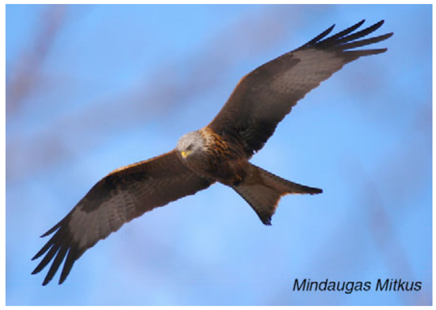
Inside JEB highlights the key developments in *The Journal of Experimental Biology*. Written by science journalists, the short reports give the inside view of the science in JEB.

Inside JEB

PARADOX OF UV VISION IN RAPTORS RESOLVED



Mindaugas Mitkus

Unlike humans, most birds have photoreceptor pigments that are sensitive to ultraviolet (UV) light, which has short wavelengths of 300–400 nm. However, for raptors such as kestrels, the purpose of this UV vision has remained elusive and puzzling. Over 15 years ago, when scientists found that the urine from Finnish voles reflected UV light, it seemed the mystery had been solved – UV vision was useful for scouting out good hunting grounds based on the abundance of UV-reflecting pee. However, 10 years later, studies suggest that the raptors' UV pigments are almost insensitive to UV and at best only detect UV light with longer wavelengths nearer 400 nm. Instead of benefiting raptor predators, UV light might be of more use to another type of prey, songbirds. These small birds have UV pigments sensitive to short wavelengths as well as UV-reflecting plumage. If raptors are truly insensitive to UV, then songbirds can use their feathers to secretly communicate with other songbirds. But are the raptors completely unaware of these UV signals or can they still use UV for hunting? With this controversy unsolved, Olle Lind, a post-doc in Almut Kelber's lab at Lund University, Sweden, decided to investigate with the help of two PhD students, Mindaugas Mitkus and Peter Olsson (p. 1819).

Lind realised that a missing key in this puzzle was that no one knew what wavelengths of light make it to the raptors' retinas: 'Even before the light hits the retina, it's filtered through the cornea, the lens and the fluids within the eye. The whole ocular media acts as a cut-off filter and sets UV sensitivity automatically – if you can't get it [UV] to the retina, you won't be able to detect it!' says Lind. Using eyes from euthanised raptors, the team measured how much UV was getting through the ocular media: 'we excised the eye and then took away a piece from the back of the eye. We were then able to shine light through the eye, which wasn't stopped by the retina and at the back of the eye we had a probe instead', explains Lind. They found that raptor eyes cut out a lot of UV light, with only UV light of higher wavelengths making it through to the retina. In one raptor, the red kite, most of the UV reaching the retina had a wavelength higher than 394 nm.

So, perhaps vole urine reflects UV light with higher wavelengths? To test this, the team collected urine from voles they had trapped in the surrounding countryside, and measured how much UV light the urine reflected – but it didn't. Lind admits that he was not entirely surprised – many other studies have characterised mammalian urine and found that it does not reflect UV. However, knowing the sensitivity of the raptor's pigments and using his newly collected measurements – UV transmittance to the retina and UV reflectance from vole urine – Lind was able to model whether vole urine can be informative in some way to raptors. He concludes: 'there is definitely no information in the UV, they can't use UV to find vole urine – at least not with Swedish voles!'

So what about songbirds? Is enough UV light getting to the retina for the raptors to eavesdrop on communicating songbirds? Using previously collected data characterising UV reflectance of songbirds' plumage and their raptor-eye model, Lind says, 'UV markings are not invisible to raptors; they can see them, but they might not be as conspicuous to them as they are to songbirds.' So it would seem that raptors are neither blind nor highly sensitive to UV, and the question still remains – what are these UV-sensitive pigments doing in raptors?

10.1242/jeb.088062

Lind, O., Mitkus, M., Olsson, P. and Kelber, A. (2013). Ultraviolet sensitivity and colour vision in raptor foraging. *J. Exp. Biol.* **216**, 1819-1826.

Nicola Stead

RIDERS TAKE LOAD OFF HORSES

Patricia de Cocq is a keen horsewoman, but her interest in horses extends beyond her passion for riding: she is also a vet. Interested in the animals' welfare, de Cocq explains that many horses that are ridden experience back pain that is hard to treat. Which made her wonder: could riders modify their technique to reduce the load exerted on their horses' backs (p. 1850)?

According to this vet from Wageningen University, The Netherlands, riders have a choice of two techniques when perched on a trotting horse: the easier 'rising trot' – when the rider bobs up and down, standing in the stirrups when off the saddle – and the more technically challenging 'sitting trot', where the rider remains firmly seated. As rising trot was thought to reduce the load exerted on a trotting horse's back, de Cocq travelled to Hilary Clayton's lab at Michigan State

McPhail Equine Performance Center

University, USA, to use Clayton's state-of-the-art 3D motion capture equipment to test the theory. By filming experienced dressage riders as they trotted using both techniques and analysing the motion of each horse and rider, de Cocq could see that the centre of mass of riders using rising trot moved much less during the standing phase than the centre of mass of sitting trot riders, reducing the force exerted on the horse's back and lessening the chance of injury.

However, while de Cocq was analysing the data, she came across a paper in *Science* (Pfau et al., *Science*, **325**, 289) that explained how the technique used by modern jockeys – where they stand in their stirrups – had significantly improved times in horse racing. de Cocq noticed that jockeys' posture was similar to the standing phase of the rising trot. She wondered whether she could build a mathematical model of a horse and rider that would simulate the movement of a rider's centre of mass and identify factors that could reduce the force exerted by the rider on a horse's back.

Teaming up with Mees Muller and Johan van Leeuwen, de Cocq built three increasingly sophisticated models, representing the horse and rider as systems of springs, dampers and point masses. Then, by varying the stiffness of the spring representing the rider in the simplest model, de Cocq successfully reproduced the motion of the rider's centre of mass during sitting trot and when using the jockey's standing posture. Then, when she repeated the calculations using the second model where she added a damper and brief free-fall to the first model, the motion of the centre of mass of the sitting trot rider and the jockey was even more lifelike. But neither model reproduced the motion of a rider's centre of mass during rising trot until de Cocq and van Leeuwen added a second spring – mimicking the rider's leg during the standing portion of the stride – to the simulated rider spring. By alternating between the two springs – activating the leg spring during the standing portion of the stride and the rider spring during the seated portion – de Cocq successfully simulated the rising trot.

de Cocq's calculations also showed how difficult the jockey's technique is. She could only simulate the relatively smooth motion of the jockey's centre of mass using a narrow range of spring stiffnesses and damping; and only one combination of spring stiffness and damping produced the optimal situation where the jockey's centre of mass followed an almost flat line. de Cocq points out that the current technique used by jockeys requires a huge amount of strength and training and adds, 'If jockeys want to improve even more they would need to go in a straight line, not move up and down, and that would be a challenge.'

10.1242/jeb.089656

de Cocq, P., Muller, M., Clayton, H. M. and van Leeuwen, J. L. (2013). Modelling biomechanical requirements of a rider for different horse-riding techniques at trot. *J. Exp. Biol.* **216**, 1850-1861.

Kathryn Knight

SLOW AND STEADY WINS THE PREY FOR LEECHES

Cynthia Harley

Although leeches may have an unsavoury taste for blood, like the rest of us, they still have to eat; they are able to sense unsuspecting prey that come across their watery lairs for a drink or bath. However, as Cynthia Harley from the California Institute of Technology, USA, points out, 'If you eat living things, those living things may move. How do you determine the location of your prey? Do you, like a ballistic missile, sense them, and move quickly and blindly to their location hoping they will still be there, or do you continually update your picture of where they are?' During ballistic tracking predators periodically stop moving to re-sense the location of their victims, whereas during continuous tracking, stopping is unnecessary; predators continuously update their sensory picture of their target's whereabouts and tweak their trajectories accordingly. However, continuous tracking requires a great deal of brainpower, as predators have to simultaneously distinguish between their own movement and location and that of their prey. As leeches only have 10,000 neurons and are often stationary between bouts of either swimming or crawling, Harley and her post-doctoral advisor, Daniel Wagenaar, suspected that the leech might use the simpler of the two options. To conclusively test this, Harley recruited the help of two enthusiastic high-school students, Matthew Rossi and Javier Cienfuegos (p. 1890).

Together, the trio set up a small pond in the laboratory and mimicked prey movements in the water by attaching a piston to a moving speaker. 'First we asked what happens if, after the animal starts moving, we turn the speaker off. If they were ballistically tracking [their target], it wouldn't matter because they've already sensed where the thing is and they've already determined where they're going to go', explains Harley. However, to their surprise, they found the opposite: 'Well, they got lost, whereas if you kept the speaker going they were fine', recalls Harley. So, the first results suggested that maybe the leeches were not ballistically tracking their prey after all.

However, given that motionless bouts, which are key signatures of ballistic tracking, are so ingrained in the leeches' behaviour, the team decided to test the leeches again in a different experiment. They reasoned that perhaps because the prey-like stimulus was removed, the leech assumed that their intended victim had left the vicinity – why waste energy tracking something that is not there? 'We decided to use two speakers, and once the leech had determined the direction of movement [towards the first speaker], we switched to the other. We wanted see if it would go towards the first one or towards the second one', says Harley. They never approached the first speaker and instead behaved as if the second speaker was the only one – strong evidence that the leeches were continuously updating the position of their target.

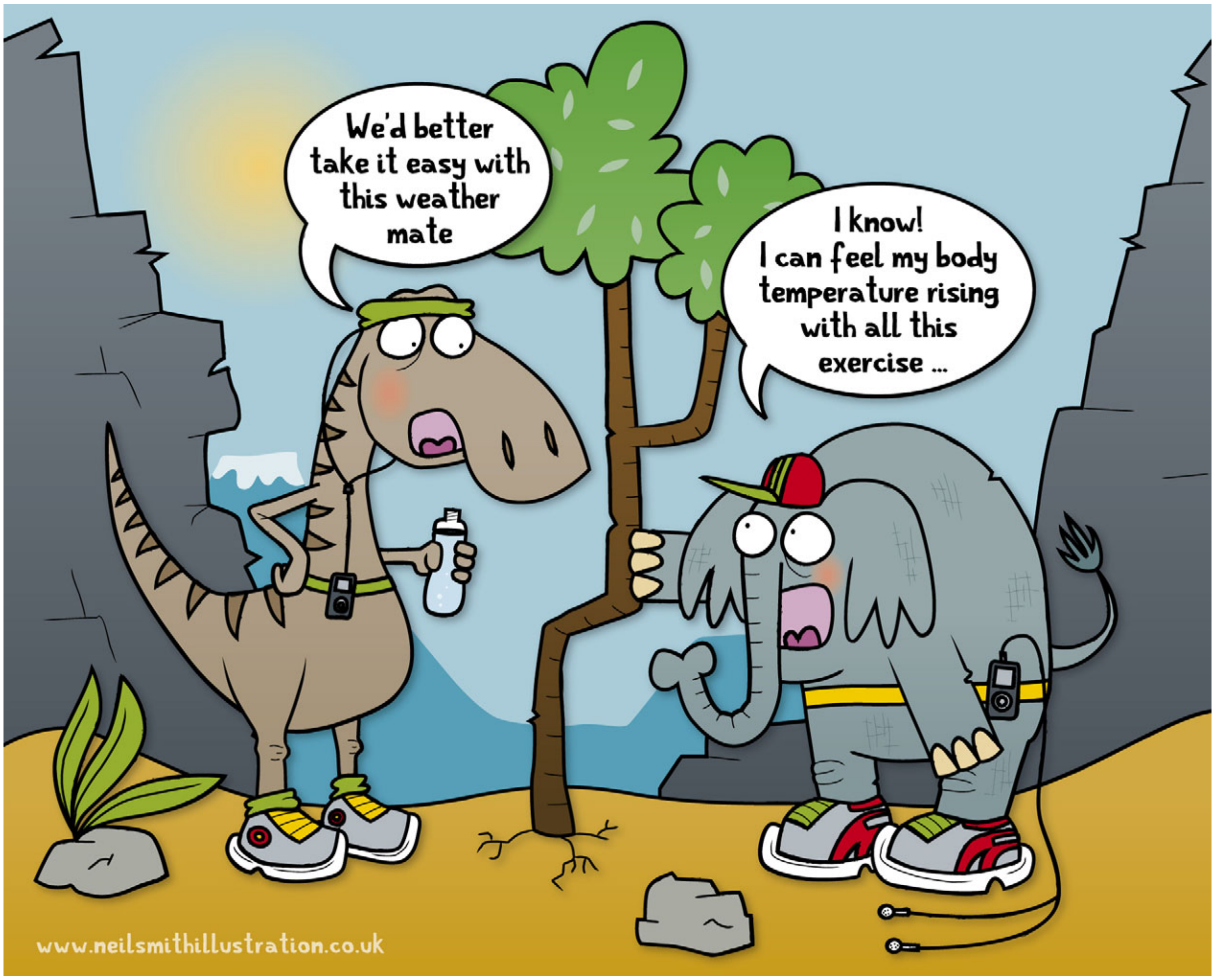
If they were not tracking ballistically, then maybe the leeches were not using their stationary periods for tracking either. The team decided to test whether the leeches tracked whilst swimming or crawling. To begin with, Rossi and Cienfuegos patiently sat and watched the leeches switching on the speaker only when they crawled. They repeated the experiment only stimulating the leeches when they were swimming. 'We found that stimulating them during crawling didn't decrease their success rate at finding the speaker, whereas when we stimulated during swimming, they never found the stimulus – they were terrible at it', says Harley. Despite swimming being the faster of the two movements, it seems that when it comes to tracking prey, crawling is essential, and when stimulated, the leeches were more likely to crawl. So, slow and steady wins the prey!

10.1242/jeb.087460

Harley, C. M., Rossi, M., Cienfuegos, J. and Wagenaar, D. (2013). Discontinuous locomotion and prey sensing in the leech. *J. Exp. Biol.* **216**, 1890-1897.

Nicola Stead

NOCTURNAL EXERCISE ADVISABLE FOR ELEPHANTS (AND DINOSAURS)



For large endothermic animals that produce their own body heat from metabolism, bouts of exercise under the sweltering sun in tropical conditions could be potentially lethal. Hefty endotherms, for example elephants or even the extinct endothermic *Edmontosaurus* dinosaur, have decreased skin surface-area-to-body-mass ratios compared with other endotherms, and this likely means they find it more difficult to get rid of excess heat produced during exercise. However, no one has ever conclusively proved this, and so Michael Rowe from Indiana State University, USA, and his colleagues set out to test how two elephants, which are also similar in size and have the same habitat as *Edmontosaurus*, would cope with exercising in hot conditions (p. 1774).

The team exercised the two elephants by walking them around a closed circuit for about 20 min under full sun, over a range of temperatures from 8 to 34.5°C. By measuring their core and skin temperatures, as well as walking speed and environmental factors such as air temperature and solar radiation, the team could then calculate how much heat they produced from increased metabolism and how much heat they lost to (or gained from) the environment. The team found that the elephants' metabolic rate increased 2- to 2.5-fold regardless of whether the animal exercised in winter, spring or summer. However, in the hot summer, radiation from the sun and the environment meant that the elephants' skin reached the same temperature as their core body (35.3°C, compared with 24.9°C in November), meaning that 100% of the heat generated by exercising was stored in core tissues, with body temperature increasing by up to 1.6°C.

From their findings, the authors could predict the limitations this put on diurnal activity in both elephants and *Edmontosaurus* dinosaurs. For elephants, 4 h of exercising in the sun would see their body temperature steadily increase to a lethal 43°C. Similarly, *Edmontosaurus* would likely only last 3.5 h. At night, without solar radiation heating up their skin, both the elephants and the endothermic dinosaur could exercise for up to 8 h without overheating. So it seems nocturnal exercise is best for gigantic endotherms.

10.1242/jeb.087106

Rowe, M. F., Bakken, G. S., Ratliff, J. J. and Langman, V. A. (2013). Heat storage in Asian elephants during submaximal exercise: behavioral regulation of thermoregulatory constraints on activity in endothermic gigantotherms. *J. Exp. Biol.* **216**, 1774-1785.

Nicola Stead
nicola.stead@biologists.com