

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

EATING FOR THE COLONY



Picture by Gabriel A. Miller

Most species only have to worry about eating for one, but when you're a forager ant you're eating for the community. You have to listen not only to your own nutritional needs, but the needs of your coworkers too. Or do you? Audrey Dussutour and Steve Simpson from the University of Sydney, Australia, wondered whether the colony as a whole was able to regulate its nutritional intake. Dussutour explains that ants' dietary requirements change as they grow; adults are able to survive several weeks without food, while hungry larvae need a constant supply. Would the colony's ability to regulate nutritional intake vary when larvae came along? Dussutour began monitoring the carbohydrate intake of green headed ant colonies to see if the collective regulated its nutritional intake (p. 2224).

Isolating individual adult-only colonies and supplying them with either concentrated (18%), medium strength (9%) or dilute (4.5%) sucrose solutions, Dussutour filmed the ants' comings and goings over a 6 week period to see how many foragers were recruited by their colonies to gather food. 'Ants have a sweet tooth,' says Dussutour, so the insects mobbed the concentrated solution during the first few hours of the week, but recruited fewer and fewer foragers as the colony's occupants 'filled up' during the week. The colony was regulating its carbohydrate intake, but not particularly well. However, it was a different matter for the insects provided with a weak sucrose solution. According to Dussutour, they didn't regulate their intake at all during the first few days, preferring to starve rather than consume the unpalatable weak sucrose.

But when larvae started coming along, things changed; 'the colony got better at regulating their intake,' says Dussutour. Even though the ants didn't like the weak nectar supply, they started sending out more and more foragers over the 6 week experiment, doubling the volume of sucrose

solution supplied to the nest. The colony was regulating its carbohydrate intake, but why? Was the colony responding to the larvae's hunger?

Dussutour increased the colony's size by adding either larvae or adults and monitored the volume of sucrose gulped down by the foragers. The colonies only sent out enough foragers to cover the extra mouths when the adult numbers increased. But it was a different matter when Dussutour increased the number of larvae. The colony not only sent out more foragers, but also massively increased the volume of dilute sucrose carried back to the nest. The colony was regulating its nutrient intake to satisfy its demanding young.

Finally, Dussutour tested whether individual ants could independently regulate their individual sucrose uptake by isolating groups of 25 adults from each colony, supplying them with sucrose for 1 h a day over 5 days, and measuring the amount each ant consumed by weighing it. The insects successfully regulated their sucrose intake. Ants supplied with concentrated sucrose gorged on the first day, but reduced their intake on subsequent occasions, while the ants fed on unpleasantly dilute sucrose barely touched it on the first day, but gradually increased their intake as they became hungrier.

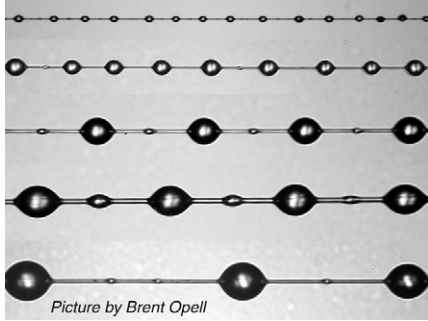
Having found that ant colonies respond to their young when filling the 'collective stomach', Dussutour is keen to find out how the larvae communicate with the colony to satisfy their hunger.

10.1242/jeb.021279

Dussutour, A. and Simpson, S. J. (2008). Carbohydrate regulation in relation to colony growth in ants. *J. Exp. Biol.* **211**, 2224-2232.

STRETCHY SILK IS STICKIER

Anyone who's got tangled in a spider web can't help but identify with the hapless victims that end up entombed in them. But what makes this remarkable material so sticky? Brent Opell explains that the spiral silk is coated in microscopic droplets of a glycoprotein adhesive and that the silk's stickiness increases as more and more droplets contact an ensnared object. Having already established that spider silk behaves almost like the suspension cable on a suspension bridge, with the adhesive droplets attaching the silk to an object in the same way that ropes connect the suspension cable to a bridge's deck [B. D. Opell and M. L. Hendricks (2008) *J. Exp. Biol.* **210**, 553-560], Opell wondered how much the spider silk's elasticity contributes



to its stickiness. Teaming up with Brian Markley, Charles Hannum and Mary Hendricks, Opell set about stretching five different spider silks and measuring how their stickiness varied (p. 2243).

But Opell had some significant technical challenges to overcome. First, he had no quality control over the silk. Spiders adjust the way they spin their silk to each web's circumstances, so the team had no idea how much a sample had been stretched before they collected it. They overcame the problem by calculating the amount of elasticity remaining in each sample. Assuming that all silks have similar mechanical properties, Opell and his team were able to use the known stress/strain curve of *Araneus didematus* silk [T. Köhler and F. Vollrath (1995) *J. Exp. Zool.* **271**, 1-17] coupled with the silk's breaking and original lengths to estimate the silk's stiffness at different extensions.

Secondly, the team had to be sure that they had accurately measured the average stickiness per drop, as the spacing between droplets increases as the silk stretches. Pressing a suspended thread against a flat contact plate and pulling them apart, the team recorded the force at the moment the two separated. Repeating the experiment after stretching the silk by two and three times, the team used proportionately longer contact plates to ensure that the same number of adhesive droplets attached the silk to the plate at each length. Dividing the detachment force by the number of droplets in contact with the plate gave the team the average stickiness per drop.

Having convinced themselves that they could accurately determine the silk's stiffness and droplet stickiness, the team found that as four of the five silks were stretched and became stiffer, the stickiness per drop decreased. 'Extensibility contributes positively to stickiness,' says Opell; in other words, the stretchier the silk the stickier it is. This is because more

droplets contribute to stickiness on a stretchy thread than on a stretched and rigid thread. Opell suspects that the elasticity of an unstretched thread contributes as much as one-third of the silk's stickiness.

10.1242/jeb.021246

Opell, B. D., Markley, B. J., Hannum, C. D. and Hendricks, M. L. (2008). The contribution of axial fiber extensibility to the adhesion of viscous capture threads spun by orb-weaving spiders. *J. Exp. Biol.* **211**, 2243-2251.

NOT ALL MUSCLES CONTRIBUTE EQUALLY



Whether stumbling over a rocky river bed or clambering up hill, every creature continually adapts their movements as they travel. Each joint is operated by several muscles, some of which work together to flex and extend, while others work in opposition. Tim Higham explains that it had commonly been assumed that muscles that work together contribute equally to joint movements, and that each muscle contributes uniformly. But Higham and Andy Biewener decided to test this. Could muscles that work together contribute differently to joint movements? And do muscles contribute uniformly along their length? Higham and Biewener put their favourite biped, the guinea fowl, through its paces to see how much work and force the synergistic medial and lateral gastrocnemius muscles contribute as the bird walks and runs on the flat and uphill (p. 2303).

'Guinea fowl are great to work with,' says Higham, 'they run forever, are happy on a treadmill and have large limbs'. However, despite the birds' sizeable legs Higham admits that placing force transducers on the birds' tendons, and EMG electrodes and sonomicrometry crystals in the birds' medial and lateral gastrocnemius muscles was a rather daunting process. After hours of surgery, Biewener and Higham

eventually had four birds ready to set running and walking on flat and inclined treadmills to see how the muscles performed.

When the birds were walking on the flat, the medial and lateral gastrocnemius muscles contributed similar amounts of work. But it was a different matter when the birds started running. The work done by the lateral gastrocnemius rocketed, while that done by the medial gastrocnemius increased much less. The muscles were not contributing equally as the birds ran. However, when the birds walked and ran up hill, their muscles only worked a little harder than if they were moving on the flat; 'speed influences the distal muscles of guinea fowl to a much greater extent than incline,' says Higham.

The biggest surprise came when the team turned their attention to the medial gastrocnemius. With length measuring sonomicrometry crystals embedded in the ankle and knee portions of the muscle, the team could see how much mechanical work different regions of the muscle were doing. Amazingly, the region of the muscle closest to the ankle did virtually no work; 'the distal part of the muscle didn't change length at all,' says Higham. At first the team were surprised, but after watching each bird run they realised that the differences were real and even greater than the differences between the two muscles.

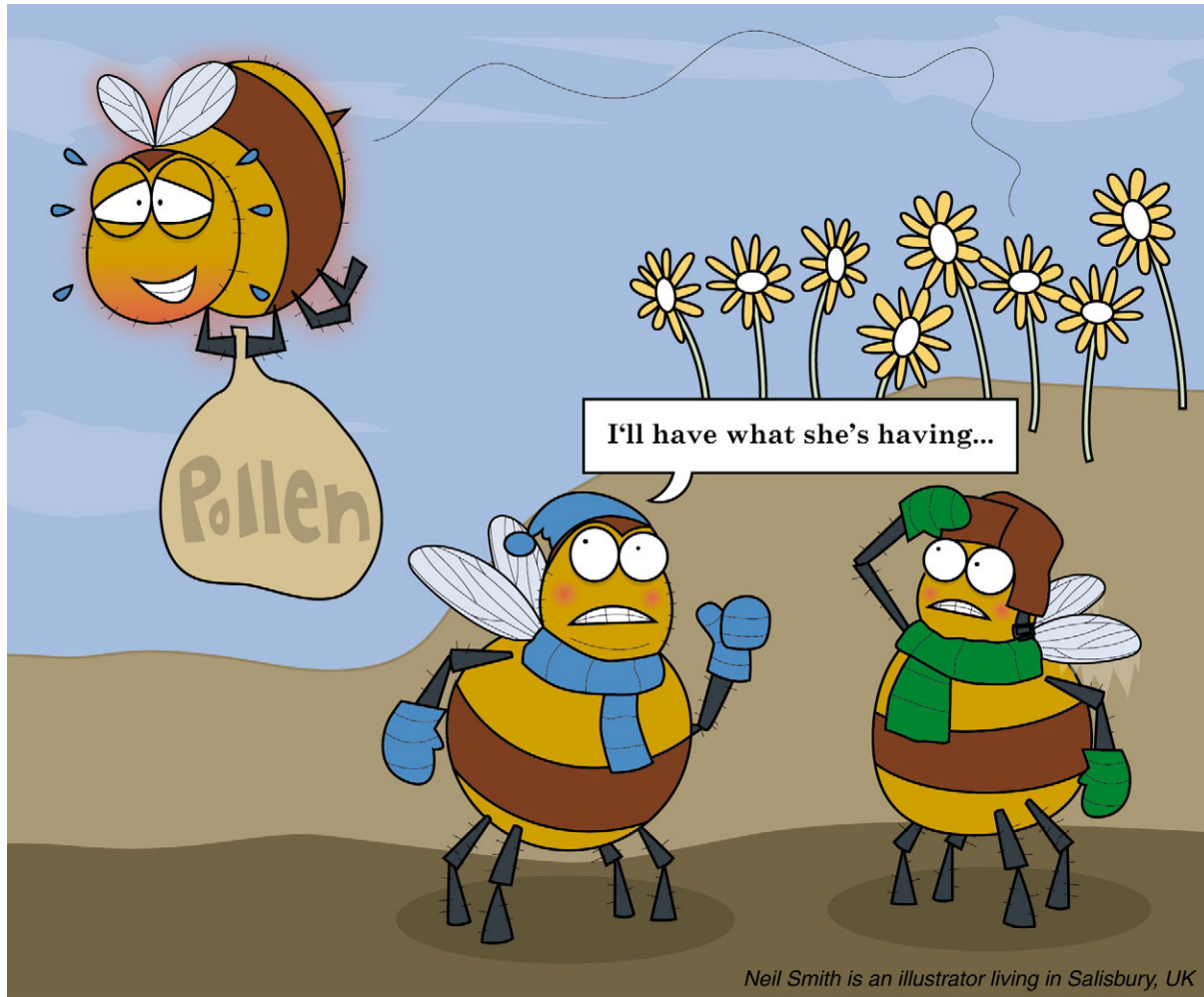
Why do the two ends of the medial gastrocnemius contribute so differently to the mechanical work that moves the bird's leg? Higham explains that there are regional differences in fibre types along the length of the medial gastrocnemius, which result in different performances in the two regions. Also, the ankle portion of the muscle is encased by a relatively stiff aponeurosis membrane, which restricts the amount of mechanical work that the ankle portion of the muscle can do.

Having found that different muscles, and even different regions of the same muscle, contribute disproportionately to the mechanical work required to move guinea fowl leg joints, Higham and Biewener are keen to find out more about the mechanisms that fine tune limb movements.

10.1242/jeb.021253

Higham, T. E. and Biewener, A. A. (2008). Integration within and between muscles during terrestrial locomotion: effects of incline and speed. *J. Exp. Biol.* **211**, 2303-2316.

POLLEN MAKES BEES HOT



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Forager bees like nothing more than a sweet supply of nectar. But bees do not live by nectar alone. One of their main sources of protein is pollen. Knowing that bees have to maintain a reasonably high thoracic temperature for their muscles to power flight, and that foragers' temperatures go up significantly as their nectar supply becomes richer, Katherine Mapalad, Daniel Leu and James Nieh wondered whether foragers' temperatures would rise depending on pollen quality (p. 2239).

Mixing good quality pollen with indigestible α cellulose, the team produced 25%, 50%, 75% and 100% pollen protein samples and offered them to a bee colony in an isolated foraging arena. Measuring foraging bees' temperatures with an infrared thermometer as they finished foraging and returned to the nest, the team found that the insects' body temperatures rose by 0.4°C with every 25% increase in pollen protein concentration. Nieh and his colleagues suspect that the insects' raised body

temperatures are beneficial for foraging flights and may help foragers to recruit more helpers when they've found a rich protein supply.

10.1242/jeb.021261

Mapalad, K. S., Leu, D. and Nieh, J. C. (2008). Bumble bees heat up for high quality pollen. *J. Exp. Biol.* **211**, 2239-2242.

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