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

LIZARDS RUN SLOW TO PROTECT BONES FROM FRACTURE


Christofer Clemente

There is one very good reason why giant mice and rabbits will always remain the stuff of Hollywood: their bones couldn't take the strain. Christofer Clemente from Harvard University's Rowland Institute, USA, explains that small mammals' crouched skeletons would snap if they were scaled up to hippo size. This is why hippos and all other large animals opted for straight-legged postures: transmitting their weight to the ground through column-like leg bones to prevent them from snapping. But how do the largest lizards avoid bone-cracking stresses while effectively holding a press-up position as they walk? Do they become more upright like large mammals, or have they opted for an alternative strategy to protect the twisting upper-leg bones from fractures? Intrigued, Clemente and his PhD supervisor, Philip Withers from the University of Western Australia, decided to measure the posture of lizards ranging in size from tiny 50 g *Varanus eremius* up to a colossal 7.9 kg *Varanus varius*, to find out how sprawling lizards protect their legs from fractures (p. 3013).

Clemente searched the Australian bush with Graham Thompson and successfully collected 11 species. Taking the animals back to Perth, Clemente then tested their running performances in David Lloyd's human movement lab. Building an impromptu racetrack from tables and chairs and filming the lizards as they ran, Clemente admits, 'The real trouble is that you have to put all these little stickers on the lizard and then you have to let it go in the lab filled with millions of dollars of equipment. That is the really scary part,' he laughs.

Selecting only the movies where the lizards ran at 45–50% of their maximum speed, Clemente measured the total limb length of each lizard and then compared that with the height of the marker on the running lizard's hip to see whether the larger lizards were running with straighter legs than the smaller species. But they were not. 'I went back and got more lizards and still didn't see anything,' remembers Clemente. 'No matter which variable I looked at for upright posture there was no change across lizards so they were clearly doing something different from mammals. The limb bones weren't breaking with stress so they were getting rid of it somehow and I had to figure out what that was,' he adds.

Next, Clemente analysed the lizard's movements and found that the larger lizards modified their strides to relieve twisting stresses in their upper leg bones. The largest lizards' feet spent more time in contact with the ground during each stride than the smallest lizards: in other words, their duty factor increased. 'This works to reduce stress by increasing the time you have to distribute the force over. You have a longer time so the peak of that force is going to be less,' explains Clemente. He also found that the largest lizards rotated their thighs less than the smaller species to reduce the stress-inducing twisting force on their femur bones during each stride.

So mammals and lizards use different mechanisms to get rid of bone stress because sprawling lizards cannot walk in a more upright posture. However, the lizards' stress relief adjustments have cost them their speed. Larger lizards will never run as fast as mammals of a similar size because they cannot rotate their thighs to stride as far, and they have to keep their feet in contact with the ground for longer to prevent their limbs from fracturing.

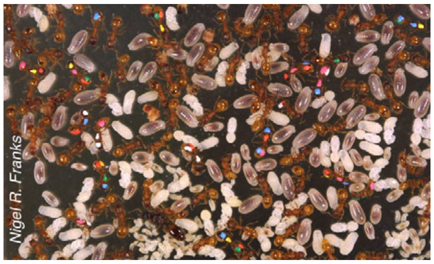
10.1242/jeb.063768

Clemente, C. J., Withers, P. C., Thompson, G. and Lloyd, D. (2011). Evolution of limb bone loading and body size in varanid lizards. *J. Exp. Biol.* **214**, 3013-3020.

Kathryn Knight

KNOWLEDGEABLE ANTS LEAD MIGRATION

It is amazing how complex social organisations simply self assemble, but this is exactly what ant nests do. Sticking to their simple functions, neighbouring foragers, nurses and maintenance workers interact and contribute to build the community's sophisticated structure. By ant standards, *Temnothorax albipennis* live in relatively small fragile colonies and each time a colony is destroyed, the residents use their powers of self-organization to select a new nest site from possible alternatives before emigrating. However, it occurred to Nathalie Stroeymeyt and Nigel Franks from the University of Bristol, UK, and Martin Giurfa from the University of Toulouse, France, that most studies investigating ant



emigration have focused on naïve insects that had been transported to an unfamiliar location. However, in reality, ants usually relocate to a nearby crevice with which they may already be familiar. The team wondered whether knowledgeable scouts and foragers that had stumbled across attractive alternative locations when the nest was secure could use this information to direct the nest's collective decision and guide the emigrating colony quickly to a new home after a disaster (p. 3046).

Stroeymeyt collected *T. albipennis* nests from their coastal homes in the southern UK and relocated them to the lab. Providing each community with a comfortable artificial nest in a wellsupplied and spacious arena, Stroeymeyt placed an alternative nest site some distance from the ants' home and recorded the insects' movements as they familiarised themselves with the surroundings. Then, a week later, Stroeymeyt carefully destroyed their home – after placing a second unfamiliar nest site on the opposite side of the arena – and recorded the entire emigration as the ants worked frantically to relocate. But which nest site would the ants occupy? Would they follow scouts that had learned about the attractive alternative site during earlier exploration, or would they search randomly, relying only on their powers of self-organisation in the hope of stumbling across a desirable location?

After months of painstaking analysis by Stroeymeyt, the team realised that the ants eventually followed the informed scouts to the familiar alternative nest that had been in the enclosure all along. Initially some of the insects went scampering off in all directions, but a few of the ants – which had discovered the location of the alternative site while scouting – ran straight to it. Having decided that the familiar site would make a good new home, they returned quickly to the devastated nest to recruit more colleagues, repeating the process and enlisting more followers until enough of the community had assembled at the new site and the decision made to relocate the entire population.

Stroeymeyt also tested whether the informed ants relied on pheromone trails to direct them swiftly to their new home or navigated using visual memories of their surroundings and found that the ants were guided by their visual memories. According to Stroeymeyt, any member of the colony in most ant species can usually follow pheromone trails, while memories are only accessible to their owner. This led her to conclude that instead of following publicly available trails, relocating nestmates are being actively led by guides with access to privileged knowledge about the new nest site.

So, even though complex ant nest societies naturally self assemble thanks to the inhabitants' simple behaviour patterns, it appears that some well-informed ants shape the collective decision-making process by leading from the front.

10.1242/jeb.063776

Stroeymeyt, N., Franks, N. R. and Giurfa, M. (2011). Knowledgeable individuals lead collective decisions in ants. *J. Exp. Biol.* **214**, 3046-3054.

Kathryn Knight

PINK SALMON BETTER AT BRAVING THE HEAT

If you like salmon, here's another reason to be worried about climate change. Over the past six decades, the peak summer temperature of the Fraser River in British Columbia, Canada has risen by 2°C, coinciding with higher death rates in sockeye salmon during their migration to freshwater spawning grounds. Yet pink salmon still manage to arrive unscathed at their spawning grounds, despite their migration period including summer months, notes fish physiologist Timothy Clark. Teaming up with colleagues Ken Jeffries, Scott Hinch and Tony Farrell at the University of British Columbia, Clark decided to investigate whether pink salmon have physiological tricks up their sleeve that allow them to cope better with heat than their counterparts (p. 3074).

The team suspected that the key to pink salmon's success during a summer heat wave is an ability to keep their muscles supplied with oxygen while struggling upstream to their spawning grounds. 'A marathon runner can dramatically increase oxygen transport during exercise,' explains Clark, 'while a couch potato can't.' In other words, pink salmon might simply be fitter than other salmon species. To see how sporty pink salmon really are, the team caught fish from a tributary of the Fraser River and brought them back to the lab.

First, the team needed to show that pink salmon sufficiently boost oxygen transport when they get hot. Placing the salmon in a doughnut-shaped swim tunnel filled with cool water, they increased the water flow until the fish were swimming at top speed, then sealed the tunnel and used oxygen electrodes to measure how quickly the fish were using up oxygen. Then, to see how the fish cope with heat, they ramped up the temperature in 3–5°C increments and repeated the swim tests. Sure enough, the fish steadily increased their oxygen consumption as the mercury rose. 'It turns out that pink salmon are very athletic,' says Clark. 'They can increase oxygen uptake during exercise when the temperature rises, and do so better than previously reported for other salmon species.'

Next, the team investigated whether pink salmon are better at pumping blood around their body while working out in warm water. They measured how much blood the fish pumped out with each heartbeat by fitting fish with blood-flow probes around the ventral aorta, the main vessel carrying blood from the heart. When the fish were again subjected to swim tests, the team saw that the pink salmon's maximum heart rate and blood flow increased as the water got warmer. 'A combination of exceptional metabolic and cardiovascular capacity means that pink salmon can exercise at higher temperatures than other salmon,' Clark concludes. 'This could help pink salmon cope with future climate change. They may even fill the niches of species that aren't able to adapt as well.'

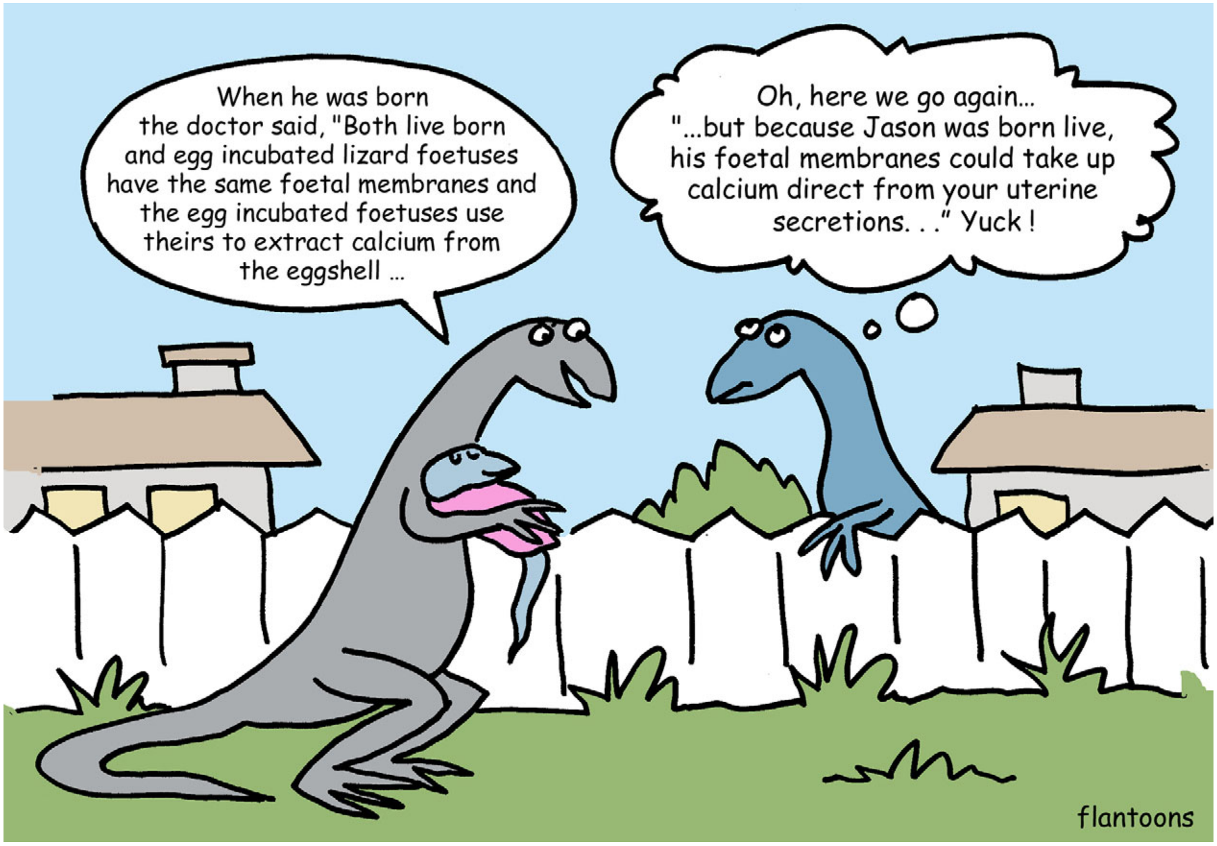
But at temperatures above 21°C, even pink salmon start to suffer. When Clark plotted maximum oxygen consumption and blood flow against water temperature, he saw that both measures clearly start to level off or decrease above 21°C. 'This means that longer exposure to high temperatures would be problematic for pink salmon too, and they might succumb to heat stress,' says Clark. Nevertheless, he adds, if their athleticism can help them get through sporadic warm patches in the river as they're heading upstream to reproduce, it might be enough to give pink salmon a competitive edge over other salmon species.

10.1242/jeb.063750

Clark, T. D., Jeffries, K. M., Hinch, S. G. and Farrell, A. P. (2011). Exceptional aerobic scope and cardiovascular performance of pink salmon (*Oncorhynchus gorbuscha*) may underlie resilience in a warming climate. *J. Exp. Biol.* **214**, 3074-3081.

Yfke Hager

LIVE BORN LIZARDS SOURCE CALCIUM THROUGH CHORIOALLANTOIC MEMBRANE



Eggshells are more than just a handy source of protection for their developing inmates. James Stewart and his colleagues from East Tennessee State University, USA, and the Station Biologique de Paimpont, France, explain that eggshell is also an essential source of calcium for common lizard embryos. ‘81% of the calcium contained in hatchlings is mobilized from eggshell,’ says the team. However, some northern populations of common lizards have opted for a less conventional form of reptile reproduction: they carry their eggs throughout gestation and give birth to live young. However, they have also done away with the egg’s calcium outer layer, leaving the embryos without their additional calcium supply. Stewart and his colleagues explain that these live-born young must somehow extract calcium from their surroundings through a placenta structure to supply their additional requirements, but it wasn’t clear how. So, the team decided to find out whether both types of embryo used the same structures to extract calcium from their environment (p. 2999).

According to the team, egg-incubated lizards extract calcium from their eggshells *via* the chorioallantoic membrane – the vascular structure that coats the egg’s internal surface and supplies oxygen to egg-incubated and live-born young – and the splanchnopleure – which connects the yolk to the embryo’s gut – through two proteins: calbindin-D_{28K} and plasma membrane calcium ATPase (PMCA). They decided to look for evidence of these proteins in both structures in the shelled and shell-less embryos.

Having collected egg-laying common lizards near Lourdes in the south of France and live-bearing common lizards near Rennes in northern France, the team found that both live-born and egg-incubated young absorbed calcium through calcium transporting proteins in the chorioallantoic membrane and the splanchnopleure. However, the shell-less young extract calcium from the uterine secretions surrounding them, while the embryos developing inside their calcium carbonate shells absorb calcium from the shell.

Stewart and his colleagues explain that live birth has evolved several times in common lizards, and the lizards have benefited from the versatility of the chorioallantoic membrane, which is equally capable of extracting calcium from eggshells and secretions surrounding them in the mother’s uterus. ‘The mechanism of embryonic calcium acquisition functions independently of the immediate source of calcium,’ says the team.

10.1242/jeb.063784

Stewart, J. R., Ecay, T. W., Heulin, B., Fregoso, S. P. and Linville, B. J. (2011). Developmental expression of calcium transport proteins in extraembryonic membranes of oviparous and viviparous *Zootoca vivipara* (Lacertilia, Lacertidae). *J. Exp. Biol.* **214**, 2999-3004.

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