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

## BRAWNY BEES ARE FEEBLE

Picture provided by Michael Dillon

Most bees have struck a pretty rich deal with the plants they frequent. Lured by the promise of a nectar feast, the insects, in turn, pollinate their flowers. But the pact between male orchid bees and their preferred blooms looks much more one-sided. In return for their nuptial role, the male's only reward is a dab of the orchid's scent. But it wasn't the bee's fragrance-harvesting habits that attracted Michael Dillon and Robert Dudley to the insects. It was their remarkable size range. Some orchid bees weigh in at 50 mg, while others tip the scales at 1 g. And they're all champion hoverers. Which made Dillon and Dudley suspect that the insects were ideal for studying the way that creatures scale up the mechanical forces that keep them aloft. Dillon headed south to the insect's homes in Panama, where he spent three months collecting bees and testing their weightlifting prowess to get to grips with allometric scaling in insect flight (p. 417).

Dillon explains that trapping the bees was easy, all he had to do was soak blotting paper in each species' favourite scent; the bees came flocking. The next trick was to attach a tiny beaded string to the insect's body, without getting stung. But this wasn't as tricky as it might sound. Only males are attracted to the orchid's scent, and they aren't armed with painful stings, although the odd female did turn up from time to time, making the encounters more lively.

Ready for their weightlifting task, Dillon filmed the insects as they lifted the beaded string until it became too heavy, and then began descending gently back to earth. Dillon was most intrigued by the moments before the weight became too great; he knew that was the point when the insects were exerting their maximum force. All Dillon had to do was measure the length of the string to measure the insect's maximum force.

Back in the lab in Texas, Dillon was faced with hours of hovering flight footage that needed painstaking analysis before he could begin to understand how the insect's aeronautic abilities scaled with size. But eventually his patience was rewarded. He realised that the larger insects were generating larger forces as they hovered, but when he looked at the force per unit mass, he realised that the larger insects were generating much less force per mg of muscle than their tinier cousins. So even though the larger insects had scaled-up their muscle size *pro rata*, the power generated per unit mass by the flight muscles had declined. And when Dillon compared the insect's wing sizes, the larger bees' wings were much bigger than if they were in the same proportion to their bodies, probably to compensate for the larger bees' relatively feeble muscles.

'It was neat to see the mass-specific force dropping with the increase in muscle mass' says Dillon, and adds that 'these data sit well' with the insect's antics in their forest homes. 'The little ones hover on a dime' he remembers 'while the big ones lumber along. You can hear them coming.'

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**Dillon, M. E. and Dudley, R.** (2004). Allometry of maximum vertical force production during hovering flight of neotropical orchid bees (*Apidae: Euglossini*). *J. Exp. Biol.* **207**, 417-425.

## SNAP-HAPPY ANTS

Watching a column of ants marching towards food is an impressive and somewhat mesmerising sight. Back and forth they go, almost as if they have a GPS system to guide them. Researchers have long known that ants use landmarks for navigation, despite having fairly poor sight. But what do the ants do if the landmarks look similar? A group from the University of Sussex have been tackling this question.

So how do ants find their way back to a food site or their nest? They simply store a view of the surrounding landmarks, like taking a snapshot. When they return they recall this snapshot and match it with the image on their retina of the landscape. 'It's a simple and economic way of using visual memories to navigate by,' explains Tom Collett.

Previous work had suggested that ants store a wide-angle snapshot while looking directly at a landmark. So if ants were given two landmarks on either side of a feeding site that cannot be seen simultaneously, they might store two snapshots, one per landmark, to help them return to the site. Paul Graham, Virginie Durier and Collett wondered how ants might recall the correct snapshot when looking at a particular landmark (p. 393).

The team initially trained ants to search for food midway between two differently sized black cylinders against a white background. Multiple visits meant that the ants had the opportunity to form clear snapshots of the landmarks: one snapshot would be of the small cylinder, while the other would be of the large. They had previously found that ants move towards a landmark that appears smaller than expected until it matches the memorised snapshot. Indeed, when the team changed the two cylinders for a pair of equal size and tested the ants, the ants still searched close to the centre as though they did not know which cylinder was which. As Collett emphasises, ‘There is a premium on retrieving the right snapshot.’ So how do the ants avoid such confusion?

To see if they use extra visual information to help distinguish similar landmarks, the training was repeated but with a patterned background. A patterned curtain was placed so it was to the left of the cylinder in one snapshot while in the other it was to the right. This time when the cylinders were changed for two of equal size in the test, the ants searched closer to the cylinder that corresponded to the large training cylinder. Collett and his colleagues suspect that the curtain primes the recognition of the correct landmark, so that the ants can identify which of the two identically sized cylinders corresponds to the small cylinder and which to the large. But how isn't clear and will be the focus for future work by Collett and his team.

So next time you see ants marching purposely across your kitchen, don't reach for the ant powder, mess with their landmarks and confuse them instead!

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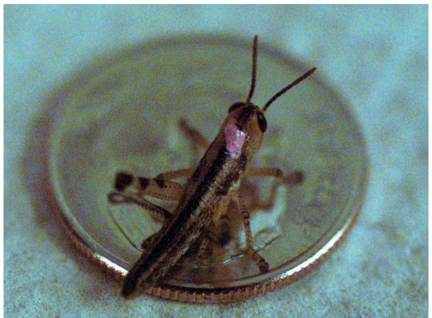
**Graham, P., Durier, V. and Collett, T. S.** (2004). The binding and recall of snapshot memories in wood ants (*Formica rufa* L.). *J. Exp. Biol.* **207**, 393-398.

## LITTLE LOCUST'S BREATHLESS START



Picture provided by Mr Chuck Kazilek

As Alice discovered during her trials in Wonderland, being small isn't easy. No one can see you, you're easily squashed, and even the tiniest drop of water poses a threat. But maybe it's not all bad if you're a newly hatched American locust. Kendra Greenlee and Jon Harrison wondered whether their minute stature gave the young insects the respiratory edge. The team suspected that the insects' scaled down respiratory systems would deliver oxygen efficiently to tissues by diffusion, making the youngsters less vulnerable to hypoxia than larger older grasshoppers. But would this turn out to be the case? The team put several insect generations through their respiratory paces, testing how well the insects coped with hypoxia during each instar period. But Greenlee and Harrison were in for a surprise. While the adults were very tolerant, the youngsters were extremely susceptible, which was completely unexpected (p. 497).

First, Greenlee needed a supply of freshly hatched grasshoppers to track their respiratory development through to adulthood. Fortunately, the adult grasshoppers were extremely cooperative, laying their eggs in cups of sand where the youngsters could hatch safely. ‘When they climb out they're clearly grasshoppers’ says Greenlee ‘but about the size of an ant’.

Working with the older insects was relatively straightforward, but the tiny insects were particularly tricky to handle. Once safely secured inside their respiratory chambers, Greenlee began monitoring each insect's breathing rate and respiratory volume, as she gently dropped the oxygen level from 21% to 0%. Although Greenlee couldn't detect the minute levels of oxygen that the tiny insects consumed, she had more success measuring the carbon dioxide they produced as she tracked their metabolic rate. Not surprisingly, the larger insect's metabolic rates were much higher then the youngster's, but when she adjusted their metabolic rates for their sizes, the tiny insects were using far more energy than their elders. So how did their respiration compare?

As Greenlee dropped the oxygen levels, she saw that the adult insects increased their abdominal pumping rates to breath faster, and as she monitored their abdominal movements, Greenlee realised that the insects had also increased their tidal volumes. They were definitely breathing harder. But when she monitored the tiny first instar insects, their breathing didn't alter at all no matter how much oxygen was available. They always breathed at the same rate. The first instar insects didn't seem able to respond to the hypoxic conditions.

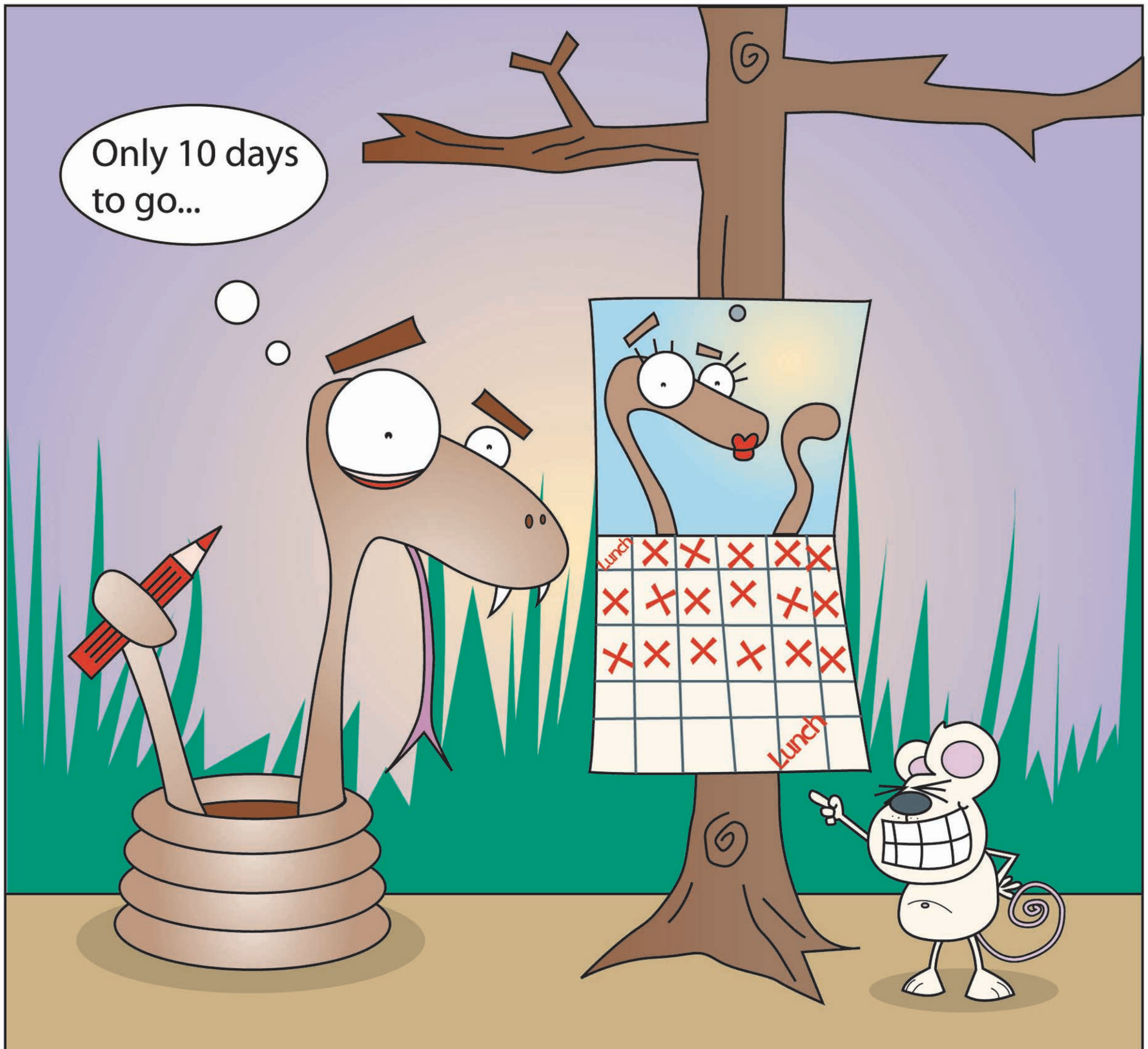
More surprisingly, the larger insects with their extensive tracheolar systems successfully maintained their metabolic rates even when oxygen levels plummeted to 2%, while the first instar youngsters couldn't sustain their metabolic rates, even when the oxygen levels were still relatively high at 14%! So instead of being better prepared, the tiny youngsters with their smaller diffusion distances were finding it much more difficult to breath. Greenlee and Harrison suspect that these immature locusts can't sense the falling oxygen levels and so fail to react, where as the elderly insects can, and do.

Next, Greenlee wondered how the growing insects cope when they're on the verge of bursting out of their shells (p. 509). Realising that the insect's tracheolar systems become more compressed as the insects expand inside their exoskeletons, Greenlee monitored their respiration to see how it changed towards the end of an instar. Sure enough, the insects' breathing frequencies increased as conditions became more cramped and they couldn't carry as much air in their compressed tracheolar systems. They also became more sensitive to falling oxygen levels, needing more oxygen to maintain their metabolic rates as they became more restricted in their undersized exoskeletons. In fact, Greenlee suspects that getting breathless could be the trigger that drives the insect's upgrade to a looser skin.

10.1242/jeb.00803

**Greenlee, K. J. and Harrison, J. F.** (2004). Development of respiratory function in the American locust *Schistocerca Americana* I. Across-instar effects. *J. Exp. Biol.* **207**, 497-508.
**Greenlee, K. J. and Harrison, J. F.** (2004). Development of respiratory function in the American locust *Schistocerca americana* II. Within-instar effects. *J. Exp. Biol.* **207**, 509-517.

# NORADRENALINE TRIGGERS VIPER'S VENOM

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Most vipers don't waste their venom on any old mouthful. It takes time and energy to produce a gland-full of venom, so profligacy isn't an option. But just what triggers toxin synthesis wasn't clear until Norma Yamanouye and her colleagues began testing the response of *Bothrops jararaca*'s venom glands to noradrenaline. The venom gland's adrenoceptor became desensitised to noradrenaline after venom was extracted from the snake, but after a month the receptor had regained its sensitivity. So once venom production was triggered, it didn't seem possible to stimulate the adrenoceptor again until the gland was recharged with venom 30 days later (p. 411).

But was noradrenaline triggering the toxin's synthetic cycle? Yamanouye tested the gland's toxin-secreting cells by first depleting the gland's own noradrenaline and then giving the cells a dose of phenylephrine, to stimulate the adrenoceptor and see whether the stimulated cells began producing venom. While the team watched, the cells appearance changed, in preparation for making the snake's venomous protein 'suggesting that stimulation of the α-adrenoceptor during or shortly after biting is essential for the onset of the venom production cycle' says Yamanouye.

10.1242/jeb.00804

**Kerchove, C. M., Carneiro, S. M., Markus, R. P. and Yamanouye, N.** (2004). Stimulation of the α-adrenoceptor triggers the venom production cycle in the venom gland of *Bothrops jararaca*. *J. Exp. Biol.* **207**, 411-416.

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