

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

DISCUS FISH PARENT LIKE MAMMALS



Richard J Maunder

Few fish are famed for their parenting skills. Most species leave their freshly hatched fry to fend for themselves, but not discus fish. Jonathan Buckley from the University of Plymouth, UK, explains that discus fish young feed on the mucus that their parents secrete over their bodies until they are big enough to forage. ‘The parental care that they exhibit is very unusual,’ says Buckley. Intrigued by the fish’s lifestyle, Buckley’s PhD advisor, Katherine Sloman, established a collaboration with Adalberto Val from the Laboratory of Ecophysiology and Molecular Evolution in Manaus, Brazil, and together with Buckley and Richard Maunder set up a colony of breeding discus fish in her Plymouth lab to find out more about their strange behaviour (p. 3787).

Unfortunately, discus fish are notoriously difficult to breed and keep in captivity. ‘Hobbyists didn’t succeed in rearing them until the 1970s,’ explains Buckley. Having imported 30 adults from breeders in Malaysia, the team reproduced the breeding conditions in the Amazon during the dry season to encourage the fish to spawn. They lowered the water level and left it for a few hours before topping the tank up with cold water, and repeated the process until the pair was ready to lay their eggs. Buckley also collected samples of the orange mucus from the fish’s flanks before they spawned and at various stages after the eggs had hatched, and monitored the parent’s behaviour as their offspring grew.

During the first 3 days after hatching, the fry remained attached to the cone where the parents laid their eggs, absorbing the yolk and gaining strength until all of the fry were able to swim independently. Then they left the cone en masse and began feeding on their parents’ mucus, feeding for up to 10 min by biting at the parent’s side until the parent expertly ‘flicked’ the shoal over

to its partner to continue feeding. The parents diligently fed their young intensely for 2 weeks. However, 3 weeks after hatching the parents’ behaviour began to change as they started swimming away from their young for brief periods. At the same time the fry began biting their parents less and investigating other food sources. By the fourth week the parents were actively swimming away from their brood for the majority of the time and the fry barely bit them at all.

‘There are a lot of parallels between the discus fish’s parental care and the parental care that we see in mammals and birds,’ says Buckley. Initially the parents invest all of their effort in raising their current batch of young, but wean the offspring when their investment in the current brood might begin affecting later broods. Buckley suspects that he sees signs of the conflict often seen between mammals and their young – where parents want to wean their offspring and the offspring continue pursuing them – in the fish’s chasing behaviour during the third week after hatching.

Monitoring the composition of the parents’ mucus before they spawned and through to the end of their parental responsibilities, Buckley found a huge increase in the mucus’s antibody and protein levels when the parents laid their eggs, similar to the changes seen in mammalian milk around the time of birth. The protein and antibody levels remained high until the third week and returned to pre-spawning levels during the fourth week after hatching. Buckley suspects that the sudden increase in protein levels at spawning is hormonally regulated, much like the changes in mammalian milk, and is keen to find out more about the hormones that regulate the fish’s mucus supply as they care for their young.

10.1242/jeb.052738

Buckley, J., Maunder, R. J., Foey, A., Pearce, J., Val, A. L. and Sloman, K. A. (2010). Biparental mucus feeding: a unique example of parental care in an Amazonian cichlid. *J. Exp. Biol.* **213**, 3787-3795.

FLUID FLOWS HELP BLIND FISH SENSE SURROUNDINGS

Blind Mexican cave fish are fine at negotiating their cave homes. Having done away with their eyes they use other senses to guide them in the dark. Shane Windsor from the University of Auckland, New Zealand, explains that all fish sense their environment using velocity sensors on their skins and pressure gradient sensors along both sides (known as the lateral line). However, for blind cave fish these pressure and velocity sensors are their main senses for detecting their surroundings. Curious to know how the fish’s surrounding hydrodynamic fields change as they



encounter obstacles, Windsor and his PhD supervisors, Gordon Mallinson and John Montgomery, put blind Mexican cave fish in a digital particle image velocimetry (DPIV) rig built by Stuart Cameron to visualise the fluid flowing around them (p. 3819/3832).

Releasing individual fish (ranging in size from 40 to 60 mm) into the DPIV system, Cameron and Windsor shone a plane of laser light into the tank and filmed the water swirling as the fish swam through the laser plane. Filming the fish when they swam perpendicular to the wall was easy; 'They follow surfaces so if you have a square tank they keep going round and round the outside,' explains Windsor. However, recording the fluid flows as the fish approached a wall head on was more difficult. The duo had to direct the fish out into open water by placing an obstacle in their path, forcing them to head directly toward the opposite wall.

Analysing the velocity of the water flowing around the fish's nose and along its sides, Windsor was able to calculate the pressure field that the fish detects with its lateral line. Comparing the pressure field surrounding the fish in open water with the pressure field as it approached a wall head on (p. 3819), Windsor says, 'When it's away from the wall there is a stagnation point – that's where the flow is coming straight in to the nose. From the point of view of the fish the flow stops and there is very high pressure.' However, as the fish approached the wall head on, at a distance of about 8–12 mm the team saw the stagnation point widen and spread across the fish's nose as the pressure rocketed, warning the fish that it needed to change course to avoid a collision.

When the fish swam parallel to the wall (p. 3832), at distances less than 4–6 mm, the team saw the stagnation point slip around to the side of the fish's head closest to the wall and spread wide as the pressure rose. The pressure at the side of the fish also dropped as the fish neared the wall.

Next the team was curious to find out how these pressure and velocity features varied as the fish swam at different speeds and distances from the wall. Windsor explains

that the fish swim faster when introduced into a new setting and the team wanted to find out if increasing the fish's speed increased their sensitivity to looming objects. However, 'You can't say "Swim this fast and this far from the wall," to the fish. You have to take what you get,' says Windsor, so he teamed up with Stuart Norris to run computational fluid dynamics (CFD) simulations where he varied the computational fish's swimming speed and distance to the wall to find out how the pressure and velocity fields were affected.

The team found that the fluid flow patterns hardly changed, even at the highest speeds. 'Everything just scales with the velocity and the form doesn't change,' says Windsor, and adds 'if a fish is sensitive to a certain relative change, say a doubling, it will pick it up at pretty much the same distance irrespective of how fast it is swimming'. So, speeding up may not help the fish detect more distant objects because the hydrodynamic changes that they respond to occur at the same distance from obstacles regardless of their speed. Also, moving fast gives them less time to respond to structures, so why do they speed up in unfamiliar water?

Windsor suspects that by swimming fast the fish increase the fluid flow around their bodies, making the hydrodynamic signal stronger and easier to interpret in noisy environments. He also suspects that the fish probably keep track of the location of the stagnation point and other flow features on the surface of their bodies. 'They can use that to interpret how things change in time and space,' says Windsor, 'to help them avoid obstacles in the dark'.

10.1242/jeb.052720

Windsor, S. P., Norris, S. E., Cameron, S. M., Mallinson, G. D. and Montgomery, J. C. (2010). The flow fields involved in hydrodynamic imaging by blind Mexican cave fish (*Astyanax fasciatus*). Part I: open water and heading towards a wall. *J. Exp. Biol.* **213**, 3819–3831.

Windsor, S. P., Norris, S. E., Cameron, S. M., Mallinson, G. D. and Montgomery, J. C. (2010). The flow fields involved in hydrodynamic imaging by blind Mexican cave fish (*Astyanax fasciatus*). Part II: gliding parallel to a wall. *J. Exp. Biol.* **213**, 3832–3842.

BUTTERFLYFISH BUCKLE SWIM BLADDER TO CROAK

Life beneath the sea is far from quiet. Apart from whales singing and dolphins clicking, there are families of fish that produce a repertoire of buzzes and whistles by vibrating their swim bladders. While toadfish and sea robins are well known for their vocal lifestyle, a few butterflyfish species have recently joined the ranks of croaking fish. Kelly Boyle and Timothy Tricas, from the University of Hawaii at



Manoa, explain that vocal fish species mainly use two methods to make calls. Some vibrate their swim bladders with intrinsic muscles that insert onto the swim bladder and vibrate it directly while other species vibrate the swim bladder by contracting muscles that are adjacent to it. Curious to find out how one species of butterflyfish, the pyramid butterflyfish (*Hemitaurchithys polylepis*), makes its croaks, Boyle and Tricas went diving on the Puako coral reef to film and record the fish calling (p. 3881).

The duo found that the fish only used their voices in the late afternoon when they were close to the reef during courtship. Back in the lab, Boyle and Tricas decided to take a closer look at the sounds the fish made and the way they made them. Filming the fish at high speed as they croaked, they noticed a small (0.2 cm²) section of the skin on the fish's side – above the swim bladder and just behind the pectoral fin – buckling. Inserting minute EMG electrodes into individual muscles in the area, the team found that one muscle group, the anterior hypaxial muscles, were firing electrical signals in synch with the patch of skin. They also recorded the croaks' spectra and found that the fish produced rapid pulses of sound. Each pulse had a peak frequency of 97 Hz and the pulses were also in synch with the buckling movement on the fish's surface. Finally, Boyle and Tricas looked at the position of the anterior hypaxial muscles and found that the muscles were not attached directly to the swim bladder, but to adjacent structures. The duo suspects that when the muscles on both sides contract, they buckle the fish's sides forcing the swim bladder out in front to produce a sound. They also explain that the pyramid butterflyfish's indirect approach is similar to that of unrelated fish and the duo suspects that these butterflyfish have independently evolved the mechanism instead of inheriting it from close relatives.

10.1242/jeb.052712

Boyle, K. S. and Tricas, T. C. (2010). Pulse sound generation, anterior swim bladder buckling and associated muscle activity in the pyramid butterflyfish, *Hemitaurchithys polylepis*. *J. Exp. Biol.* **213**, 3881–3893.

Kathryn Knight
kathryn@biologists.com

© 2010. Published by The Company of Biologists Ltd