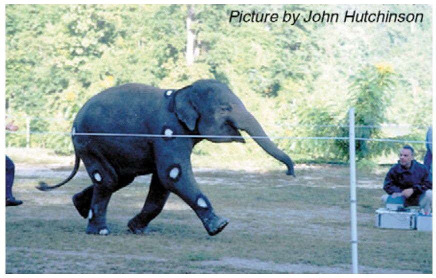
Inside JEB is a twice monthly feature, which highlights the key developments in the *Journal of Experimental Biology*. Written by science journalists, the short reports give the inside view of the science in JEB.

Inside JEB

ARE HIGH-SPEED ELEPHANTS RUNNING OR WALKING?



Picture by John Hutchinson

John Hutchinson is intrigued by the way big animals move; crocodiles, elephants, even extinct mammoths fascinate him. So when Hutchinson met Rodger Kram in Berkeley, he recognised a kindred sprit to discuss big animal biomechanics with. One question that puzzled Hutchinson was how baby elephants move; massive adults never run, but Hutchinson wondered whether smaller, calf sized, youngsters could. Curious to find out what was known about elephant locomotion, the pair turned to the literature, but soon found it littered with confusion and anecdotes. Hutchinson realised that before he could satisfy his curiosity about the youngsters, he'd have to clear up the confusion and collect some reliable data on the adults (p. 3812).

Filming captive African elephants at local zoos in the USA, Hutchinson began analysing their movements over a range of speeds. But the animals never went faster than a leisurely 4 m s^{-1}, always proceeding with a pendulum like gait reminiscent of walking. Hutchinson soon became suspicious that the couch-potato captives might not be capable of reaching the speeds that fit and active elephants reach routinely. He began contacting elephant experts around the globe in search of fitter animals, and realised that he'd probably found the ideal elephants when Richard Lair sent him stopwatch times recorded at elephant races in Thailand; the Asian elephants were moving at speeds approaching 7 m s^{-1}. Hutchinson converted the speeds into the dimensionless Froude number, often used as an indicator of walking or running gaits, and realised that it was well above the transition value of 1 (where walking gaits switch to a bouncing run) at the animals' top speeds. Were these elephants running? Hutchinson needed more evidence about the animal's unorthodox running style to decide, so headed to Thailand.

Arriving in Lampang, Hutchinson and Dan Famini filmed 42 animals, ranging in size from 600 kg youngsters to 3000 kg adults, as they hurtled along accompanied by their trainers. He remembers that it was clear on the first day that these animals were outpacing the captive zoo animals and says 'we knew right then we would get the data we wanted'.

After weeks of filming, the pair returned to the USA to begin laboriously analysing each 'run', frame by frame. Recording each animal's footfall pattern and hip and shoulder movements, Hutchinson combined his observations with African elephant data from Robert Dale in Indiana and Delf Schwerda and Martin Fischer in Germany, and compared the African and Asian animals' gaits to see whether the animals were walking or running. Sure enough, at speeds below about 4 m s^{-1}, both the species seemed to use a pendulum-like walking gait and there was virtually no difference between the African and Asian elephants' movements.

But what happened as the Asian animals moved up a gear and passed the gait-transition Froude number of 1? Were they running or walking? Scrutinising the animals' footfall patterns, the team noticed subtle changes. The animals' rear legs appeared to begin 'running' as they became bouncier and both feet became airborne simultaneously. Meanwhile the front legs remained relatively rigid, despite becoming simultaneously airborne too. However, the rear and front legs never become airborne at the same instant. All of the elephants always kept at least one foot in contact with the ground, even at a record-breaking 6.8 m s^{-1} top speed. Considering the speed and motions, Hutchinson and colleagues suspect that the animals were using their limbs like bouncy pogo sticks; just like runners. The animals were effectively running, even though they never left the ground.

And how did the babies, which had set Hutchinson off on this odyssey, compare with their elders? Their running style was just a scaled down version of the adults. Hutchinson isn't sure why the youngsters fail to trot or gallop; 'it would certainly be an advantage to them escaping predators' he explains, but suspects that the elephant's curious running style is hardwired from an early age.

10.1242/jeb.02515

Hutchinson, J. R., Schwerda, D., Famini, D. J., Dale, R., Fischer, M. S. and Kram, R. (2006). The locomotor kinematics of Asian and African elephants: changes with speed and size. *J. Exp. Biol.* **209**, 3812-3827.

CRABS PRIORITIZE DINNER

In a body of water as large as the Pacific Ocean, you might think that salinity levels would be fairly constant; and they are in the ocean depths. But head closer in to shore, and it can be a very different matter. At stormy times of year, coastal freshwater run-off can dramatically reduce the water's salinity, and the situation is often exacerbated at low tide. So how do coastal sea creatures cope with this environmental variability? Some have gone for the metabolically costly option of maintaining high tissue salt levels, even when the sea is relatively dilute, while others go with the flow, allowing their salt levels to rise and fall. The medium-sized graceful crab (*Cancer gracilis*), found along the Pacific coast of North America, is one coastal resident that has opted for the low-cost alternative, allowing its salt levels to fluctuate, even when the salinity becomes perilously low. Iain McGaw from the University of Nevada at Las Vegas was intrigued to find out how the animals cope during a bout of low salinity with an additional metabolic burden; digestion. Knowing that most animals ramp up their metabolism during digestion, McGaw was curious to find out how the crabs balance the potentially conflicting demands of low salinity survival with the demands of digesting dinner (p. 3766).

Fortunately, McGaw didn't have to worry about keeping the crabs in the Mojave Desert. He had long-term contacts with the Bamfield Marine Sciences Centre on the west coast of Vancouver island, so he packed up his Nevada lab and drove almost 1500 miles north to the remote field station to investigate the crabs' habits. Having set up home for a 15-month sabbatical, McGaw collected crabs from the ocean, ready to measure their physiological responses to digestion in low salinity.

But first he needed to know how the crabs responded to low salinity alone. McGaw measured the unfed animals' blood flow and oxygen uptake rates as he simulated coastal dilution during low tide by dropping the salinity from 100% seawater to 65% for a 6-hour period. The crustaceans lowered their heart rates and blood flow, as well as reducing their oxygen uptake by clamping their gills shut and becoming inactive. However, their metabolic rates and cardiac activity rapidly returned to normal when the crabs were returned to 100% seawater. Next he measured the crabs' physiological responses to a fish dinner in 100% seawater; their blood flow and heart rates increased slightly, but their oxygen demand rocketed 2-3 fold and remained high for several days as the animals digested their meal and incorporated it into their own tissues.

So what happened to the crabs' cardiac activity and metabolic rate when McGaw simulated a drop in salinity as the sea went out after dining? He fed the crabs in 100% seawater, before dropping the salinity levels to 65% 3 hours later. Their heart rates rose a little as the salinity dropped and their oxygen uptake fell slightly too, but soon recovered as if the crabs were feeding in the comfort of full-strength seawater. The crustaceans' metabolism was reacting as if they were digesting their meal in high salinity, despite the uncomfortably low salt levels; they appeared to prioritize digestion over their metabolic responses to low salinity.

McGaw admits that he was surprised, he had thought the crustaceans would prioritize their low-salinity survival strategy in the harsh conditions, but it seems that digesting dinner takes precedence. Which made McGaw wonder exactly what was going on in the crustacean's guts (p. 3777), but first he had to figure out how to film the crabs' internal workings.

McGaw hit on the idea of filming the animals with a portable low-power X-ray machine, much like an airport baggage X-ray system. Knowing that the crabs' digestive systems would easily sort and discard lead-glass tracking beads from a hearty meal, a colleague suggested that electrolytic iron powder might pass through the animals' systems unhindered. Mixing the powder with fish, the crabs tucked in and McGaw was ready to feed the crabs in 100% seawater before X-ray filming their digestive tracts over a range of salinities.

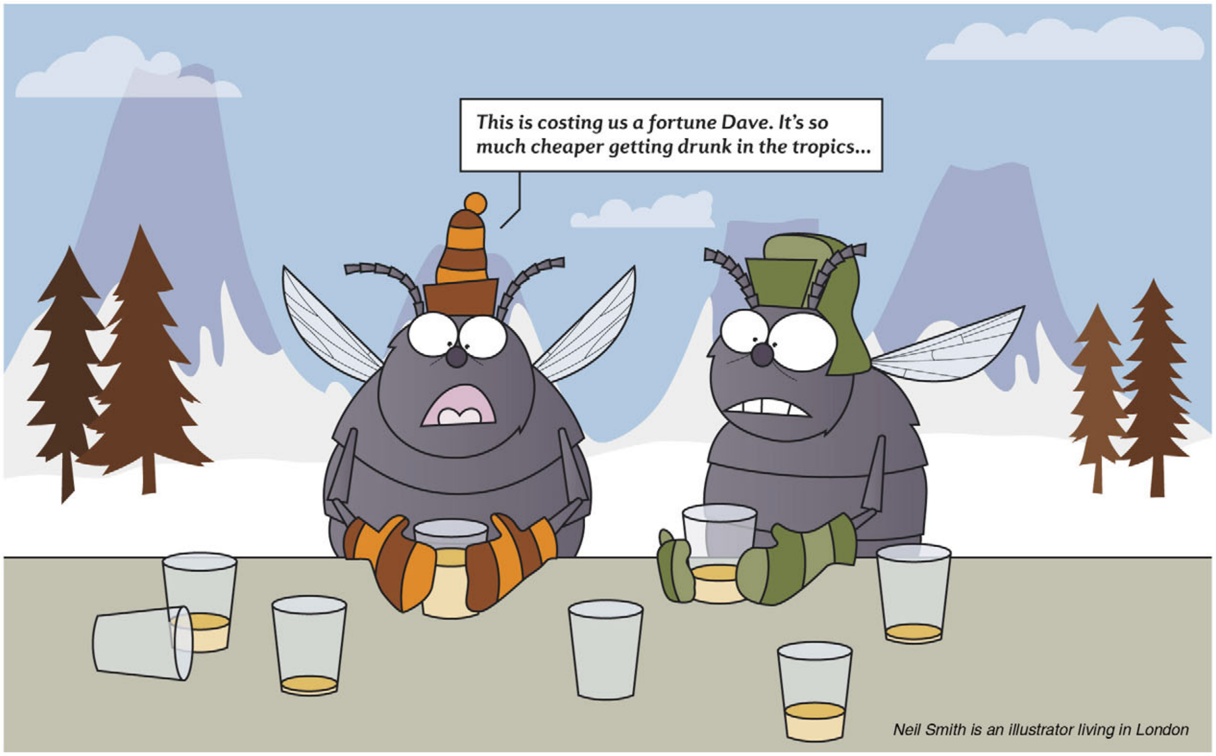
Tracking a meal through the crustacean's digestive tract, McGaw realised that the animals were able to slow the digestive process as the salinity dropped, so crabs fed at 100% seawater digested their meals faster than animals fed in 80% seawater. However, the crabs in the lowest salinity (60%) conditions hardly ever completed digesting their meals. Having ground up the fish slowly in their foregut, the crabs regurgitated the majority of the meal about 6 hours later, possibly saving themselves the burden of completing digestion and the metabolically costly process of incorporating the meal's components into their own tissues.

McGaw admits that he isn't sure whether the crabs make an active decision to conserve energy for other body systems by discarding the meal before cellular uptake starts, or they simply lack the reserves needed to fuel the entire digestion process. However, he's keen to compare the graceful crab's digestive behaviour with species that regulate their ion levels to find out whether osmoregulators are able to balance or prioritize the conflicting demands of ionic regulation and digestion.

10.1242/jeb.02513

McGaw, I. J. (2006). Feeding and digestion in low salinity in an osmoconforming crab, *Cancer gracilis*. I. Cardiovascular and respiratory responses. *J. Exp. Biol.* **209**, 3766-3776.
McGaw, I. J. (2006). Feeding and digestion in low salinity in an osmoconforming crab, *Cancer gracilis*. II. Gastric evacuation and motility. *J. Exp. Biol.* **209**, 3777-3785.

ETHANOL TOLERANCE IN TEMPERATE *DROSOPHILA*



A piece of rotting fruit may not look particularly appetizing to us, but to *Drosophila*, it's almost pure heaven; they like nothing more than settling down for a good feast on the decaying flesh. However, packed full of acetic acid and ethanol, decaying fruit poses a toxic threat to its guests. Fortunately, fruit fly populations in high latitudes seem to be well defended against the effects of acetic acid and ethanol, while tropical populations are less so. How these geographically distinct populations maintain their ethanol resistance puzzled Kristi Montooth, Kyle Siebenthall and Andrew Clark. Knowing that ethanol disrupts membranes, and that a key factor (dSREBP – *Drosophila* sterol regulatory element binding protein) regulating membrane composition also regulates the final stage of ethanol and acetic acid detoxification, the team decided to investigate to effects of temperature on the insect's ethanol detoxification and membrane physiology (p. 3837).

Working with fruit flies from tropical north eastern Australia and temperate Tasmania, the team found that both alcohol dehydrogenase and acetyl-CoA synthetase expression and activity were increased in the Tasmanian and warm acclimated insects, contributing to their enhanced ethanol tolerance. Temperature had upregulated the essential enzymes to increase the Tasmanian insect's ethanol tolerance. Looking at the effects of cold temperatures on the insect's membrane structure, the team found that at low temperatures, the flies had increased levels of lipid biosynthetic enzymes such as phospholipase D to counteract the membrane's increased rigidity. Montooth also points out that phospholipase D utilizes ethanol, possibly contributing to the insect's ethanol tolerance. And when the team suddenly dropped the temperatures, the insect's ethanol tolerance improved too. Montooth suspects that the high-latitude insect's ability to counteract increased membrane rigidity at low temperatures protects them from the damaging effects of ethanol, improving their tolerance.

So temperature influences *Drosophila*'s ethanol and acetic acid tolerance by altering both the detoxification pathways and membrane physiology. Montooth explains that fruit flies probably experience both temperature and toxin stresses simultaneously and frequently, so *Drosophila* could teach us how 'physiological pathways and mechanisms evolve in the face of multiple selection pressures in nature' she adds.

10.1242/jeb.02514

Montooth, K. L., Siebenthall, K. T. and Clark, A. G. (2006). Membrane lipid physiology and toxin catabolism underlie ethanol and acetic acid tolerance in *Drosophila melanogaster*. *J. Exp. Biol.* **209**, 3837-3850.

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