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Inside JEB

HOLASPIS GUENTHERI GLIDES LIKE A FEATHER

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Most lacertid lizards are content scurrying in and out of nooks and crannies in walls and between rocks. However, some have opted for an arboreal life style. *Holaspis guentheri* leap from branch to branch as they scamper through trees in the African forest. There are even anecdotes that the tiny African lizards can glide. But without any obvious adaptations to help them to upgrade a leap to a glide, it wasn't clear whether the reptiles really do take to the air and, if they do, how they remain aloft. Intrigued by all aspects of lacertid locomotion, Bieke Vanhooydonck from the University of Antwerp and her colleagues, Anthony Herrel and Peter Aerts, decided to find out whether *H. guentheri* really glide. Recruiting undergraduate Greet Meulepas to the team, they began filming dainty *H. guentheri* lizards, gliding geckos (*Ptychozoon kuhli*) and landlocked *Podarcis muralis* lacertid lizards as the animals leapt from a 2 m high platform to see if the African lizards really could glide (p. 2475).

Unfortunately, filming the tiny lizards was extremely difficult. Having startled the small animals into leaping off the platform, the team had little control over the animal's direction, and couldn't guarantee that it was parallel to their camera. It was also difficult to capture each trajectory with a single camera and tricky to get the lighting conditions right. But after weeks of persistence the team finally collected enough film, as the lizards leapt, to compare their performances.

At first, it didn't look as if the African lizard was gliding any better than the *P. muralis*. Both animals were able to cover horizontal distances of 0.5 m after leaping from the platform, while the gliding gecko covered distances greater than 1 m, aided by its webbed feet and skin flaps. But when the team compared the lizards' sizes, they noticed that there was a big difference between the two lacertid lizards. The tiny African reptile only weighed 1.5 g, almost 1/3 of the larger lacertid lizard's weight and 1/10 the gliding gecko's mass, so Aerts calculated how far each lizard would travel horizontally if they fell like a stone. This time it was clear that the tiny *H. guentheri* was travelling 0.2 m further than he would have expected if it were simply jumping off the platform. *Holaspis guentheri* was definitely delaying its descent and landing more slowly than *P. muralis*; it was gliding.

But how was the tiny lizard able to remain airborne for so long? Maybe the lizard was squashing itself flat while gliding to increase its surface area and generate more lift. But when the team analysed the lizards' trajectories, *H. guentheri*'s shape did not change. And when Aerts calculated the amount of lift each lizard generated as they descended, it was clear that *H. guentheri* was unable to produce a lift force. The team realised that instead of increasing its surface area to generate lift, *H. guentheri* is able to glide because it is so light. The lizard's 'wing loading' (mass:surface area ratio) was the same as that of the gliding gecko (assisted by skin flaps and webbed feet) so the lizard was able to glide like a feather because it was so light.

Curious to find out why *H. guentheri* is so light, Herrel contacted Renaud Boistel, Paul Tafforeau and Vincent Fernandez at the European Synchrotron Radiation Facility to scan all three lizards' bodies. Visualising the animals' skeletons with X-rays, it was clear that *H. guentheri*'s bones were packed full of air spaces, making the lizard's skeleton feather light for gliding.

10.1242/jeb.035519

Vanhooydonck, B., Meulepas, G., Herrel, A., Boistel, R., Tafforeau, P., Fernandez, V. and Aerts, P. (2009). Ecomorphological analysis of aerial performance in a non-specialized lacertid lizard, *Holaspis guentheri. J. Exp. Biol.* **212**, 2475-2482.

ENERGETIC BOTTLENECK FACTORS IN WINTER WRECKS

It's a terrible sight: hundreds of dead seabirds washed up on the seashore. These catastrophic events occur in the winter and are known as winter wrecks. No one knows why the birds perish, and it is almost impossible to study the animals out in stormy winter seas to find out how they meet their fate. With the birds' tough life style in mind, Jérôme Fort and David Grémillet from the CNRS Centre d'Ecologie Fonctionnelle et Evolutive in France decided to try to estimate the energetic demands placed on two alcid species (little auks and Brünnich's guillemots) by their aquatic lifestyle to find out whether battling the harsh conditions may simply be too energetically demanding for the little seafarers (p. 2483).

As it is impossible to gain access to the offshore birds in winter to directly measure their energy requirements, Fort and Grémillet teamed up with Warren Porter, who models the effects of environmental conditions on terrestrial animals, to estimate the birds' metabolic demands. Adjusting Porter's Niche Mapper^{TM} computational model to take account of the ocean environment and the birds' physiology, the team included environmental data for two regions of the Atlantic Ocean (off Newfoundland and Greenland) occupied by little auks and Brünnich's guillemots. They also detailed the plumage, physiology and behaviour of individual birds and calculated the animals' metabolic demands for the months from September to March.

The results were startling. Both species' energy demands were relatively low during the months of September and October, but rocketed by 16–20% in November and remained high for the rest of the winter. The team realised that an energy demand of 430 kJ day^{-1} for the tiny, 150 g little auks and 1306 kJ day^{-1} for the Brünnich's guillemots must place the animals under enormous strain as they battle the environment. And when the trio converted the birds' caloric requirements into the amount of food that each animal would have to find and consume daily, it came out at a colossal 289 g of zooplankton for the little auks (almost twice their own body weight) and 547 g of fish and crustaceans for Brünnich's guillemots (just over half of their body weight).

Fort says 'For seabirds, this is an energetic bottleneck'. He explains that as the winter sets in, increased wind speeds, low temperatures and vicious winter storms all conspire to raise the birds' metabolic demands. At the same time food becomes scarce and more difficult to capture. Coupled with the increase in their energy demands, the birds only carry limited reserves, placing them at an increased risk of starvation.

Given that most winter wrecks occur in November and December, Fort and his colleagues suspect that the energetic bottleneck could be a major contributory factor to the mass loss of life. Having modelled the effects of the climate on individual animals, the team is eager to look at the environment's impact on alcid populations and the effects on the food stocks that the birds depend upon. They are also keen to find out whether other ocean going species suffer the same catastrophic increase in energy demand as little auks and Brünnich's guillemots, raising their risk of succumbing to winter wrecks as the days draw in.

10.1242/jeb.035501

Fort, J., Porter, W. P. and Grémillet, D. (2009). Thermodynamic modelling predicts energetic bottleneck for seabirds wintering in the northwest Atlantic. *J. Exp. Biol.* **212**, 2483-2490.

TMT SMELLS OF FEAR

When rodents get a sniff of their predator's stench, one of their first reactions is to freeze. But many components of a predator's odour simply smell bad rather than striking fear into their prey's heart. Figuring out which scents simply stink and which scare the life out of an animal is critical for scientists that want to understand the physiology of fear. They have to be sure that animals are genuinely terrified rather than simply avoiding a repulsive smell. Thomas Endres and Markus Fendt from Universität Tübingen decided to test the effects of two stenches on rats to find out whether 2,4,5-trimethyl-3-thiazoline (TMT), derived from fox faeces, produces a genuine fear response (p. 2324).

Knowing that rats take evasive action when they sniff TMT, Endres and Fendt tested how young rats reacted to different concentrations of TMT and another unpleasant smell that rats avoid, butyric acid. Placing a scrap of filter paper carrying a tiny drop of either TMT or butyric acid in the corner of an arena, the team filmed the rats' reactions to the smells to find out how much time they spent avoiding the unpleasant smells. Endres and Fendt found that the rats avoided both smells, but the rodents really disliked visiting the corner that smelled of TMT. The animals tolerated a 0.387×10^{-6} mol drop of TMT, avoided a 3.87×10^{-6} mol drop and strongly disliked the large 38.7×10^{-6} mol drop while the rats only avoided the largest drop of butyric acid (54.7×10^{-6} mol) and were unaffected by small drops. So the rats avoided both smells but seemed much more sensitive to the TMT than the butyric acid.

But was the animals' avoidance behaviour a reflection of their dislike of the smells or a case of being frightened off? Endres and Fendt placed either a 3.87×10^{-6} mol drop of TMT or a 54.7×10^{-6} mol drop of butyric acid next to individual rats and filmed their reactions.

The rats placed in close proximity to the butyric acid seemed uncomfortable, but continued moving around the enclosure. They were not terrified; they just didn't like the smell. However, the rats that sniffed the TMT froze with fear, crouched down and barely breathed until the smell had gone; they were terrified.

So the rats avoided both butyric acid and TMT because of their unpleasant odours, but TMT terrified the animals. Endres and Fendt point out that avoidance and fear should not be confused, and conclude that TMT is a genuine smell of fear.

10.1242/jeb.035030

Endres, T. and Fendt, M. (2009). Aversion- *vs* fear-inducing properties of 2,4,5-trimethyl-3-thiazoline, a component of fox odor, in comparison with those of butyric acid. *J. Exp. Biol.* **212**, 2324-2327.

FULL-UP BLOOD SUCKERS GO OFF DINNER

When a blood-sucking *Rhodnius prolixus* bug settles down to lunch, it is often at risk of being thwacked by its prey; no one likes being dined upon. Given the risks that a hungry insect runs when filling up, Aurélie Bodin and her colleagues Clément Vinauger and Claudio Lazzari wondered whether fully fed bugs ignored tempting cues sent by their food in a bid to prolong life (p. 2386).

Knowing that hungry bugs respond to vital signs, such as exhaled CO_2 and warmth, the trio tested hungry and well fed bugs' responses to a jet of CO_2 and warmth. All of the insects responded enthusiastically to the jet of CO_2 by approaching it before dining, but as soon as they had eaten, their behaviours changed. The males failed to respond to the CO_2 jet, wandering in all directions, and at first the females and larvae were equally unresponsive to the CO_2. However, several days after sucking blood, both the larvae and females began backing away from the CO_2 jet; instead of attracting them, the gas was repelling them. Eventually, after almost 3 weeks and another period of disinterest in the gas jet, the insects rediscovered their taste for CO_2, and started heading towards it again, presumably in the hope of catching another blood meal.

Curious to find out how the bugs' motivation changes after a meal, the team tested how the bugs responded to signs of life after feeding on saline solution that distended the insects' abdomens but didn't provide nutrition. The insects were no longer attracted to the CO_2, but females and larvae were no longer actively repelled by the gas either, suggesting that there was something in the blood meal that turned the females and larvae off hunting for hosts.

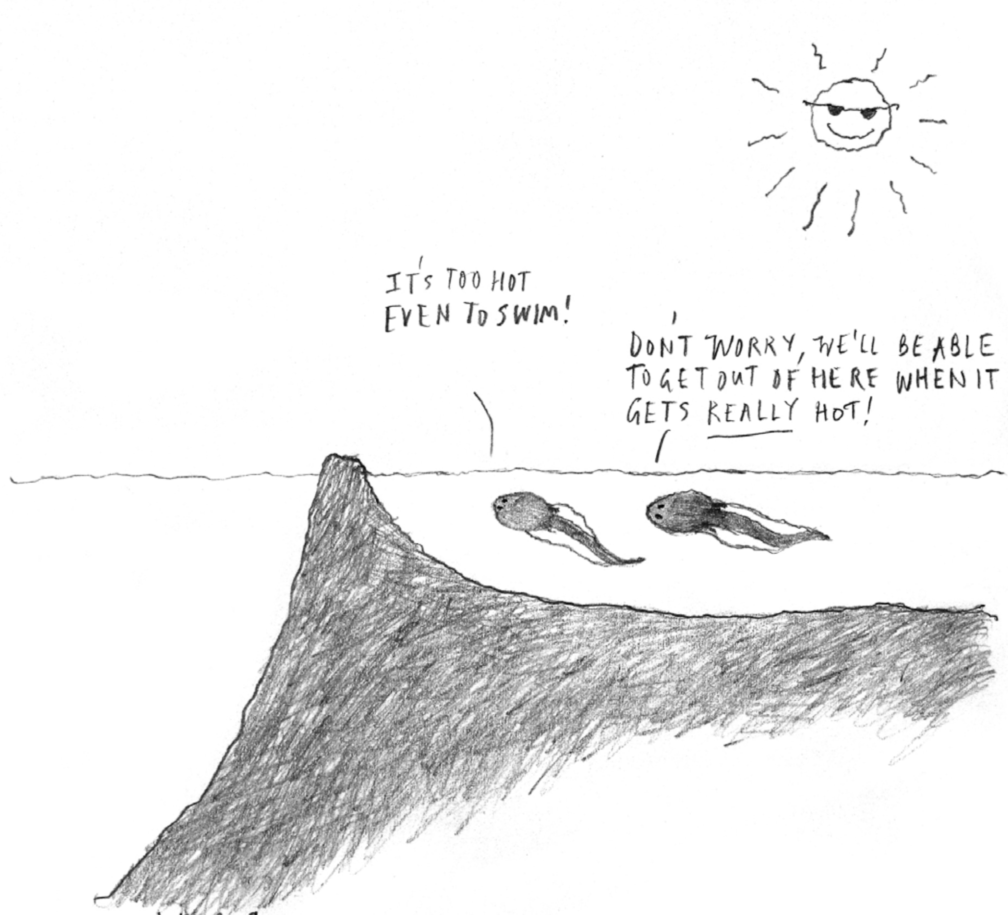
The team also tested injected starved bugs with haemolymph taken from newly fed bugs and successfully turned off the starved bugs' attraction to CO_2 and warmth, making Bodin and her colleagues suspect that whatever reduces the well fed insect's attraction to CO_2 is carried in the haemolymph.

So *Rhodnius* bugs are turned off searching for signs of life after a blood meal, presumably to reduce their risk of being squashed to death by their dinners.

10.1242/jeb.035055

Bodin, A., Vinauger, C. and Lazzari, C. R. (2009). Behavioural and physiological state dependency of host seeking in the blood-sucking insect *Rhodnius prolixus*. *J. Exp. Biol.* **212**, 2386-2393.

TADPOLES C-START OUT OF HOT WATER



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Escaping your enemies is key to most creatures' survival, but sometimes your environment can conspire against you too. According to Keith Sillar from the University of St Andrews, UK, and Meldrum Robertson from Queen's University, Canada, the neural circuits that control escape manoeuvres in response to predators are well understood. A neuron, called the Mauthner cell, twists escaping fish and larvae into a tight C-shape before they give an explosive tail flip for freedom, known as a C start. But less is known about the neural circuits that control fish and larvae's escapes from dangerous changes in their environment.

Curious to find out how African clawed frog tadpoles respond when their lakes warm up (p. 2356), the duo electrically stimulated tadpoles and made recordings from the neural circuits that control swimming as they raised the temperature to see how the animals responded. At first the tadpoles' swimming circuit showed normal behaviour, but as the temperature rose the electrical activity declined until it tailed away to nothing at 28°C. However, the swimming tadpoles' electrical activity returned when the temperature fell below this critical level.

Next the team warmed the water above 30°C, and found a new pattern of electrical activity that was similar to the 'C start' electrical activity triggered when a tadpole needs to escape a predator.

Having recorded the electrical activity that controls how the tadpoles swim, the duo warmed the tadpoles' water and filmed them swimming to see how the youngsters reacted to hot water. Sure enough, as the temperature rose the tadpoles began swimming at high speed, but eventually became immobilized at 28°C.

But what happened when the team really turned on the heat to over 32°C? The larvae twisted themselves into a tight C shape and triggered a short fast swimming cycle to escape the uncomfortable water. According to Sillar and Roberston, the first tail flip after bending into a C was so strong that the tadpole almost jumped out of the water.

So why do tadpoles stop swimming as the temperature rises, but switch to an explosive swimming technique when the temperature gets really hot? Sillar and Robertson suspect that warm temperatures incapacitate the tadpoles' swimming circuitry, forcing them to sink into cooler waters where they recover from the heat. But when the temperatures become dangerously high, the tadpole can give a hearty tail flip to escape to cooler waters, and if the edge of the pool is in danger of drying up, this may even catapult them to safety in deeper water.

10.1242/jeb.034983

Sillar, K. T. and Robertson, R. M. (2009). Thermal activation of escape swimming in post-hatching *Xenopus laevis* frog larvae. *J. Exp. Biol.* **212**, 2356-2364.

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