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

CORMORANTS TAKE TURNS WITH THEIR TAILS

Picture by Tamir Strod

Cormorants are superb at catching fish. Diving near the surface, cormorants easily outpace most fish. However, cormorants fight a constant battle against buoyancy caused by air trapped in their lungs and plumage. They overcome the tendancy to float by swimming fast, but how do the predators manage to execute tight turns when pursuing a tasty treat? Gal Ribak explains that most creatures slow down before turning, but a loss of speed would place a cormorant at risk of bobbing to the surface. Ribak and his colleagues Daniel Weihs and Zeev Arad from the Technion, Israel, decided to see how cormorants overcome their buoyancy while diving through a submerged obstacle course (p. 3009).

According to Ribak, the team had no problems finding cormorants to work with. He explains that great cormorants regularly raid local tilapia and carp farms, so the team were able to rescue two wild birds tangled in nets above ponds. The rest had been raised in captivity from eggs and had taken to diving with ease.

Encouraging the cormorants to dive though a 1 m deep tunnel in a pool was also straightforward; 'They'll do anything for fish,' says Ribak. Having trained the birds to dive through the tunnel, the team introduced three obstacles: a barrier across the top of the tunnel near the entrance, a barrier across the bottom of the tunnel at the middle, and a barrier across the top near the end. The cormorants had to swim under the first barrier, over the second and under the last, making a bell shape as they passed through the tunnel. After several days of practice, the team attached a marker to the birds' wing and filmed the birds from the side as they negotiated the obstacles. How tight a turn could the birds manage? Gradually moving the two outer barriers inwards, the team eventually narrowed the bird's bell-shaped swim from a width of 180 cm to a minimum of 72 cm; the radius of the birds' tightest turn was less than half their length.

After weeks of filming, Ribak began analysing the birds' trajectories and speeds and found that the birds did slow a little as they manoeuvred between the barriers, but not much. Even during the tightest manoeuvre, the birds only reduced their speed by 12%. So which forces were driving the divers through their high-speed rollercoaster ride?

Measuring the angles that the cormorants' tails, bodies and necks made relative to horizontal, and calculating the turning forces they generated during the tight vertical turn, Ribak found that the birds took advantage of their buoyancy to bob upwards as they approached the second barrier. But which part of the body was generating the forces needed to dive down? According to Ribak it's the tail, which pushes the body into the correct orientation to generate sufficient downward force to overcome buoyancy and allow the bird to dive down again. Ribak adds that the cormorant's long neck contributes little as the bird overcomes its buoyancy, but the team suspect that the neck's flexibility could allow the bird to snap up fish that might otherwise out manoeuvre them.

10.1242/jeb.024158

Ribak, G., Weihs, D. and Arad, Z. (2008). Consequences of buoyancy to the maneuvering capabilities of a foot-propelled aquatic predator, the great cormorant (*Phalcrocorax carbo sinensis*). *J. Exp. Biol.* **211**, 3009-3019.

IDENTIFYING GENE MODULES THAT SHAPE CICHLID SOCIETY

Cichlids are remarkably social fish. Susan Renn and Hans Hofmann explain that some cichlids are monogamous, while the males from other species surround themselves with a harem. *Astatotilapia burtoni*, on the other hand, form schools of silvery subordinate males and females that wander through the territories of brightly coloured males. But these social structures are far from rigid, and once a subordinate male becomes big enough, he can overthrow a weaker dominant male and take his place. Having spent years studying *A. burtoni*'s physiology, Hofmann decided to take a genomic approach to understanding the physiology underlying the fish's social interactions when setting up his own lab at Harvard. Teaming up with Renn and Nadia Aubin-Horth, the trio set out to identify key differences in gene expression patterns between the brains of dominant and subordinate *A. burtoni* males, to begin understanding what sets

subordinate and dominant males apart (p. 3041).

But first the team had to design a custom-made cDNA microarray, carrying approximately 4000 of the genes that are expressed in *A. burtoni* brains. After months of painstakingly isolating genes, sequencing them and searching DNA databases to identify as many of the genes on the microarray chip as possible, the team were ready to test the fish's brains. Setting up nine independent groups of fish, each containing 2–3 males and 2–3 females, the team monitored the fish's behaviour for 5 weeks, clearly establishing which males were dominant and subordinate, before extracting RNA from the fish's brains and comparing the gene expression patterns of dominant males, subordinate males and egg carrying females on the microarray.

According to Renn, the team found that the expression of 87 genes increased in the brains of dominant males, while expression of another 84 genes was increased in the subordinate males' brains. Some of the upregulated genes in the dominant males' brains had already been identified by more classical experiments, such as neuropeptide hormones involved in reproductive dominance and pair bonding in other species. The team also found increased gene expression of tubulin and actin in the dominant males' brains, which could suggest changes in neuronal architecture as the fish ascend the social hierarchy. Also the expression of two neurotransmitter receptors was affected by the male's social status. GABA receptor increased in the dominant males while the kainate receptor increased in the subordinate males. Although the exact role of these receptors in regulating social status is not clear, Hofmann and his collaborators know that the different expression patterns will have profound effects on the electrophysiology of dominant and subordinate male's brains.

After identifying lists of genes whose expression levels change in response to the fish's changing social status, the team used a 'systems level' approach, where they looked at differences in the overall gene expression patterns to identify groups, known as modules, that function together to produce specific characteristics. Renn admits that having assumed that the dominant males would simply be souped-up versions of subordinate males, the team were surprised to find that 'many genes that are upregulated in females seem to be important for determining social status in males too,' and adds 'dominant males are not "super males".'

Since beginning this work, the trio have gone their separate ways, but all three are keen to find out more about the roles of gene modules in social functions, each from a slightly different perspective. Ultimately they hope to learn more about how gene modules function together to shape cichlid social structures.

10.1242/jeb.024141

Renn, S. C. P., Aubin-Horth, N. and Hofmann, H. A. (2008). Fish and chips: functional genomics of social plasticity in an African cichlid fish. *J. Exp. Biol.* **211** 3041-3056.

BIRDS LAY OFF BLOOD CELLS WHEN LAYING EGGS

It doesn't seem to make sense to be at a low ebb during a physiologically demanding time, but this is what happens to female birds when laying eggs. Their red blood cell numbers plummet and they become anaemic, a metabolic hit that the birds can ill afford when reproducing. But what causes this loss of oxygen carrying capacity at such a challenging time? Emily Wagner and her colleagues, Christine Stables and Tony Williams from Simon Fraser University, Canada, explain that there could be several reasons for the birds' anaemia: the birds' blood has become diluted by an influx of materials destined for egg yolk; the birds have redirected the energy required for red blood cell production to reproduction; the birds reduce red blood cell production while laying eggs; or several of these factors conspire to compromise the birds' fitness. Wagner and her colleagues set out to find out why birds become anaemic when they lay a clutch (p. 2960).

Working with zebra finches, the team fed one group of birds on a high quality diet, while the others were fed on regular birdseed as they mated and laid eggs. Then the team swapped the groups, so that the poorly fed birds received the high quality diet, while the previously well-fed birds switched to birdseed before mating and laying again. Monitoring the females' blood as they laid and incubated their eggs, the team found that even the birds on the poorest diet experienced the same level of anaemia, with all of the females' red blood cell counts falling by ~8%. Wagner explains that as all of the females experienced the same reduction in red blood cell levels, regardless of their diet, the anaemia is probably caused by dilution with compounds destined for egg yolk.

However, this wasn't the only cause of the birds' anaemia. The team suspect that egg-laying female zebra finches also become anaemic because they reduce red blood cell production. Wagner found that the proportion of immature red blood cells released into the bird's blood continued rising after the females stopped laying their eggs, peaking around the time when the eggs hatched. 'This is consistent with enhanced production and release of larger immature cells into the circulation following suppression of erythropoiesis,' says Wagner, before speculating that the hormone oestrogen could be responsible for reducing the birds' red blood cell production levels while laying eggs.

Wagner adds that the metabolic burden associated with recovery from a bout of egg-laying anaemia could account for the negative impact that egg laying has on brooding mothers.

10.1242/jeb.024133

Wagner, E. C., Stables, C. A. and Williams, T. D. (2008). Hematological changes associated with egg production: direct evidence for changes in erythropoiesis but a lack of resource dependence? *J. Exp. Biol.* **211** 2960-2968.

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