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

BUILT TO RUN

Photo by James Usherwood

It is easy to appreciate an antelope's grace as it bounds across the savannah, but how about an ostrich? At first glance they seem to be unlikely runners, with their huge egg-shaped torsos and skinny legs. However, these birds have evolved to run and manoeuvre at speed to shake off predators. Devin Jindrich of Arizona State University and his colleagues report that it is their shape and behaviour that allow running ostriches to change direction so effortlessly, improving their chances of escape (p. 1378).

'We want to get at what makes them graceful,' explains Jindrich. While movement in one direction has been well modelled mathematically, the same models cannot easily be applied to variations in movement such as stops, starts, or changes in direction. Jindrich has developed his own mathematical model to describe such changes, so that he can understand how the effects of stability and manoeuvrability constrain organism design. Initially tested on cockroaches and humans, Jindrich wanted to test his model on a high-performance two-legged runner. Ostriches are ideal since they evolved as runners long before humans and have a completely different body shape. Alan Wilson, Nicola Smith and Karin Jespers at the Royal Veterinary College were already studying straight-line running in ostriches, and invited Jindrich to collaborate with them.

The team trained ostriches to run along a track and over a plate that measures the force as the foot hits the ground. They recorded the ostriches' body position using motion capture as they ran in a straight line, or around obstructions. An obstruction on the running track immediately after the plate caused the ostriches to change direction while stepping on the plate. They either turned to the left with a crossover step – stepping with the left leg and crossing over the right – or took a side step with the right leg to bypass the obstruction.

To make a successful turn, a runner needs to move in the intended direction without over- or under-rotating. Jindrich calculated that the ostrich's egg-shaped, horizontally orientated body has a higher inertia than the more vertical human body shape. As objects with a higher moment of inertia are more difficult to rotate, Jindrich predicted that ostriches were less likely to over-rotate than humans. Indeed he found that while humans decelerate to prevent over-rotation, on average ostriches generate fewer deceleration forces. In individual cases the birds generated both acceleration and deceleration forces to control their body orientation, but these are reduced because of their body shape with its higher inertia.

To find out if the ostriches were using twisting forces, or torques, in turning, the team used markers placed near the leg joints to measure the torques produced by the leg muscles. They found that as the leg hits the ground, the angle of the leg is very close to the angle of the force. This reduces the torque and produces similar forces to those recorded during straight running. So rather than twisting at the joints, the torque is maintained and ostriches change direction by simply rolling their body into the turn.

It is this combination of body shape and behaviour that allows running ostriches to change direction so gracefully. Exactly how the muscles generate stabilising forces while manoeuvring will be the focus of future work, along with neural control of the muscles. In the future Jindrich aims to apply his findings to design engineering solutions for patients with spinal cord damage. While he may not get patients running, just regaining some ability to manoeuvre would be a huge achievement.

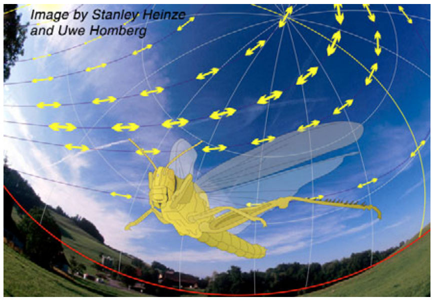
10.1242/jeb.02770

Jindrich, D. L., Smith, N. C., Jespers, K. and Wilson, A. M. (2007). Mechanics of cutting maneuvers by ostriches (*Struthio camelus*). *J. Exp. Biol.* **210**, 1378-1390.

Sarah Clare

LOCUSTS' LIGHT RESPONSE

Many migrating animals, including insects, rely on a celestial compass to navigate. They mostly use UV and polarised light, which are invisible to humans. While waves of unpolarised light are orientated in many different planes, some sunlight is scattered by the atmosphere and becomes polarised, meaning that the waves oscillate in one plane only. Scientists use a term called the *E*-vector to describe the plane of orientation of a polarised light wave, perpendicular to the direction the light wave is travelling. A group of neurons in the locust's brain, called POL neurons, respond to polarised



light, but Uwe Homberg from the University of Marburg, Germany, wanted to know how the neurons would respond to different light wavelengths, too. To start categorising POL neurons' responses, Homberg and his colleagues Michiyo Kinoshita and Keram Pfeiffer focussed on two large and easily accessible POL neurons called LoTu1 and TuTu1 in locusts' brains (p. 1350).

To find out which light stimuli the two neurons responded too, the team recorded their electrical activity using microelectrodes while shining polarised and unpolarised lights of different wavelengths, and from different directions, onto one of the locusts' eyes. They found that both neurons had different and varied responses to the different types of light: green, blue and UV, either polarised or unpolarised.

The team found that LoTu1 responded to unpolarised green light shining from the side onto the eye, but shining unpolarised UV light from the same direction stopped all activity. When the team shone unpolarised blue light onto the top of the eye, there was no activity in LoTu1, however when the light was polarised, the neuron responded but the strength of the response depended on the *E*-vector orientation. This means that the neuron would respond more strongly when the sun was in a certain position relative to the locust.

The team found that TuTu1 responded in the opposite way to LoTu1 to light shining from the side: it responded to unpolarised UV light, but unpolarised green light inhibited the response in most experiments. However TuTu1 responded in a similar way to LoTu1 to polarised blue light, shone onto the top of the eye, firing most strongly at specific *E*-vector orientations. When they shone unpolarised blue light on the locusts' other eye, activity in the neuron stopped, suggesting that signals from the opposite eye can block neuronal signals in TuTu1.

The team were surprised that both neurons responded to unpolarised and polarised light. 'We wouldn't expect a neuron to be sensitive to different colours and intensities' says Homberg, 'it would interfere with the polarisation signal'. However, relying on polarised light alone means that an insect can't tell if the sun is to its left, or to its right. Being able to respond to unpolarised light as well as differences in the sky's colour would pinpoint the sun's position and solve this dilemma. Another possible advantage is that the responses to polarised and unpolarised light would be used at different times of day. When light levels are low, and the insect can't see the sun, the polarised response could dominate. However if the sun was visible, the unpolarised response would be more reliable. The insects are probably 'combining features of the sky' to tell them where they need to go, Homberg explains.

10.1242/jeb.02771

Kinoshita, M., Pfeiffer, K. and Homberg, U. (2007). Spectral properties of identified polarized-light sensitive interneurons in the brain of the desert locust *Schistocerca gregaria*. *J. Exp. Biol.* **210**, 1350-1361.

MOTHS MAKE DECISIONS

When a hawkmoth (*Manduca sexta*) is searching for its next meal it has more than just its sight to go on: dinner has to smell right, too. While moths can locate food sources using sight or smell alone, in reality the situation is more complicated. Moths integrate information from both senses to evaluate which food items are potential tasty morsels. Concentrating on the visual and olfactory cues that attract moths to flowers, Joaquín Goyret and colleagues Poppy Markwell and Robert Raguso at the University of South Carolina investigated how moths use this information to make a decision to feed or not (p. 1398).

To attract the moths, the team used white artificial flowers as the visual cue, accompanied by a cotton swab soaked in bergamot oil as the attractive olfactory cue. They placed both objects in a wind tunnel, passing a flow of air over them which created an odour plume from the cotton swab for the moths to smell. They found that when the flower and the cotton swab were in the same place, creating the impression of a scented flower, most of the moths responded by approaching the flower and preparing to feed by extending their proboscises.

'Then we started separating the odour source from the flower, to find out how these two stimuli are used when a moth is deciding to extend its proboscis' says Goyret. The team found that as they increased the distance between the flower and the bergamot odour, the moths' responses dropped off dramatically. Of those moths that did prepare to feed, they took longer to make that decision than when the flower and the odour were in the same place. 'The animal is evaluating both signals, and the spatial separation is creating a conflict in the decision making process, making them less likely to approach the flower and try to feed,' Goyret says.

Having shown that separating the two cues by distance affected the moths' response, the team wondered what would happen if they were separated in time. They already knew that the moths were not very likely to try and feed when they were using just sight or smell alone. Would presenting a puff of bergamot odour before the moths saw the flower make them more likely to respond to the scentless flower? The answer was yes; 'the response was much higher than to a scentless flower without prior olfactory stimulation,' says Goyret; although the response was still not as high as to a scented flower. Finally to test which cue the moths innately preferred, they were given a choice between the flower, or the bergamot odour. The flower was most moths' first choice, but some of them also chose the odour after visiting the flower, showing that while moths prefer visual signals, they rely on smell too.

These results show that the moths' decision making process is very flexible. Not only do they rate cues in order of importance, they integrate information about when and where they perceived them to decide whether to feed or not. '[A moth] is not just a visual or an olfactory animal,' Goyret explains, 'maybe we could better understand sensory systems, and how they affect behaviour, by addressing them as sub-systems that work together and have evolved together, instead of as isolated components'.

10.1242/jeb.02772

Goyret, J., Markwell, P. M. and Raguso, R. A. (2007). The effect of decoupling olfactory and visual stimuli on the foraging behavior of *Manduca sexta*. *J. Exp. Biol.* **210**, 1398-1405.

NEURONS SURVIVE BETTER IN DOMINANT CRAYFISH

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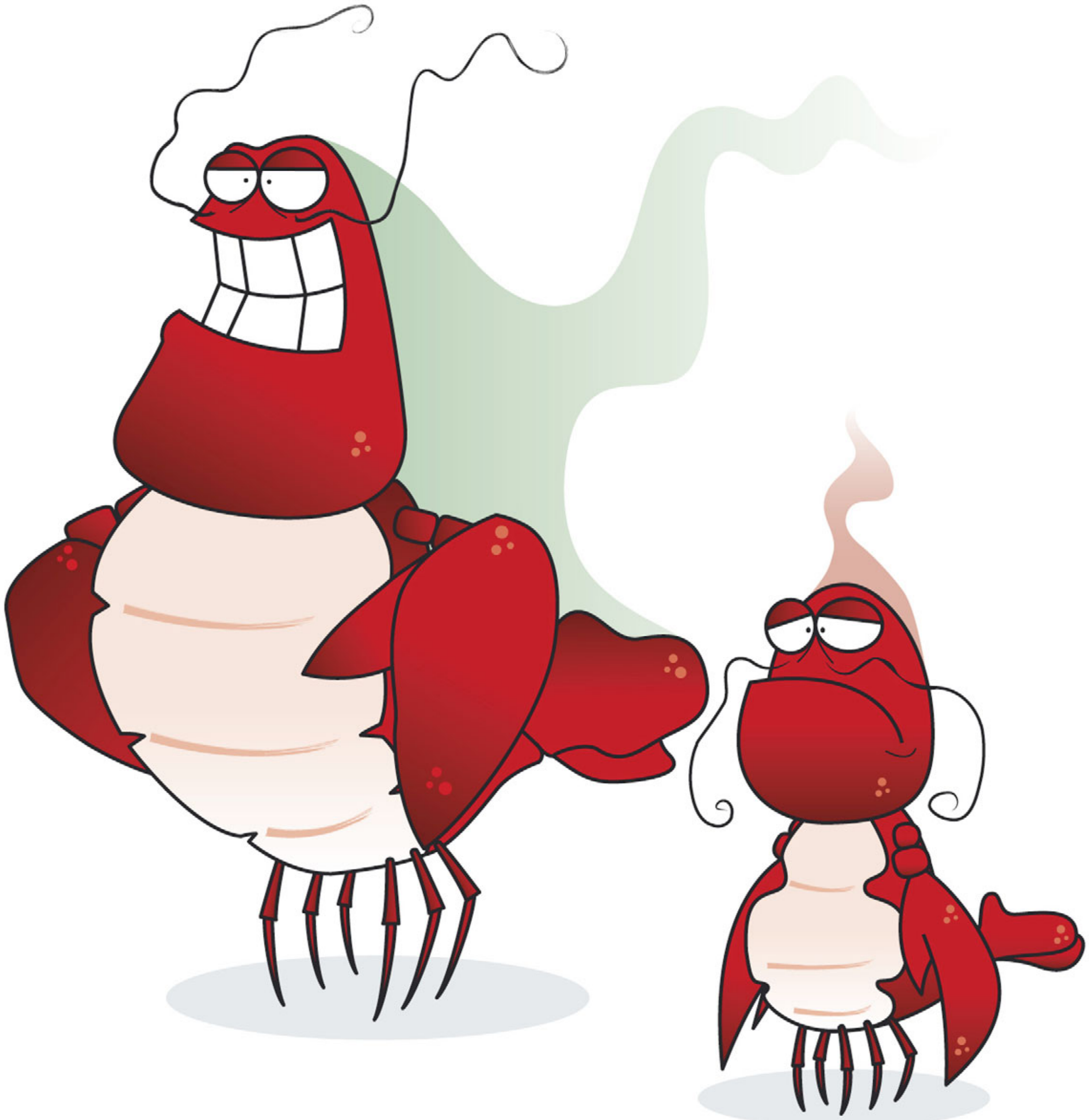

If a crayfish wants to know who's boss, it will use its sense of smell. Crayfish (*Procambarus clarkii*) fight each other and use chemical signals to form stable dominance hierarchies, with the winners becoming dominant and the losers subordinate. In the crayfish's brain, there are two clusters of cells, 9 and 10, containing neurons which process smell. New cells are added throughout an animal's life, which could help in the processing of olfactory signals to work out who's at the top. During her PhD research at Georgia State University, Atlanta, Cha-Kyong Song (now at Ewha Womans University, Korea) and colleagues hoped to find out if social interactions affected proliferation and survival of neurons in these two brain areas by measuring DNA synthesis and cell division in clusters 9 and 10 (p. 1311).

The team paired up juvenile crayfish and filmed their behaviour to find out who was dominant, and who subordinate, before examining their brains. While neuron proliferation was the same in subordinates and dominants, newborn neurons were more likely to survive in cluster 9 in dominant crayfish 14 days after their social interaction, even when body growth rate was taken into account. This suggests that social dominance enhances the survival of newborn neurons involved in processing smell, helping crayfish sniff out the opposition.

10.1242/jeb.02773

Song, C.-K., Johnstone, L. M., Schmidt, M., Derby, C. D. and Edwards, D. H. (2007). Social domination increases neuronal survival in the brain of juvenile crayfish *Procambarus clarkii*. *J. Exp. Biol.* **210**, 1311-1324.

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