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.

ANTS OBEY ROAD RULES TO KEEP TRAFFIC FLOWING


photo courtesy Alex Wild/myrmecos.net

Getting stuck in traffic is an everyday 21st century experience. But ants never seem to encounter the same traffic problems. Traipsing back and forth along a path while foraging, they always seem to solve problems before jams take hold. Vincent Fourcassié from the Université Paul Sabatier, France, explains that foraging army ants avoid getting into a jam by adhering to well-defined rules. They avoid head on collisions by staying in their lane. But what if you don't stick to your lane, like leaf-cutter ants? Audrey Dussutour wondered how these cargo-carrying ant juggernauts manage to avoid getting in a jam when they must be involved in head on collisions all the time. Travelling to the University of Illinois at Urbana-Champaign, USA, to work with Samuel Beshers' leaf-cutter ant colonies, Dussutour tried to get the ants jammed in a tight spot to see how they overcome the problem (p. 499).

Linking a well-stocked foraging site to the ants' nest with a wide bridge, Dussutour could see the ants scurrying to and fro, returning with pieces of leaf. But what happened when she replaced the wide bridge with a bridge that was too narrow for the ants to pass two abreast?

The traffic never ground to a halt, it always kept flowing. Unladen outbound ants heading to the foraging site always gave way to the cargo-carrying foragers as they returned. The outbound ants simply stepped down onto the side of the bridge and let the leaf-carting foragers go by. So, instead of flowing continually, the traffic broke down into clusters with groups of homebound ants following a cargo carrier, while groups of outbound ants stepped off onto the side of the bridge to let them go past.

Dussutour also noticed that the returning cargo-carrying ants were slower than the ants returning empty handed, but instead of jostling past, the unladen ants stayed patiently behind their burdened nestmates that made a path home through the outbound foragers. Fourcassié explains that this is like the clusters of cars that build up behind slow trucks on our own highways. Calculating the amount of time that a fast, unladen nest-bound ant would waste in head on collisions with outbound foragers, Fourcassié explains that the insects could waste up to 64 s on a 300 cm bridge. However, by slowing down and following an unimpeded cargo-carrying ant, the empty-handed foragers would only be delayed by 32 s, returning faster than if they'd muscled past.

But what does all this mean for the nest's leaf supply? Surprisingly it was more efficient on the narrow bridge than on the spacious bridge. Fourcassié explains that the returning ants' patience is rewarded by speeding up the leaf delivery process. He also suspects that the fast-moving outbound ants encounter more head on collisions with cargo-carrying returners than with empty-handed returners, which could encourage the outbound insects to carve up more leaves at the foraging site, improving the nest's leaf supply.

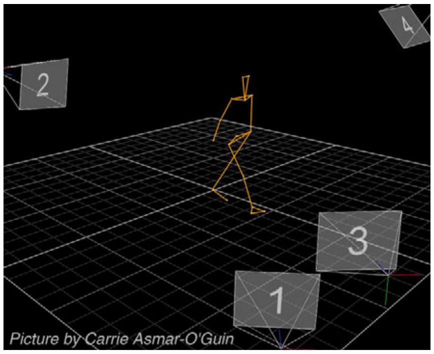
10.1242/jeb.029132

Dussutour, A., Beshers, S., Deneubourg, J. L. and Fourcassié, V. (2009). Priority rules govern the organization of traffic on foraging trails under crowding conditions in the leaf-cutting ant *Atta colombica. J. Exp. Biol.* **212**, 499-505.

WALKERS SWING ARMS PASSIVELY

When Herman Pontzer was a teaching assistant for an undergraduate class designed to show that shoulder muscles drive arm swinging as we walk, he was in for a surprise. The class's results showed that arms and legs weren't swinging completely out of sync, as he had expected. Also, the torso muscles were firing simultaneously, as if they were stabilising the body's rotation rather than driving it. Discussing his results with colleagues Daniel Lieberman and David Raichlen, Pontzer speculated that arm swinging could be entirely passive and driven by the body's rotation, caused by the swinging legs. Pontzer remembers that Lieberman and Raichlen weren't so sure, believing that there must be some shoulder muscle activity driving the movement. But when Pontzer turned up in the lab the next day with a model man built from lego bricks and showed that the model's arms swung naturally when he set the legs swinging, Lieberman and Raichlen became more convinced. But they still needed evidence that something as complex as a human body with nerves, muscles and tendons could drive arm swinging simply as a consequence of dissipating the body's rotational energy (p. 523).

Setting up his own lab at Washington University, Pontzer had access to a



Picture by Carrie Asmar-O'Guin

treadmill and team of enthusiastic students to test his theory. Recruiting active joggers, Pontzer had the students run and walk on the treadmill while he filmed their movements. Then he repeated the experiments, either attaching a 1.2 kg weight to the athlete's arms, or asking the students to fold their arms across their chests to see how changing the limbs' weight distribution affected their movements. Pontzer also measured muscle activity in the students' shoulders to see if any of the muscles could be driving the swinging arms.

Working with John Holloway to track 15 points on each student's body, Pontzer saw that changing the arm's moment of inertia (mass distribution) by folding them across the chest had a significant effect on the body's rotation when the students ran. The runners' shoulders twisted significantly more than when their arms were free to swing. And when Pontzer increased the arms' moment of inertia by adding weights, the runners' shoulders twisted less. The swinging arms were dissipating the upper bodiy's rotation to prevent the torso from twisting too much, as he expected.

Pontzer also realised that the muscle activation pattern in the joggers' shoulders was completely wrong for driving the swing. If the shoulder muscles swung the arm, then the front shoulder muscle would be active as the arm swung forward, and the back muscle active as the arm swung back. Instead, he found that both muscles activated simultaneously, as if they were stabilising the arm. So the shoulder muscles do not drive arm swinging.

But where does the rotation that swings the arms coming from? Pontzer explains that the rotation is transmitted from the swinging legs, through the hips and torso to the shoulders and arms. He adds that the arms don't swing perfectly out of sync with the legs because of damping of the leg's rotation as it is transmitted through the body.

Pontzer suspects that we have evolved to take advantage of our body's intrinsic mechanics because it is metabolically and neurologically cheaper than micromanaging our every move. And by swinging our arms, we stop our heads from twisting too, making it easier to keep an eye on what's in front.

10.1242/jeb.029140

Pontzer, H., Holloway, J. H., 3rd, Raichlen, D. A. and Lieberman, D. E. (2009). Control and function of arm swing in human walking and running. *J. Exp. Biol.* **212**, 523-534.

ENERGY EXPENDITURE CALCULATED FROM ACCELERATION


Picture by Lewis Halsey

Energy is the currency of life. Whether you're embarking on a 10,000 km migration or deciding whether it's worth catching the next meal, it's a matter of making sure that the energetic balance tallies up. Over the years biologists have come up with various ingenious ways of measuring energy expenditure, including measuring heart rate. But some techniques can be tricky to use in the field, which led Rory Wilson and a team based in Birmingham to come up with an alternative method: accelerometry (Wilson et al., 2006, *J. Animal Ecology* 1081–1090). Having shown that it is possible to measure an active animal's energy consumption from its acceleration while moving, Lewis Halsey and Jonathan Green wondered whether the method could also produce reliable estimates of energy consumption when an animal is stationary, and old English bantam chickens proved to be the perfect animals to test their ideas on (p. 471).

'The chickens were very cooperative; they are happy sitting still,' explains Green, who had access to an entire flock of them while working in Peter Frappell's lab in La Trobe University, Australia. Halsey travelled from the UK to join Green with some of Rory Wilson's accelerometers, and the team were ready to compare the bird's predicted energy expenditures, based on their acceleration, with their predicted energy expenditures based on their heart rate. First they set the birds a jogging test on a treadmill. Fitting the chickens with a heart rate monitor, the team measured the birds' oxygen consumption (a measure of the amount of energy expended) as they trotted along. Then they swapped the heart rate monitor for an accelerometer and repeated the experiments. Calculating the birds' overall dynamic body acceleration (ODBA) from the acceleration traces, Green and Halsey found that it agreed well with the animals' exertions predicted by their heart rate.

But what happened when the birds exerted themselves during more static activities? After giving the chickens a hearty meal and switching the lights off to settle them down, the team recorded the animals' heart rates, body accelerations and oxygen consumption rates as the birds ramped up their metabolic rates and got on with digestion. The team also tested whether accelerometery could tell them anything about the birds' energy expenditure when they cooled the chickens down and warmed them up.

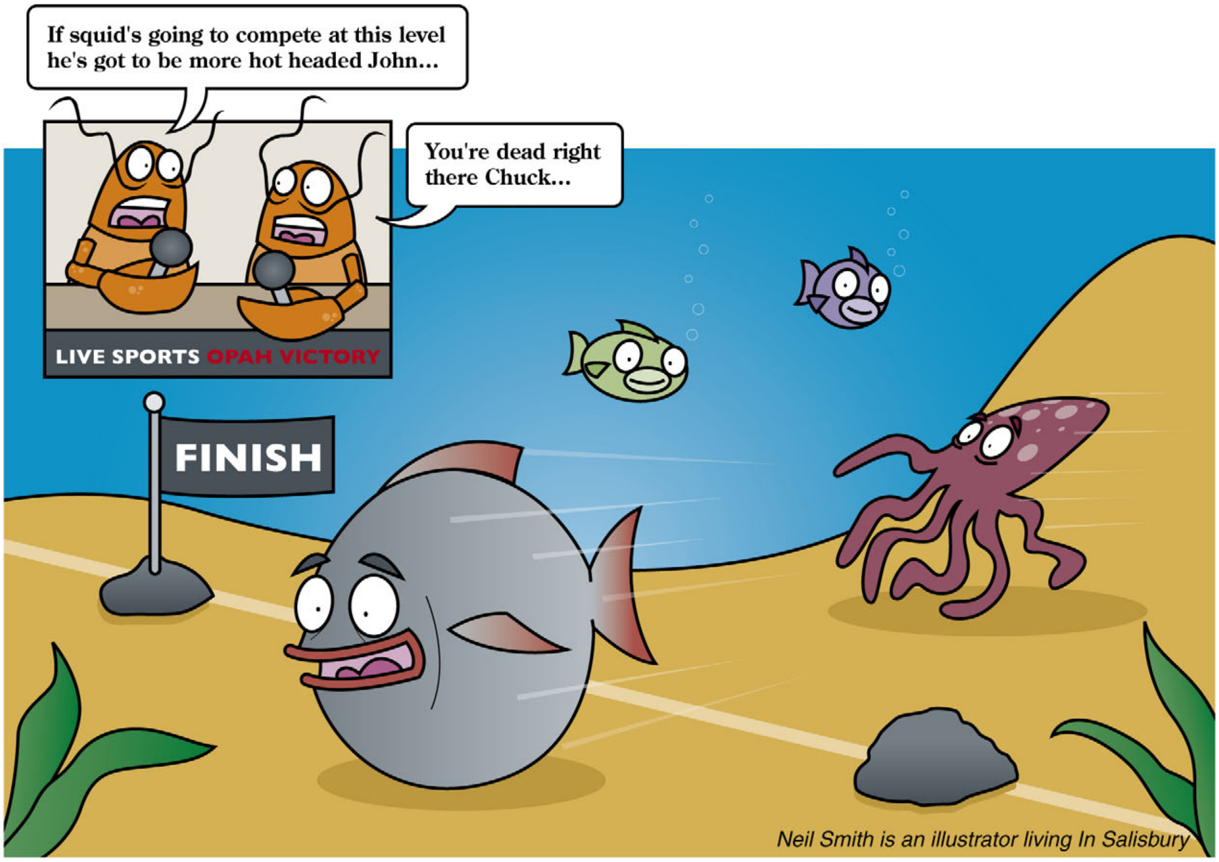
At first glance it was clear from the acceleration traces what activities the birds were up to, but the energy calculations based on the acceleration patterns didn't seem too accurate. However, when the team looked at the margin of error of the calculated energy expenditure, Green and Halsey realised that the acceleration data could provide a realistic estimate of the animals' energy expenditure. Green explains that when the birds were inactive, the error margin on energy expenditures based on heart rate was 6%, while the error margin from estimates based on the animals' weight was 20%. However, when the team calculated the error margin based on the animals' acceleration data, it was only 12%, significantly better than 'guestimation' from the literature, and not far off the errors from heart rate measurements.

So it is possible to use an animal's acceleration pattern to identify their activity pattern and estimate their energy expenditure, whether they are on the move or digesting dinner. And Green suspects that there are many more acceleration data sets out there that could tell us a lot about animal activity and energy expenditure patterns in the wild.

10.1242/jeb.029165

Green, J. A., Halsey, L. G., Wilson, R. P. and Frappell, P. B. (2009). Estimating energy expenditure of animals using the accelerometry technique: activity, inactivity and comparison with the heart-rate technique. *J. Exp. Biol.* **212**, 471-482.

DEEP-DIVING OPAH HAVE HOT HEADS



Neil Smith is an illustrator living In Salisbury

Staying at the top of the food chain takes a lot of effort. Some fish, such as sharks and tunas, have even gone to the extent of warming their brains. Kathryn Dickson from California State University Fullerton, USA, explains that having a warm brain probably allows fast-moving foragers to maintain nervous function and see well as they dive deep in cold waters. But it wasn't clear whether deep-diving squid-chasing opah had gone to the same lengths as other pelagic predators to ensure their place at the top of the pyramid (p. 461).

Catching opah in the Pacific Ocean, the team measured the temperature behind the fish's eyes, in the brain and in the myotomal muscle, and found that the fish's eyes were 2.1°C warmer than the rest of their bodies and their brains were also significantly warmer. They were warming their eyes and brains, much like sharks and tunas.

Curious to find out where the heat was coming from, the team dissected some fish heads and found that one of the muscles attached to the eyeball, the well insulated lateral rectus muscle, was probably the heat source. Closer inspection also showed that the blood flow through the muscle is arranged to minimise heat loss.

So opah seem to warm their brains and eyes, which probably gives them an advantage over their prey when plunging into cold water.

10.1242/jeb.029173

Runcie, R. M., Dewar, H., Hawn, D. R., Frank, L. R. and Dickson, K. A. (2009). Evidence for cranial endothermy in the opah (*Lampris guttatus*). *J. Exp. Biol.* **212**, 461-470.

Kathryn Knight
kathryn@biologists.com