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.

HONEY BEES SUCCUMB TO COCAINE'S ALLURE


Picture by Mario Pahl

Since its discovery in the 18th century, cocaine has been a scourge of western society. Strongly stimulating human reward centres in low doses, cocaine is extremely addictive and can be fatal in high doses. But this potent compound did not evolve to ensnare humans in addiction. Andrew Barron from Macquarie University, Australia, explains that cocaine is a powerful insect neurotoxin, protecting coca bushes from munching insects without rewarding them. Knowing that foraging honey bees are strongly motivated by rewards (they dance in response to the discovery of a rewarding nectar or pollen supply) and that this behaviour is controlled by similar mechanisms to the ones that leave humans vulnerable to cocaine addiction, Barron and Gene Robinson from the University of Illinois at Urbana-Champaign wondered whether bees may be vulnerable to cocaine's allure at the right dose. Teaming up with Ryszard Maleszka at the Australian National University, Barron set about testing how honey bees respond to cocaine (p. 163).

Setting up his hives on a farm just outside Canberra, Barron trained the insects to visit a feeder stocked with a sugar solution. Then he gently applied a tiny drop of cocaine solution to the insect's back, and waited to see how enthusiastically the foraging insects danced when returning to the hive. Amazingly, low doses of the drug stimulated the insects to dance extremely vigorously. They behaved as if the sucrose solution was of a much higher quality than it really was. The cocaine seemed to be hitting the insects' reward centres, but were they really responding to the drug like humans or was the drug stimulating some other aspect of the insects' behaviour to look as if they were becoming addicted?

Working with a team of undergraduate students, Barron tested whether cocaine stimulated the insects' locomotion centres by monitoring their movements after a dose of the drug. The insects behaved normally, so the drug probably doesn't affect their movements. However, when Paul Helliwell tested the bees' sensitivity to sugar solutions, the drugged bees responded more strongly than the undrugged insects, so cocaine was increasing their sugar sensitivity. But was it only increasing their sensitivity to sugar, or increasing their response to all rewards? Barron offered the drugged insects pollen to see if cocaine increased their sensitivity to other floral rewards and found that the foragers were equally overenthusiastic, dancing as if the pollen quality was much better than it really was.

Finally Barron and Helliwell wondered whether bees that had been on cocaine for a few days had become dependent and went into withdrawal when the drug was withheld. Testing the insects' ability to learn to distinguish between lemon and vanilla scents, they found that the bees were fine so long as their cocaine supply was maintained. But as soon as the drug was withdrawn the bees had difficulty learning the task, just like humans going into withdrawal.

Barron is confident that honey bees are as susceptible to cocaine's allure as humans, and is keen to find out more about the drug's effects. He hopes to identify the neural pathways that it targets to find out more about the mechanisms involved in human addiction and to find out whether the drug has as devastating an effect on honey bee society as it does on human society.

10.1242/jeb.028159

Barron, A. B., Maleszka, R., Helliwell, P. G. and Robinson, G. E. (2009). Effects of cocaine on honey bee dance behaviour. *J. Exp. Biol.* **212**, 163-168.

CRICKETS SYNCHRONISE WING VIBRATIONS

When a male cricket wants to attract the ladies, he starts serenading. Positioning the right wing over the left, he opens and closes his wings to produce a finely tuned tone. According to Fernando Montealegre-Z, the insects produce their song by rasping a 'file' structure on the upper wing across a 'plectrum' structure along the edge of the lower wing, generating vibrations in both wings. But if that is all that the insects do, they couldn't make their distinctive chirrup. Montealegre-Z explains that Henry Bennet-Clark pointed out in 2003 that the insect's wings would, in theory, be vibrating in opposite directions, disrupting the sound's constant and even tone. Crickets must have found a way around this paradox by switching the direction of the vibration in


Picture by Fernando Montealegre-Z

one of the wings so that both wings vibrate in sync, but it wasn't clear how. Having discussed the conundrum with Daniel Robert at a meeting in Toronto in 2006, Robert invited Montealegre-Z to join his lab in Bristol, UK, to see if they could find a switch in the plectrum wing's vibration (p. 257).

The team decided to try to get a plectrum wing to sing by dragging a file across it. But getting the wings to vibrate in the lab was extremely challenging. Montealegre-Z remembers that he tried to drive the plectrum wing's vibrations with watch gears and other minute spinning file-like structures, but the hard materials destroyed the insect's delicate wings. Then he tried extracting file structures from mature males' wings and attaching them to a wheel spinning above the plectrum, but the files were too rigid. Eventually it occurred to Montealegre-Z to try wing files from recently moulted young males. They were flexible enough to successfully bend and attach to the wheel, but would they set the wing vibrating?

Turning the motor on, Montealegre-Z gradually slowed the spinning wheel to see if it could drive the wing to sing. Amazingly the plectrum wing began making the distinctive cricket chirrup as the wheel reached the speed at which the wings rub against each other.

Having successfully reproduced the plectrum wing's vibrations in the lab, Montealegre-Z teamed up with electronics engineer James Windmill to laser scan and record sound from the plectrum wing to find out how it tuned its vibrations to the file wing's vibrations.

Scanning hundreds of points on the vibrating wing's surface, the team reconstructed the wing's motion on a computer. They could clearly see that when the plectrum region of the wing vibrated downwards, the harp region, which radiates the sound, moved upwards. The sound-emitting harp region was vibrating almost in sync with the file wing, even though the plectrum section was vibrating out of sync. And when the team focused on the anal node region of the wing, where the vibration changed direction, they could see that the direction switch happened along one of the wing veins. The wing always moved downwards on one side of the vein while moving upward on the other side, like a see-saw rocking on its pivot, just as Henry Bennet-Clark had predicted. So crickets have found a clever way of synchronising their wing vibrations to make a loud sound to catch the ladies' attention.

10.1242/jeb.028183

Montealegre-Z, F., Windmill, J. F. C., Morris, G. K. and Robert, D. (2009). Mechanical phase shifters for coherent acoustic radiation in the stridulating wings of crickets: the plectrum mechanism. *J. Exp. Biol.* **212**, 257-269.

STICK INSECTS USE DISTINCT MOTOR PATTERNS TO TAKE A TURN


Picture by Matthias Gruhn

Clambering through dense foliage, stick insects always maintain a stable foothold. They are masters of adaptation, adjusting to move through any vegetation. Matthias Gruhn from the University of Cologne explains that you can learn a lot about the neural control of movement from studying how stick insects coordinate their six legs, but little was known about how they organize their limbs while taking corners. Does each leg know what it must do to steer the animal around a corner? Do individual limbs know whether they are on the inside or outside of the curve? And do stick insects' legs communicate with each other to fine-tune their movements as they negotiate a turn? Curious to find out how the insects manoeuvre round bends Gruhn, Lyuba Zehl and Ansgar Büschges decided to film them as they walked and turned on a slippery surface (p. 194).

Filming the insects as they walked in a straight line on a surface coated in glycerol and salt, the team could see that they always kept two feet on the ground on one side, while one or two feet touched the ground on the other side. This is just how the insects walk on a normal surface and so the slippery surface was not affecting their movements.

Next the team guided an insect around a corner to see how it managed its feet while turning. Recording the amount of time each foot remained in contact with the ground while filming the animal's movements, Gruhn and his colleagues saw that the insect's legs behaved completely differently depending on whether they were on the inside or outside of the bend. The outer legs took longer strides to push the insect's body around the curve, while the legs on the inside became more upright and took smaller steps. The insects even reversed the direction of their inner footsteps on some occasions, like a rower rowing backwards on the inside of a tight turn in a boat.

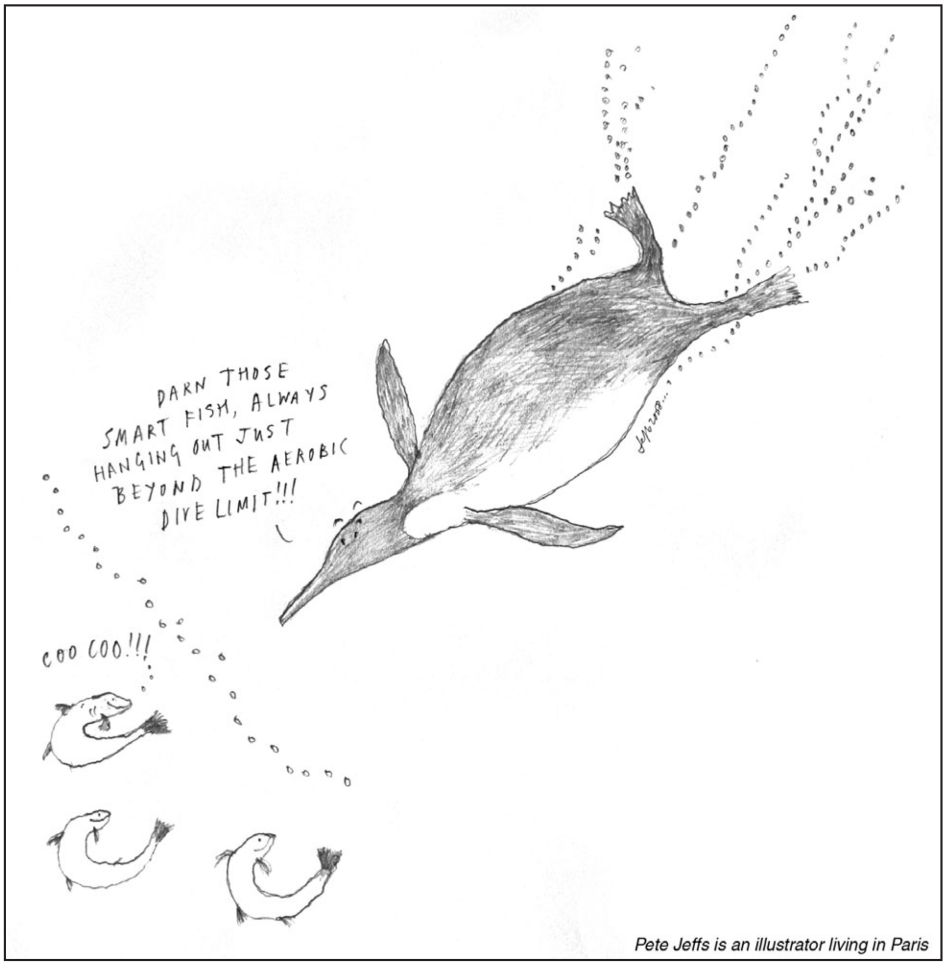
Wondering whether the stick insects' walking behaviour was centrally controlled, or each leg was controlled individually, Gruhn tested the insects' turning behaviour as they walked with only two front or two middle legs. Remarkably both legs behaved as if the insect was walking on all six feet. The outer leg took longer steps while the inner leg took tiny steps, although the position where the insects placed their feet on the ground shifted forward slightly. Even more surprisingly, when the team tested the insects walking on one leg alone they could clearly see the leg adopt the correct movement pattern, depending on whether it was on the inside or outside of the curve, even though it was deprived of feedback from other limbs.

Gruhn suspects that the front legs have three motor patterns to control their walking (straight forward, turning with the leg on the outside and turning with the leg on the inside of the bend), while the middle legs may only need two (straight forward and turning with the leg on the inside of the bend). He explains that the insects probably fine-tune these motor patterns in response to sensory information about the leg's position and contact with the ground, and is keen to find out more about the neuronal circuitry that takes insects around the bend.

10.1242/jeb.028167

Gruhn, M., Zehl, L. and Büschges, A. (2009). Straight walking and turning on a slippery surface. *J. Exp. Biol.* **212**, 194-209.

PENGUINS SHUNT BLOOD TO STOCK UP ON O_2



Pete Jeffs is an illustrator living in Paris

Any air-breathing animal that dives must manage its oxygen stores with care. How emperor penguins manage their limited oxygen supply intrigues Paul Ponganis and his colleagues from the Scripps Institution of Oceanography. Travelling to Antarctica, Ponganis and his team fitted minute electrodes in either the aorta or vena cava of penguins, as well as ingeniously collecting blood samples from the birds while they were diving, to find out how they manage their oxygen stores while submerged (p. 217).

Analysing the diving birds' blood oxygen levels, the team realised that the birds shunt oxygenated blood from the arteries to the venous system (which usually carries deoxygenated blood), probably *via* the wings for oxygen storage prior to the dive. During the dive the birds absorb oxygen from the lungs, continue shunting oxygenated blood into the venous system to increase oxygen storage, and also appear to isolate muscle from the rest of their circulatory system. Using these strategies, the birds are able to maximise use of oxygen stored in the lungs, reduce their blood oxygen depletion rate by isolating muscle from the circulation and maximise pre-dive blood oxygen storage by shunting oxygenated arterial blood through the wings into the venous system.

Given that the diving penguins' muscle tissue is isolated from the animals' circulation, Ponganis suspects that the increase in lactate found in penguins at the surface after a dive that has exceeded their aerobic dive limit is caused by the release of lactate from the muscle where it accumulated during the dive.

10.1242/jeb.028175

Ponganis, P. J., Stockard, T. K, Meir, J. U., Williams, C. L., Ponganis, K. V. and Howard, R. (2009). O_2 store management in diving emperor penguins. *J. Exp. Biol.* **212**, 217-224.

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CORRECTION: 100 m WORLD RECORD COULD GO AS LOW AS 9.48 s

There were three factual errors in the Inside JEB article, '100 m world record title could go as low as 9.48 sec', published in issue 24 of volume 211 of *The Journal of Experimental Biology*. The prediction for the women's 100 m world record is 10.39 s and not 10.19 s. This would take 0.1 s off the current world record. The prediction for the women's marathon world record is 2 h 15.25 min, and not 2 h 12 min and 41 s. I apologise for these errors.