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

SEA LIONS DIVE FOR DINNER

When sea lions go in search of a tasty morsel they have to rely on more than just the air in their lungs as they swim into the depths. The lungs of diving mammals, like sea lions, seals and whales, tend to collapse as they dive deeper and hold very little air, so these animals depend on oxygen stored in their blood and muscles instead. Knowing how much oxygen a diving mammal can store gives researchers a clue as to how deep they can dive, and for how long. Interested to know more about the diving ability of the California sea lion (*Zalophus californianus*), Michael Weise at the University of California, Santa Cruz, and his colleague Daniel Costa looked at blood and muscle oxygen stores in pups through to adults of both sexes (p. 278).

To find out how much oxygen is carried in the blood, the team took blood samples from five groups of sea lions ranging from 5 month old pups to fully grown adults. They measured the percentage of the blood that was made up of red blood cells, the amount and concentration of the oxygen-carrying pigment haemoglobin in the red blood cells, and estimated each animal's blood volume. Using these measurements, they then calculated how much oxygen a sea lion could store. Taking into account each animal's size, they found that nine month old recently weaned pups could only store half as much oxygen in their blood as adults, and didn't catch up until they were between 1.5 and 2.5 years old. This suggests that young sea lions won't be able to dive as deep or for as long as the adults, but the seas around California are very productive, so they probably don't have too much trouble finding something to eat when conditions are good.

Having shown that sea lions' ability to store oxygen in their blood improved with age, the team turned to muscle stores. They took samples from the muscles that control the fore flippers, which sea lions use to propel themselves through the water, and measured the concentration of the oxygen-holding pigment myoglobin in the fibres. 'We came up with some interesting results' says Weise. The team were expecting that ability to store oxygen in myoglobin would develop at the same rate as blood oxygen storage, but instead found that myoglobin stores did not reach adult levels until 4–6 years of age. 'This could be because muscle takes longer to develop than blood' says Weise, 'there could be a cost to developing myoglobin'.

The next surprise came when they compared myoglobin concentration in adult males and females – they found that females had greater myoglobin concentrations than males, meaning that per gram of muscle, females can store more oxygen. The team think that there are two reasons for this difference. After mating and giving birth, females stay in Southern California with their pups, while the males travel further north. In southern California 'the females have to dive deeper and longer to access prey,' explains Weise, 'in the North, males can dive shallower to find food'. Males are also larger than females and have a greater blood volume, so can rely on their bulk to store the oxygen they need for their more leisurely dives. The team suspect that the females compensate for their tougher dives, smaller body size and the added strain of rearing pups by increasing their myobglobin concentration.

10.1242/jeb.02686

Weise, M. J. and Costa, D. P. (2007). Total body oxygen stores and physiological diving capacity of California sea lions as a function of sex and age. *J. Exp. Biol.* **210**, 278-289.

GALLOPING, DOG STYLE

It's not just horses that gallop – if a dog is chasing after its favourite ball at full speed, it will be galloping too. When dogs walk or trot, the right and left legs do the same thing, using the same muscles to apply the same forces to the ground, at the same rate. However a gallop is different because all four legs have an individual role. To find out the different roles of the individual limbs during galloping, David Carrier and Rebecca Walter at the University of Utah enlisted a team of cooperative canines to sprint down a track, measuring their speed and the forces produced by the different limbs (p. 208).

When they are running flat out, dogs use a style of galloping called the rotary gallop. Just like walking, the limbs are placed on the ground in a certain order. Starting with the front legs, the so-called 'trailing' leg lands first, followed by the 'leading' leg,

which lands further in front. The trailing and then the leading front legs are lifted off the ground so that the animal is airborne. Then, the trailing hind leg – which is on the opposite side to the trailing front leg – is placed on the ground followed by the leading hind leg. Once the trailing and then the leading hind legs have been lifted off the ground, the dog is airborne again, ready to start the cycle over.

They filmed the dogs at 250 frames s^{-1} sprinting down a 40 m runway, chasing a tennis ball, or encouraged by an experimenter holding a hot dog. 'We wanted to see how they ran when they really went for it' says Walter; most of the dogs managed a top speed of around 10 m s^{-1}, which gives Olympic sprinters a run for their money. A force plate embedded in the floor measured the vertical, braking and accelerating forces produced by each leg when it landed, and while it was on the ground.

Comparing the forces produced by the forelimbs, they found that the lead forelimb was on the ground for longer than the trailing forelimb, but that the average force produced by the lead forelimb was lower. This meant that the force produced over time – known as the force impulse – was the same for both legs. Examining the accelerating and decelerating forces showed that the trailing forelimb accelerated the body more while the lead forelimb decelerated it more. Turning their attention to the hindlimbs' forces, they found that the roles were reversed: the trailing hindlimb applied lower vertical force for a longer period of time, while the lead hindlimb produced greater accelerating forces. The results suggest that the trailing hindlimb and lead forelimb are not producing as much force as they should. 'They could apply greater power, but it would probably be inefficient', Walter says. She suspects that the balance of forces between the legs needs to be just right so no energy is wasted during galloping. However, the differences in forces between the limbs could help dogs to turn when galloping.

The team also upturned one prediction about galloping. 'People had predicted that the forelimbs would do more braking and the hindlimbs would do more acceleration' explains Walter, but the team found that both sets of limbs contributed equally to acceleration, while the forelimbs applied more deceleration that the hind limbs. Given that there were no major differences in the galloping styles of the different breeds, Walter thinks that her and Carrier's results will help researchers trying to learn more about galloping in four-legged creatures of all shapes and sizes.

10.1242/jeb.02687

Walter, R. M. and Carrier, D. R. (2007). Ground forces applied by galloping dogs. *J. Exp. Biol.* **210**, 208-216.

PEDOMETER HELPS ANTS GET HOME

Despite being only a few millimetres long and living in what most humans would perceive as a featureless environment, desert ants (*Cataglyphis fortis*) have no problems finding their way back to the nest having meandered around on a foraging expedition. Ants use path integration to navigate: to get back home, they keep track of their travel direction, by using a celestial compass, and their travel distance. Until now, scientists were less clear about how ants measured distance, strongly suspecting that they use an internal pedometer. This takes into account an ant's stride length and stride frequency on the outward journey, telling them the distance of the return journey. Matthias Wittlinger and Harald Wolf from the University of Ulm, Germany, and their colleague Rüdiger Wehner from the University of Zürich, Switzerland, show that adjusting the length of ants' legs proves that they do use a pedometer to calculate distance (p. 198).

Wittlinger made a chance observation that clipping ants' legs shorter before they make their homeward journey causes them to start searching for the nest earlier, suggesting that they have an internal pedometer. He suspected that ants with short legs probably take shorter strides and should underestimate distance, while their longer legged peers should overestimate distance because they take longer strides.

To investigate further, the team trained ants to walk down a 10 m run from their nest to a feeder. After training, they caught ants at the feeder and clipped their legs to form stumps, or lengthened their legs by gluing on pig bristles so that they walked on stilts. Carrying tasty morsels provided for them by the experimenters, the ants were put into a test run immediately next to the training run. The team measured where the ants thought their nest was by noting where they started their nest searching behaviour. They found that ants on stilts overestimated the distance to the nest, while ants with stumps underestimated the distance. While this told the team that different leg lengths affected the ants' ability to find the nest again, they had to be sure that they were using information about their leg movements and not other information, such as travel time, to calculate their home journey.

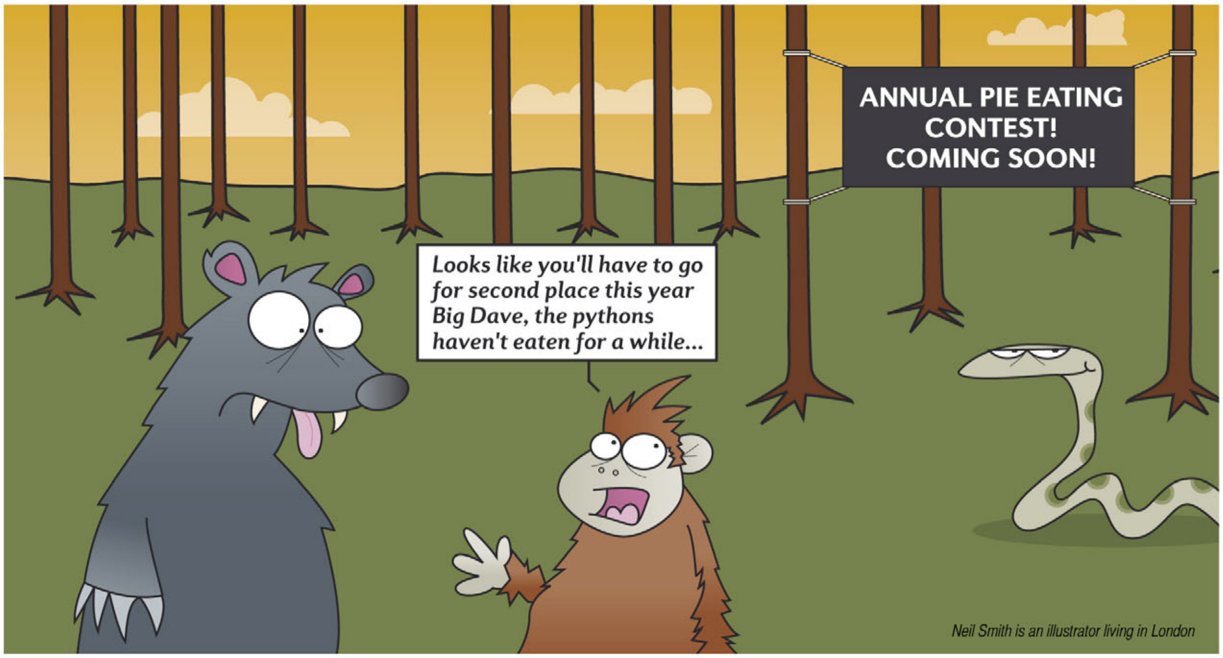
To scrutinise the ants' leg movements in more detail, they filmed them walking to the nest, gave them stilts or stumps, and then filmed the return journey. They measured the ants' stride length, stride frequency and walking speed as they marched along on stilts or stumps, and found that at a given walking frequency, ants on stumps took shorter strides and ants on stilts took longer strides than normal ants. They also found that ants with longer legs strode at a slightly lower frequency, on average, than ants with shorter legs. And despite the experimenters' best efforts, the ants were very adept at walking stably on their short or long limbs without stumbling.

The team's results confirmed that changes in stride length and frequency, caused by manipulating the ants' legs, made them to go awry when searching for their nest, proving that ants rely on an internal pedometer to help them get around their desert home.

10.1242/jeb.02688

Wittlinger, M., Wehner, R. and Wolf, H. (2007). The desert ant odometer: a stride integrator that accounts for stride length and walking speed. *J. Exp. Biol.* **210**, 198-207.

PYTHONS PAUSE POSTPRANDIALLY



Pythons don't rely on the standard three square meals a day: in an eating regime that would finish off most animals, they go for weeks or months on end without eating, and then gorge themselves on a huge meal before their next fast. Burmese pythons cope with this cycle of extreme feeding and fasting by increasing their metabolism and their intestines' ability to absorb food after meals, shutting down the gut when it's not needed during fasting.

To find out if other species of python can do the same, Brian Ott and Stephen Secor from the University of Alabama measured metabolic rate, nutrient absorption, intestine morphology and enzyme activity in five python species, ranging in size from short and stout to long and slender (p. 340). Using the pythons' oxygen consumption to measure metabolic rate, the team found that metabolic rates peaked to between 10–15 times normal levels 1.5 days after eating a delicious rodent meal, returning to normal 6–8 days later.

Interested to know what changes were happening in the gut during digestion, they found that the meal increased activity in the aminopeptidase-N enzyme, which breaks down proteins, and triggered faster absorption of animo acids and glucose by the gut. The mass of the intestine also doubled, because the membranes and cells involved in absorbing food increased in mass and volume. The results show that different species of python share the ability to make the most of their enormous, yet infrequent meals, soaking up nutrients to see them through leaner times.

10.1242/jeb.02689

Ott, B. D. and Secor, S. M. (2007). Adaptive regulation of digestive performance in the genus *Python*. *J. Exp. Biol*. **210**, 340-356.

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