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

PERFUMED FEMALE'S SEX APPEAL

Picture provided by Jean-Francois Ferveur.

When a male fruit fly wants to track down a gal, he follows his nose along her attractive scent trail. Jean-François Ferveur explains that this alluring bouquet is a complicated mixture of 16 hydrocarbon compounds, but it wasn't clear which of the cocktail's components turns a female fruit fly into a femme fatale. He adds that two of the female's scent components were suspected of being sex pheromones but 'testing the allure of dummy females scented with these chemicals may not tell us much about the sexual advances of male flies towards live females'. Ferveur needed to test the aphrodisiac effects of the two mysterious substances on flesh and blood flies. Teaming up with Fabrice Marcillac, their idea was simple: create mutant flies lacking both hydrocarbons, apply a dab of scent to one and allow a male fruit fly to decide which takes his fancy; scented or unscented females (p. 3927).

But the team needed to find a way of applying the natural females' aroma to the mutants. Fortunately, the mutants quickly picked up the natural flies' scent when crowded together in a tiny jar. After spending a day together, the mutant females' pheromone scent was indistinguishable from the wild-type females'. Ferveur was ready to see how the males responded to the mutants' topped up scent.

Selecting a perfumed female and her unperfumed sister, Ferveur waited to see which of the two would prove irresistible to a waiting male. The aphrodisiac properties of the substances were abundantly clear; the perfumed sisters won the male's affections almost every time. 'When we saw the first males courting the perfumed mutant, we knew we were on to something', says Ferveur. But what really astonished the two researchers was that the two pheromones appeared to act both as a 'start' button for male mating behaviour, triggering earlier copulation, as well as an 'off' button, terminating copulation. 'The males began mating more rapidly with the perfumed females and copulation lasted longer than with the unperfumed females', says Ferveur. So the hydrocarbons don't simply send out a sexy signal; they also have a dramatic effect on the male's sexual performance.

But there was an unexpected twist to the story; the fruit fly Viagra had some interesting side-effects. Ferveur was surprised to find that the perfumed females had fewer daughters than the unperfumed females. 'There appears to be a trade-off', explains Ferveur, 'a female with these two pheromones may attract more males, but also leave behind fewer female progeny'. Although he admits that he is not sure why this is happening, these tantalising results certainly hint at conflict between the sexes.

10.1242/jeb.01294

Marcillac, F. and Ferveur, J.-F. (2004). A set of female pheromones affects reproduction before, during and after mating in *Drosophila*. *J. Exp. Biol.* **207**, 3927-3933.

Yfke van Bergen

FLIGHT CONTROL

Despite a century of manned flight, when it comes to aerobatics, we're still a long way behind insects. And even though their agility can be extremely frustrating when evicting an unwanted guest, insects can teach us a great deal about the complex forces that keep them aloft and the mechanisms that control them. Michael Dickinson is fascinated by all aspects of insect flight: from the aerodynamic forces they generate to the complex neural systems that control each intricate wing beat. But it hadn't been possible to correlate variations in insect wing beats and the muscles that control them, with the effects they have on a flight path until recent technical developments allowed Claire Balint, a student in the Dickinson lab, to simultaneously monitor flight muscle activity and wing movements to see how flies steer their erratic path (p. 3813).

But flies are notoriously mobile; the only way for Balint to collect the high speed flight recordings she needed to analyse the insect's wing movements was to tether the insect in a flight arena while focusing three ultra-high speed cameras on the flapping insect to capture its intricate manoeuvres. And by skilfully inserting microscopic electrodes into five of the insect's flight muscles, she could record flight muscle activity simultaneously as they flew into a mild headwind. But Balint also needed to measure the aerodynamic forces generated by each wing beat before she could begin correlating the insect's muscle activity with the forces generated. Digitising the positions of both right and left wings over a total of almost 870 wingbeats, Balint was able to calculate the forces generated by the wings as they moved through the air, as well as measuring them on a scaled-up mechanical model, before beginning the painstaking task of correlating the forces that keep the insect aloft with individual muscle activity.

Balint explains that 'although a reasonably robust theory exists for predicting the forces resulting from an arbitrary change in wing motion, the link between aerodynamically relevant changes in wing kinematics and the activity of specific steering muscles was less clear'. She and Dickinson also knew that certain muscle groups were responsible for three individual aspects of the insect's wing beat movements; the downstroke deviation, the dorsal amplitude and a shift in the ventral amplitude known as 'mode'. Undaunted by the enormous amount of data generated by the flapping insects, Balint began analysing the aerodynamic forces generated by the insects according to each of these wing beat features, to see how they affected the insect's aerodynamic performance. Thanks to this novel approach, the team soon realised that specific sets of muscles were responsible for different aspects of the insect's aerobatic armoury. 'The basalare muscles primarily control lift and roll by varying the downstroke force, the muscles of pteralae III and I control thrust and yaw by controlling the upstroke force and an unknown muscle group controls lift and roll by varying the upstroke force inclination', explains Balint.

Having found that it's the flies' ability to control several force generating mechanisms in concert that allows them to dodge and weave so effectively, Dickinson is keen to know more about the elusive insect's flight and pursuit strategies.

10.1242/jeb.01295

Balint, C. N. and Dickinson, M. H. (2004). Neuromuscular control of aerodynamic forces and moments in the blowfly, *Calliphora vicina*. *J. Exp. Biol.* **207**, 3813-3838.

Kathryn Phillips

DEER MICE RUN FOR FUN

Picture by Mark Chappell.

For anyone interested in exercise physiology, whether it's in mice or men, the tool of choice is nearly always the treadmill; just set the treadmill rolling and measure the animal's metabolic rates as it scampers along the track. But that was until Mark Chappell and his co-workers at the University of California, Riverside, wondered whether forcing an animal to run at set speeds can really tell us much about the energetics of voluntary running, and whether the costs of voluntary exercise in various climatic conditions might vary. Knowing that the North American deer mouse has to cope with a range of temperatures across seasons, Chappell and his colleagues wondered how different thermal environments would affect the metabolic costs of roaming free (p. 3839).

But Chappell explains that measuring the rodents in their mountain top homes wasn't practical; the mice are nocturnal and spend much of the winter running in tunnels under snow! Fortunately, Chappell had access to a lab-based deer mouse population, and when given a chance the creatures happily spent time running in exercise wheels. So the team decided to measure the animal's metabolic rate in a specially designed sealed cage where the mice had free access to a wheel and Chappell could continuously monitor their oxygen consumption as they exercised. Placing the customised respirometer in an incubator also allowed the team to vary the ambient temperature to see how the rodents fared. Chappell admits that it wasn't clear whether his new respirometer could successfully measure the rodents' metabolic rates, but remembers that he was relieved 'when we plotted our first positive relationship between running speed and oxygen consumption, and knew it was going to work'.

After testing 32 deer mice exercising at 3, 10 and 25°C over periods of a day or more, the team were surprised to find that the animals did not stick to a narrow range of 'preferred' running speeds, as humans and horses do. The team also found that the mice spent more energy overall as the ambient temperature dropped. Chappell explains that large mammals use heat produced by exercise to keep warm when the temperature falls. The deer mice were also saving energy by substituting some exercise heat for other forms of heat production, such as shivering, which could clearly come in useful in chilly conditions.

While exercise heat might be energy-saving at some temperatures, the deer mice did not seem overly concerned about economy; they did not prefer to run at high speeds, which have the lowest transport costs. The little creatures were clearly not pushing themselves, since Chappell found that the rodent's maximum voluntary running speed was 4 to 5 $km\,h^{-1}$, considerably lower than their maximum sprint speed of 13 $km\,h^{-1}$. 'We also didn't see any 'wind sprints', Chappell recalls, 'the mice almost never chose to run at speeds that required maximum oxygen consumption'.

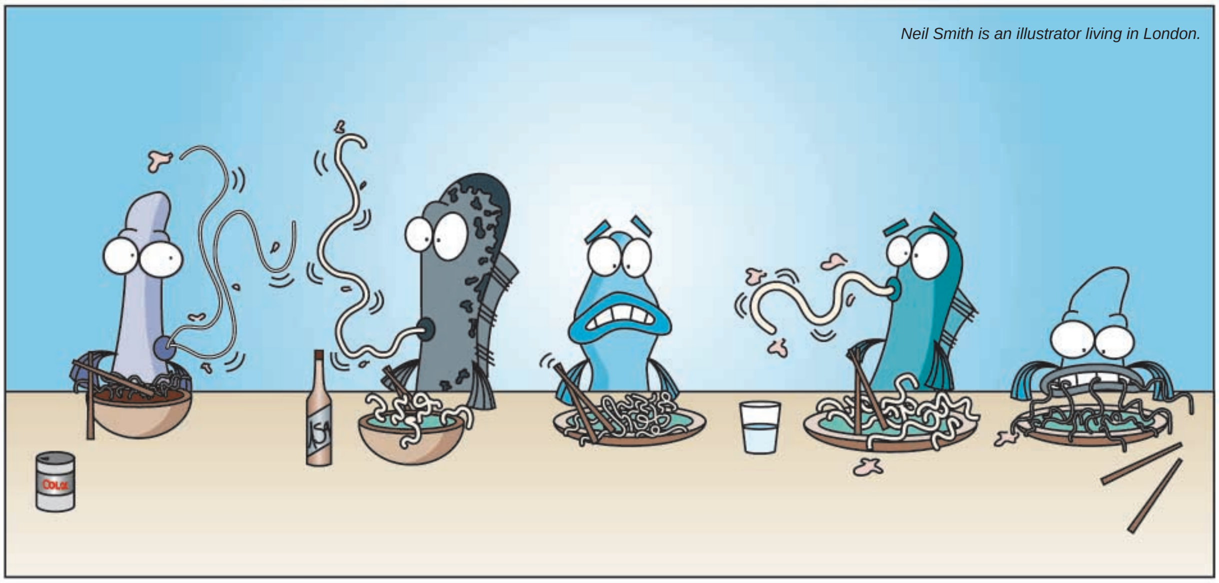
But Chappell is still puzzled by what motivates deer mice to run. The team hope that they will one day understand what motivates voluntary running in mice and other small rodents, and that their novel setup may eventually provide the key to many other questions that forced-exercise methods cannot answer.

10.1242/jeb.01296

Chappell, M. A., Garland, T., Jr, Rezende, E. L. and Gomes, F. R. (2004). Voluntary running in deer mice: speed, distance, energy costs and temperature effects. *J. Exp. Biol.* **207**, 3839-3854.

Yfke van Bergen

SUCTION LIMITS



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Pursuing a live meal means you have to be quick on the draw. Which is why many fish feed by explosive mouth expansion, drawing the hapless victim into their mouths and beyond. Andrew Carroll explains that suction feeding is widespread, and while some species have small mouths and others large, no one had successfully modelled the relationship between mouth morphology and the suction pressures generated by a hungry teleost. Curious to know how fish's feeding performance varies as a function of morphology, Carroll and a team of scientists from California and Florida designed a model based on four head morphological measurements (p. 3873). But how would the model compare to real pressure measurements, straight from the fish's mouth?

Choosing five species of centrarchid fish, the team tempted famished fish while measuring the pressure in their mouths as they gulped down food. The results were surprisingly good, with the measured minimum pressures agreeing well with the values predicted by the team's model; the team reports that 'epaxial musculoskeletal morphology limits suction pressure capacity'.

The team also found direct tradeoffs between morphology and the size of a fish's swallow. For example, fish that feed on large prey need large mouths, which limits the pressure they can generate. However, they may compensate for their poorer performance in other ways, by lunging at passing mouthfuls, rather than sucking them in.

10.1242/jeb.01297

Carroll, A. M., Wainwright, P. C., Huskey, Collar, D. C. and Turingan, R. G. (2004). Morphology predicts suction feeding performance in centrarchid fishes. *J. Exp. Biol.* **207**, 3873-3881.

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