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

UP, UP AND AWAY

Picture by Anders Hedenström

When swift fledglings depart the nest, there's no going back. They may not touch down again for another two years, and many swifts only perch to mate and raise young. According to Per Henningsson from Lund University, Sweden, the bird's aerial life style is reflected in their extreme build. With streamlined bodies and long slender wings, swifts are perfectly designed for life on the wing. 'They are like no other bird' says Henningsson 'which makes them very interesting'. What is more, little was known about the ultimate aeronaut's aerodynamics 'which makes them an important piece of the puzzle to understand animal flight' adds Henningsson. Knowing that much can be learned about an animal's flight by analysing the complex fluid flows in their wake, Henningsson and Anders Hedenström teamed up with Geoff Spedding from the University of Southern California to make the first aerodynamic measurements of swifts during flapping flight (p. 717).

However, adult swifts are extremely sensitive birds that are notoriously difficult to keep in captivity. Fortunately, there was an alternative; to collect fledgling birds just before they left the nest. Capturing two juveniles, Henningsson returned to the lab before introducing them to the Lund University wind tunnel for their maiden flights. 'They didn't know about real life' says Henningsson 'so they just accepted the wind tunnel'. In fact, the birds flew so well that Henningsson was able to begin collecting data within a day of the fledglings' first flights.

Filming the birds from behind, Henningsson recorded 80 complete wing beats while the birds flew comfortably at three different speeds. As the birds' speeds increased, Henningsson noticed that their wing beat frequency dropped while the birds raised their wings higher at the start of every wing beat. The birds' muscles were shortening at a fixed rate, regardless of their flight speed 'like an engine with one gear' says Henningsson.

Having analysed the birds' wing beat geometry, Henningsson moved on to visualise the air flows in the birds' wakes. Introducing a thin fog into the flight tunnel, Henningsson visualised the eddies and currents in narrow slices of the birds' wakes with a fine plane of laser light. Digitally tracking the trajectory of individual fog particles in the laser plane and combining individual wake slices, Henningsson could build up a complete picture of the wake to see how the birds remain aloft.

Analysing the reconstructed wake, the team could see that the wing generated both lift and thrust as the swift brought its wing down, just like any other flapping bird. But the aerodynamics of the wing beat's upstroke was completely different. Henningsson explains that most birds retract their wings during the upstroke to minimise the effect of drag, despite the loss of lift. However, the team could clearly see that the swift's wings remained extended, generating lift while reversing the thrust direction, resulting in an effective drag. The swifts got a smoother ride despite the incurred cost. And the wake structure was completely different from anything that had been seen, or modelled, before; the birds continually shed force-generating vortices during the course of each wing beat. Most remarkably, the swifts generated the highest lift-to-drag ratio that had ever been measured for birds during flapping flight.

10.1242/jeb.017475

Henningsson, P., Spedding, G. R. and Hedenström, A. (2008). Vortex wake and flight kinematics of a swift in cruising flight in a wind tunnel. *J. Exp. Biol.* **211**, 717-730.

MOTHER'S GIFT IMPROVES CHICK'S GROWTH

Resisting infection takes a lot of strength, and sometimes that strength comes at a cost. For example, the growth of newborns exposed to infection can be restricted. But newly hatched chicks aren't completely unprotected from infection; they emerge with antibodies supplied by the mother when she laid the egg. Jennifer Grindstaff, from Oklahoma State University, wondered whether the mother's antibody gift may benefit aspects of a youngster's physiology other than immunity, such as growth? Curious to know whether inherited antibodies could counteract infection and maintain the chick's growth rate, Grindstaff set about recording the growth patterns of 200 chicks after exposure to a fake infection (p. 654).

But first Grindstaff needed to find out if specific maternal antibodies would be transmitted through a mother's egg to her chick. Starting off with 32 female quail, Grindstaff exposed 21 of the mums-to-be to fake bacterial and viral infections. Injecting

Picture by Jennifer Grindstaff

12 birds with a bacterial cell wall factor (lipopolysaccharide, LPS) and nine with an inactivated avian virus, Grindstaff tested the mothers' immune systems several days later and found that they had all developed antibodies against their fake infections. But had they passed the antibodies on to their eggs? Testing the yolks of fake-infected mum's eggs, Grindstaff was able to identify antibodies to both fake infections. The antibodies had been passed on to the eggs, but would the chicks inherit their mother's resistance?

Grindstaff collected eggs from each of the fake-infected mothers and a group of mothers that had not received fake infections, until she had over 200 eggs ready to hatch in an incubator. Grindstaff admits that the project was a logistical nightmare. 'I had spaced all of the eggs out so they wouldn't all hatch on the same day', says Grindstaff, but the chicks conspired against her. 'They call to each other in the egg', Grindstaff explains, 'and they synchronised, hatching over a 2-day period'. Faced with a population explosion, Grindstaff and her team of undergraduate helpers, Liliana Martinez, Kari Smith and Rosanna Fidler, marked each chick at birth so they knew which family it belonged to. Next the team measured each youngster's vital statistics and collected tiny blood samples to see if the fake-infected mother's antibodies had been passed on. They had, but how would the chicks' immunity, handed down from their mothers, influence their growth if they experienced the same fake infection their mothers had received?

Randomly assigning each of the chicks to one of three groups, Grindstaff immunised the youngsters, by injecting them with one of the fake infections, or injected them with a sterile solution that wouldn't simulate an infection, before monitoring their growth. After a week of franticly measuring the chicks as they grew, Grindstaff realised that the immunised chicks' growth was significantly worse than the chicks that had been injected with the sterile solution. Dealing with the inflammation caused by the fake infections had restricted the chick's growth.

But how had the fake-infected chicks that had received antibodies from their mums grown compared with fake-infected chicks that had not? The results were startlingly clear. Fake-infected chicks that had received maternal antibodies grew much better than fake-infected chicks that had not received maternal antibodies. The mothers' antibodies had apparently protected their offspring, allowing them to deal with the fake infection's inflammation without seriously compromising their growth.

10.1242/jeb.017459

Grindstaff, J. L. (2008). Maternal antibodies reduce costs of an immune response during development. *J. Exp. Biol.* **211**, 654-660.

WORMS FOLLOW PHEROMONE

It's a calm, moonlit summer's evening, and the perfect scene for a romantic encounter; well, it's perfect if you're a marine ragworm (*Nereis succinea*) in search of a mate. Emerging from their estuary mud homes, males and females swarm to the surface, embarking on brief close-range courtship dances, which culminate in duos circling around each other 'as they release clouds of sperm and eggs into the water', says Jeffrey Ram from Wayne State University. How the 2–4 cm-long worms orchestrate their moonlit encounters in vast estuaries puzzled Ram's long-time collaborators Jörg Hardege and Thomas Breithaupt. Could trails of the metabolically costly female pheromone, which stimulates males to spawn, lead a courting male to his girl? In the summer of 2006, Ram travelled to Hardege's Hull laboratory (UK) to test out whether the males follow pheromone trails to find a mate (p. 757).

Collecting immature animals from Cardiff Bay in the Severn Estuary, the team reared the youngsters back in the lab before testing the worms' reactions to artificial pheromone trails. Unfortunately, the worms persistently swam along the tank's sides, often getting lodged in corners instead of swimming through the pheromone trail. That was until Hardege suggested introducing an internal apex into a circular tank to make a heart-shaped arena. Ram built the surprisingly shaped tank and, this time, the worms happily swam towards the pheromone trail, speeding up and veering to either the left or right as they crossed it.

Teaming up with student Michelle Danaher, Ram filmed successive pheromone trail encounters and realised that the animals predominantly circled over concentrated trails, while they weaved back and forth along dilute pheromone trails. And, when the trail was dilute enough, Danaher and Ram recorded nine worms swimming along the trail; one followed it for 18 cm.

But were they turning in the right direction to catch a mate? After weeks of digitally capturing and annotating the worms' trajectories in Hull, Danaher sent the results to Ram, who realised that the worms veered towards the left and right in roughly equal numbers. The worms' choice of direction was random. Given that the worms' responses to pheromone trails were governed by probability, Ram wondered whether he could simulate the worms' trail-following behaviour to find out more.

Working with Xubo Fei and Shiyong Lu from the Computer Science Department at Wayne State University, Ram designed a computational male worm based on previous observations of their behaviour to see if he could reproduce the animals' responses to pheromone trails. According to Ram 'the results were surprisingly life like'. Testing whether the simulated male could locate a female by following her pheromone trail, the team found that the simulation's chances of finding a mate improved 3-fold compared to worms that had left it to chance. More significantly, the calculations showed that the males could track females at pheromone concentrations well below the levels needed to stimulate spawning. Ram adds 'despite the high cost to the female of releasing pheromone all the time, this dual use of helping the male to find her and then turning him on makes it all worth while'.

10.1242/jeb.017442

Ram, J. L., Fei, X., Danaher, S. M., Lu, S., Breithaupt, T. and Hardege, J. D. (2008). Finding females: pheromone-guided reproductive tracking behavior by male *Nereis succinea* in the marine environment. *J. Exp. Biol.* **211**, 757-765.

FALL WEBWORMS DICE WITH DEATH

GREAT ! AFTER EATING THIS STUFF I'LL BE DECLARED A TOXIC WASTE DUMP

A cyanide-laced diet would seem to be a recipe for disaster; but not for fall webworm larvae. According to Terrence Fitzgerald, the larvae thrive on black cherry leaves packed with the cyanide-producing chemical prunasin. How fall webworm larvae stomach their toxic diet puzzled Fitzgerald. Were the insects immune to cyanide, or maybe they'd found a way to hamper cyanide production in the chewed leaves (p. 671)?

Fitzgerald tested the larvae's resistance to cyanide fumes. Half of the larvae curled up and died, while the other half survived, only to die later from their injuries. The larvae weren't immune to the toxin.

Next he measured the cyanide production potential of black cherry leaves, larvae faeces and gut contents, as well as the defensive vomit the larvae produce when threatened, and found that the concentration of cyanide precursors in the insect's faeces was even higher than in the leaves. The insects were able to survive their toxic diet because they had somehow prevented the breakdown of prunasin into cyanide. But how?

Fitzgerald measured the pH of the insect's foregut and faeces and found that both were extremely alkaline at a pH of 12. Could the high pH prevent prunasin from releasing its fatal toxin? Fitzgerald tested cyanide release from crushed leaves over pHs ranging from 7 to 11 and found that prunasin readily released cyanide at pH 7, but the rate fell significantly at pH 10 and had fallen to zero by pH 11. The insects are protected from their toxic diet by their incredibly alkaline gut, which halts cyanide production as the poisonous plant passes through them.

10.1242/jeb.017467

Fitzgerald, T. D. (2008). Larvae of the fall webworm, *Hyphantria cunea*, inhibit cyanogenesis in *Prunus serotina*. *J. Exp. Biol.* **211**, 671-677.

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