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

FAST FOOD

Picture by Anthony Herrel

Blink and you might miss it: a thorny devil eating its lunch is just too fast. Jay Meyers from Northern Arizona University is intrigued by the speedy eating habits of these spiky ant-eating lizards. To find out exactly how the specialist feeders catch their prey, Meyers teamed up with Anthony Herrel of the University of Antwerp to film lizards grabbing their grub (p. 113).

Meyers explains that the thorny devil has to eat a lot of ants to get a square meal, since the tiny insects are not very nutritious. Thorny devils need to eat about 2000 ants a day to stay alive, but catching such large numbers of small prey is incredibly time-consuming. Lizards that do not specialize in ant-eating are slow eaters. If these non-specialists were forced to feast on ants only, given their average prey capture speed, they would have to spend eight hours a day chomping ants to survive. Clearly this leaves no time for other essential activities like mating and sleeping, so ant-eating specialists like the thorny devil need to eat fast. But how do specialist lizards manage to eat faster than other species? Meyers and Herrel decided to compare high-speed video recordings of two ant-eating specialists, the Australian thorny devil and the North American horned lizard, with those of two species that only occasionally eat ants, the Australian bearded dragon and the North American fringe-toed lizard.

Scampering around Arizona's sand dunes to catch the North American species was straightforward enough. Then Meyers and Herrel flew to Australia for a conference, planning to extend their stay to film thorny devils. But here they hit a snag. 'We drove for 10,000 miles and only managed to find one devil' Meyers recalls. Discouraged, and with little else to do in the middle of the desert, the pair visited a reptile centre in Alice Springs to raise their spirits. To their astonishment, they found ten thorny devils munching away on ants. Luckily the centre's owner was happy to help and allowed them to film the spiky creatures. 'We set up a high-speed camera in the lizards' enclosure, set a column of ants marching towards the camera, and collected our data in just a few days' says Meyers.

Back in Arizona, the team began analysing the videos. Using seven anatomical landmarks around the reptiles' mouths as x and y co-ordinates on each frame, they were able to time 27 kinematic variables, such as the duration of mouth opening, tongue movement and prey processing. 'It was immediately obvious that the ant-eating specialists were eating faster than the non-specialist lizards' says Meyers, 'but most noticeable was that the thorny devils' behaviour was strikingly different from the other three species.' He explains that lizard feeding behaviour normally begins with a slow mouth-opening phase during which the animal languidly decides whether to eat its prey. But when the team looked at the lizards' kinematic profiles, they saw that the thorny devil completely skips this traditional slow mouth-opening phase. It opens its mouth quickly and flicks its tongue out to catch its hapless prey. Even more surprising is that thorny devils barely process their prey; they don't chew their food but swallow it whole. 'Thorny devils have simply modified their behaviour' says Meyers, 'they are not doing anything clever physiologically that other lizards wouldn't be able to do.'

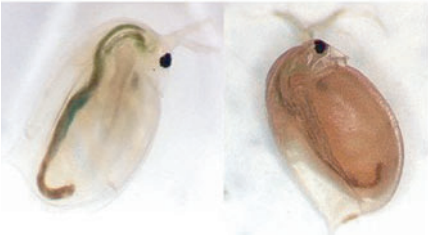
So the secret of the ant-specialists' success is bad table manners; they open their mouths quickly to snatch their food and they swallow without chewing. Meyers calculates that, thanks to their superfast feeding, thorny devils can meet their energy requirements by eating for just two hours a day. Clearly, these are no lounge lizards.

10.1242/jeb.01413

Meyers, J. J. and Herrel, A. (2005). Prey capture kinematics of ant-eating lizards. *J. Exp. Biol.* **208**, 113-127.

STRESSFUL SEX

Sex and stress may be more closely linked than you might think. Gerald LeBlanc of North Carolina State University is intrigued by the relationship between environmental stress responses and reproduction. Reproduction in the tiny freshwater crustacean *Daphnia* is normally an asexual all-female affair. But a stressful environment can trigger a switch to sexual reproduction in these creatures, producing freeze- and desiccation-tolerant eggs with better chances of coping with a hostile environment. Exploring this relationship between sex and stress, LeBlanc and colleagues found that the same hormonal



Picture provided by Gerald LeBlanc

pathway is responsible for two common environmental stress responses in *Daphnia* (p. 15).

LeBlanc already knew that a hormone called methyl farnesoate causes *Daphnia* eggs to develop into males. He had also noticed that *Daphnia* exposed to this hormone turned a copper colour. 'Then I received a serendipitous phone call from Thomas Gorr of Harvard Medical School' LeBlanc recalls, 'who suggested that the animals might be turning red because the hormone was triggering production of the oxygen-transporter haemoglobin.' Puzzled by this apparent link between haemoglobin accumulation and male offspring production, LeBlanc and Gorr began a joint venture to see if the methyl farnesoate hormone was regulating both of these stress responses in the little crustacean.

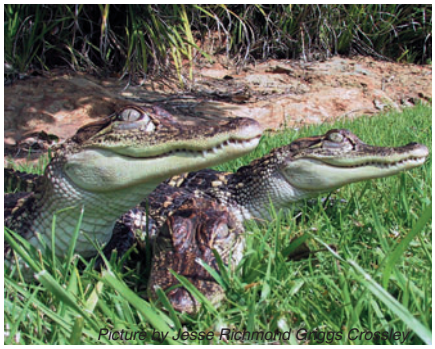
'If the same hormonal signalling pathway regulates haemoglobin production and male offspring production' LeBlanc reasoned, 'exposing *Daphnia* to the hormone should trigger both haemoglobin and male offspring production.' The team decided to examine the response of 11 *Daphnia* clones to the hormone; five of these could produce male offspring, but the other six could not produce males. Sure enough, after the hormone treatment, haemoglobin levels in the five male-producing clones shot up and all but one of the clones also began producing male offspring. Clearly, the hormone was triggering both haemoglobin and male offspring production in these clones. But would the non-male-producing clones also increase their haemoglobin and male offspring production in response to the hormone? The team found that five of the six non-male-producing clones did not produce male offspring or haemoglobin after hormone treatment. This suggests that these clones lack a common component of the signalling pathway, most likely a receptor for the hormone. The co-responsiveness of haemoglobin accumulation and male offspring production in these 11 clones indicates that the same hormonal pathway regulates these two processes. 'Discovering that haemoglobin is hormonally regulated is exciting' says LeBlanc, 'because we already know a lot about the haemoglobin gene that responds to methyl farnesoate. So we now have an array of genetic tools to study this new stress signalling pathway.'

But why are haemoglobin and male offspring production linked in this way? 'Stressful environmental signals that tell the animals to switch to sex might coincidentally be correlated with low environmental oxygen levels' LeBlanc suggests, 'for example, overcrowding may result in a drop in oxygen levels. When the environment has suddenly turned hostile, increased haemoglobin production to help the animals transport oxygen and male offspring production resulting in eggs with better survival chances might both come in handy.'

10.1242/jeb.01412

Rider, C. V., Gorr, T. A., Olmstead, A. W., Wasilak, B. A. and LeBlanc, G. A. (2005). Stress signaling: coregulation of hemoglobin and male sex determination through a terpenoid signaling pathway in a crustacean. *J. Exp. Biol.* **208**, 15-23.

MINI-ALLIGATORS WITH BIG HEARTS



Picture by Jesse Richmond Griggs Crossley

Chicks are the model system of choice for researchers interested in the effects of low oxygen, or hypoxia, on embryo development. But since birds' nests are usually above ground, getting enough oxygen is not high on a developing chick's list of concerns. Young American alligators, on the other hand, are much more likely to find themselves in an oxygen-starved nest, since crocodilian mothers lay their eggs underground. Dane Crossley at the University of California Irvine decided to see how developing alligators cope when oxygen levels plummet (p. 31).

Teaming up with Jordi Altimiras at Linköpings University in Sweden, Crossley began tracking down alligator eggs. Collecting eggs with wary mothers protecting their nests is a hazardous task, so Crossley got in touch with alligator expert Ruth Elsey at the Rockefeller Wildlife Refuge in Louisiana, who agreed to collect eggs from field nests for him. To ensure that his fragile cargo emerged unscathed from its journey to California, Crossley decided to travel with the eggs. He admits that he was so concerned for the youngsters' wellbeing that he even took some eggs on board as hand luggage, to the bemusement of other passengers.

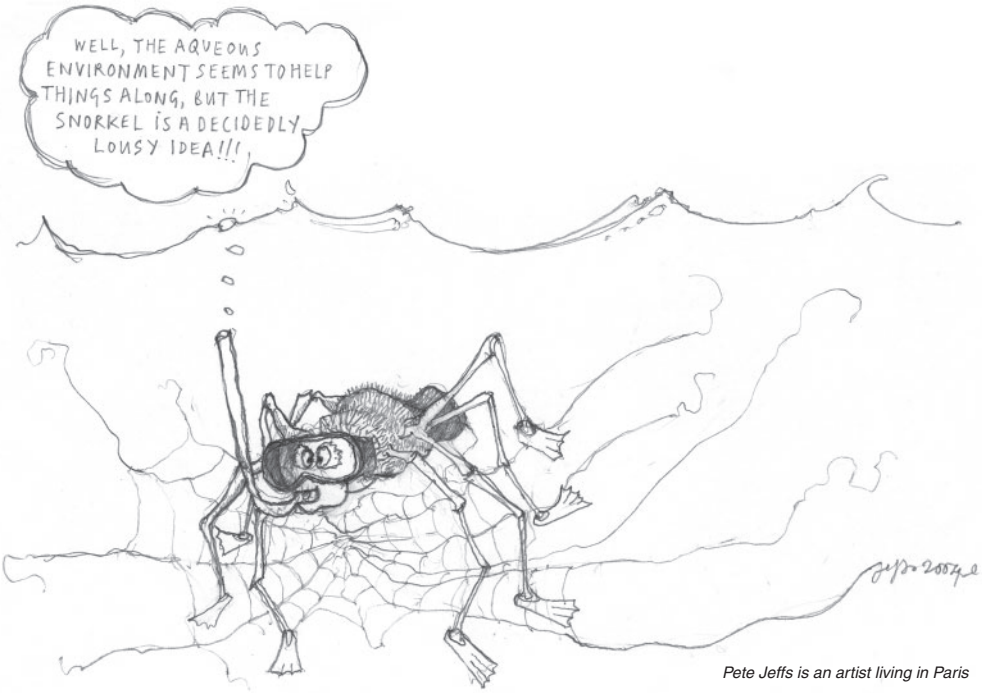
Once the eggs had arrived safely at the Californian lab, the team incubated the eggs at three different oxygen levels: a normal 21% oxygen level and hypoxic 15% and 10% oxygen levels. They exposed the alligator embryos to a sudden drop in oxygen to see how the youngsters coped at four stages of development – at 60%, 70%, 80% and 90% of the normal incubation period of 72 days. Plunging the eggs into a low-oxygen chamber, the team measured the embryos' blood pressure and heart rate by making a small hole in the eggshell and placing a catheter into an artery. Between 70% and 80% of incubation, the normal-oxygen animals responded to plummeting oxygen levels with a dramatic drop in heart rate, and an increase in blood pressure once they were recovering back in comfortable oxygen levels. But the team were surprised to find that the heart rate and blood pressure of the embryos reared at hypoxic 10% oxygen levels were unaffected by a sudden exposure to low oxygen. So low-oxygen reared embryos were less responsive to sudden low-oxygen stress than normal-oxygen reared reptiles. 'It was as if the hypoxic-reared alligators had got used to low oxygen levels, so their bodies just didn't respond to a sudden drop in oxygen' says Crossley. At 90% of incubation the team noticed two profound morphological changes in the embryos. Those reared in low oxygen were miniature versions of the normal-oxygen embryos. Even stranger was that the oxygen-starved alligators had enlarged hearts. 'They hatched at the same time and were at the same developmental stage as normal-oxygen alligators, but they were just incredibly tiny with very big hearts' says Crossley.

Crossley suspects that a bigger heart and a blunted cardiovascular response to a sudden drop in oxygen levels might represent a repertoire enabling the youngsters to survive in hypoxic nests. But the mechanisms and genes involved in this response remain elusive for now.

10.1242/jeb.01411

Crossley, D. A., II and Altimiras, J. (2005). Cardiovascular development in embryos of the American alligator *Alligator mississippiensis*: effects of chronic and acute hypoxia. *J. Exp. Biol.* **208**, 31-39.

SUPERCONTRACTED-SILK SPINNERS



Pete Jeffs is an artist living in Paris

Spiders' silk constructions have fascinated researchers for years, yet many of the structural and mechanical properties of spider silk remain elusive. One strange mechanical property of spider silk, in particular, puzzles silk researchers: when submerged in water, silk fibres supercontract to half their original length. But it was unclear if supercontraction happened at any point during the natural spinning process. Manuel Elices' team decided to investigate the biological significance of supercontraction (p. 25).

The team reasoned that if they could show that the tensile properties of man-made supercontracted silk were identical to those of naturally spun silk, this would indicate that supercontraction plays a significant role during natural silk spinning. But for biologically meaningful results, the team had to ensure that the man-made supercontracted fibres were subjected to the same influences that natural silk fibres would experience in the spiders' silk gland. Using a simple but innovative approach to create the man-made supercontracted fibres, they submerged silk in water until it was completely supercontracted, stretched the silk to a particular length under water and then dried the fibres. When the team tested the stress–strain characteristics of these fibres, they found that they could mimic the entire range of tensile properties of natural silk fibres. Elices' team concludes that wet-stretching and subsequent drying of supercontracted fibres may play an important role in spider web-building.

10.1242/jeb.01414

Guinea, G. V., Elices, M., Pérez-Rigueiro, J. and Plaza, G. R. (2005). Stretching of supercontracted fibers: a link between spinning and the variability of spider silk. *J. Exp. Biol.* **208**, 25-30.

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