is the distance between an observer and the zooplankton.

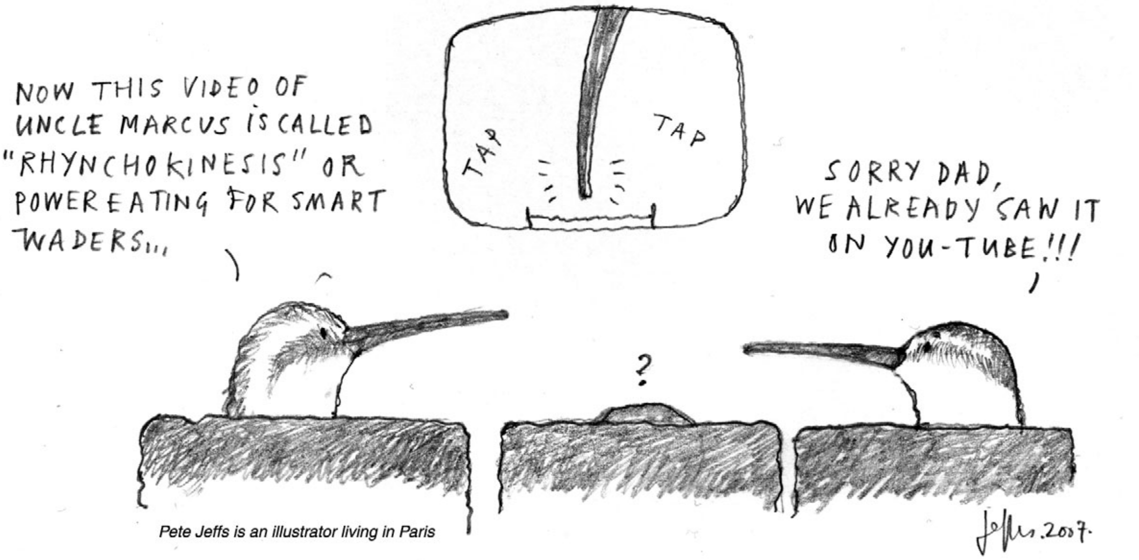
At depths of up to 40 m, most of the animals were brighter than the background, and were easiest to see when observed horizontally or from diagonally above and below. This means that at less than 40 m depth, it is much harder so see the animals by looking directly down onto them, or directly up. In general, the less transparent animals could be seen from further away.

At greater depths, however, there is a cross-over such that the background is brighter than the animals, but the point at which this happens varies depending on the viewing angles and the depth. Theoretically, at this point the animals should be very difficult to see as they have a similar brightness to the background. A little deeper, though, and they become less bright relative to the surrounding water. The best viewing angle also changed at depths below 40 m, to looking directly upwards. These results suggest that the predators that feed on the zooplankton will have to pick their viewing position carefully if they want to spot their next meal.

10.1242/jeb.013326

Gagnon, Y. L., Shashar, N., Warrant, E. J. and Johnsen, S. J. (2007). Light scattering by selected zooplankton from the Gulf of Aqaba. *J. Exp. Biol.* **210**, 3728-3735.

BENDY BEAKS



Pete Jeffs is an illustrator living in Paris

Modern birds have highly sophisticated jaws, much more flexible than our rigid skull and mandible. Birds can move their whole upper jaw, or parts of it, relative to their cranium, because of regions of thinner bone called bending zones. One of these forms of flexibility is called distal rhynchokinesis, where a section of the upper beak, near the tip, bends relative to the rest of the beak. Interested to know why long-billed shore birds use this unique form of beak bending, Sora Estrella and José Masero filmed wild and captive shorebirds – curlew sandpipers, dunlins, sanderlings and little stints – as they fed on brine shrimp in water (p. 3757).

Analysing films of the birds' feeding habits, Estrella and Masero found that both wild and captive birds used distal rhynchokinesis to capture prey. Captive dunlins used rhynchokinesis in around 90% of prey strikes, where they are aiming for their brine shrimp prey with their beak open, and also 76% of the time when they grabbed prey. Rhynchokinesis helped them transport the shrimp from the tip of the beak and into the mouth 42% of the time, and sped up this process. The birds also used rhynchokinesis more with larger shrimp, and in these cases the beak bent more. The authors suspect that this mechanism allows the birds to feed flexibly and opportunistically, saving time and energy, and may also have contributed to their ability to exploit habitats that other birds might ignore.

10.1242/jeb.013318

Estrella, S. M. and Masero, J. A. (2007). The use of distal rhynchokinesis by birds feeding in water. *J. Exp. Biol.* **210**, 3757-3762.

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