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

DORSAL FIN STABILISES TROUT

Keeping on the straight and narrow is significantly more complicated for fish than insects; coordinating as many as seven fins is a much more complex task than the two wings most insects have to bother about. How fish propel themselves through water has puzzled people for a long time. Only recently have scientists begun unravelling the complex fluid dynamics generated by each fin as fish scythe through the currents. More recently George Lauder at Harvard University, working with his colleague Elliot Drucker, have turned their attention to a fin whose role might be less obvious. They wondered how the dorsal fin contributes to a fish's comings and goings. Having studied the sunfish's dorsal fin several years before, they suspected that the trout's dorsal fin was also essential for high speed swimming. But the team were surprised when they found that trout use their dorsal fins less and less as they speed up, and when they looked closer, realised that instead of helping to propel the fish forward, the dorsal fin seemed to stabilise the fish in the water (p. 4479).

Lauder's technique of choice to investigate fish fluid dynamics is DPIV. Focusing a thin plane of laser light into a flow tank filled with microscopic reflective beads, the team encouraged the fish to swim at a constant speed so that their body or fins intersected the plane of light, while filming the swirls and vortices generated by their fins visible in the laser light. But this is where DPIV becomes less of a science and more of an art. Lauder admits that the main quality you need for success with this technique is limitless patience. He and Drucker remember spending hours cajoling the timid trout to perform in front of the cameras, but eventually the team had enough data to begin analysing the fish's dorsal fin.

Swimming the fish at a range of slow and high speeds, the team quickly realised that the fish used their dorsal fin most when swimming at slow speeds, with the fin hardly moving at all once the fish were cruising at a high speed of 2 total body lengths per second. And when they calculated the forces generated by the fin at different speeds, they realised that it didn't contribute to the fish's forward thrust at all. The fin seemed to be producing a large sideways force at low speeds that diminished as the fish cruised at higher speeds. Lauder and Drucker realised that the dorsal fin was stabilising the fish rather than helping to propel it forwards, which is in complete contrast to what they found when they looked at the sunfish's spiny dorsal fin; that seemed to contribute significantly to the fish's forward momentum. Lauder suspects that the support offered to the sunfish's dorsal fin by its spines help propel the fish forward.

Most surprisingly, Lauder and Drucker have identified a new 'gait' which they call M-BCF and is distinct from median paired fin gait (MPF) and body caudal fin (BCF) gait. In this new gait, the fish combine dorsal fin oscillations with movements of the body and tail fin at low speeds. The team also suggest that this new gait may be part of a natural progression between the two previously identified and distinct gaits. But Lauder admits that future work on other fish species will be needed to test this idea.

10.1242/jeb.01952

Drucker, E. G. and Lauder, G. V. (2005). Locomotor function of the dorsal fin in rainbow trout: kinematic patterns and hydrodynamic forces. *J. Exp. Biol.* **208**, 4479-4494.

Kathryn Phillips

DETOX FOR INSECTS

Insects have ingenious ways of ridding themselves of unwanted toxins. Multidrug resistance genes, for example, code for transporters in some insects' Malpighian tubules that pump a wide range of noxious molecules out of insects' bodies. Two of these transporters are p-glycoprotein (p-gp) and multidrug resistance associated protein 2 (MRP2). Nestled in cell membranes, p-gp and MRP2 pump toxins out of insect tissues and are suspected to help insects resist insecticides. If we know which insects have these transporters, we might be in a better position to foil pest species' defences. Curious to find out whether fruit flies and the cricket *Teleogryllus commodus*, a pest species in New Zealand, possess these two toxin transporters, John Leader and Mike O'Donnell designed a clever technique to measure the transport rates of toxic fluorescent compounds (p. 4363).

To calculate how quickly fruit flies and crickets excrete the fluorescent compounds that are transported by p-gp and MRP2, the pair decided to measure fluorescence intensity in the insects' Malpighian tubules.

After bathing Malpighian tubules in Texas Red, a fluorescent compound that's transported by MRP2, Leader and O'Donnell stimulated fluorescence by shining a laser through the tubules and then tried to measure the resulting fluorescence intensity. But they couldn't measure the fluorescence intensity because the laser light kept bouncing off small clumps of inorganic material sequestered in the Malpighian tubules.

Pondering how to measure the fluorescence intensity of the insects' secretions, Leader decided to extract a sample of the secreted fluid to analyze it outside the Malpighian tubules. Leader and O'Donnell suspended a drop of fluid containing fluorescent compounds in a layer of paraffin oil and bathed Malpighian tubules in the drop. Carefully pulling the open end of a tubule into the surrounding paraffin, they made a small cut in the tubule to collect a sample of secreted fluid. Realizing that measuring the sample's fluorescence in a round capillary wouldn't work, as the light would bounce off the capillary's curved edges, the pair inserted a rectangular-shaped capillary into the secreted droplet to suck up a fluid sample. Placing the flat capillary under a microscope, they shone a laser light through the secreted fluid sample to measure the sample's fluorescence intensity. They compared this to a calibration curve to calculate the concentration of the secreted fluorescent compound. To their delight, 'the technique worked beautifully the first time we tried it, and every time after that', O'Donnell recalls. Now that they could reliably measure the concentration of the secreted fluorescent compounds, the pair set out to show that both fruit flies and crickets possess p-gp and MRP2 in their Malpighian tubules. Sure enough, when the team added known inhibitors of the two transporters to the bathing fluid, they noticed that the fruit fly and cricket tubules stopped secreting the fluorescent compounds; both species clearly possess these two transporters.

Using their new technique, Leader and O'Donnell calculated the transport rates of various fluorescent toxins, concluding that p-gp and MRP2 play a big part in toxin excretion for fruit flies and crickets. They hope that their simple, accurate technique to measure the activity of these two transporters will inspire researchers to apply the technique in other research areas.

10.1242/jeb.01951

Leader, J. P. and O'Donnell, M. J. (2005). Transepithelial transport of fluorescent p-glycoprotein and MRP2 substrates by insect Malpighian tubules: confocal microscopic analysis of secreted fluid droplets. *J. Exp. Biol.* **208**, 4363-4376.

Yfke van Bergen

INSECTICIDE TARGETS MECHANOSENSORY CELLS

Picture provided by Hartmut Kayser

Every gardener knows the frustration of finding their prize crop covered in aphids. But the pest's impact is even greater on agriculture, causing enormous financial damage. Harald Wolf, from the University of Ulm, Germany, explains that most insecticides incapacitate their victims by blocking receptors in the central nervous system. So when Hartmut Kayser, a biochemist from Syngenta, told Wolf about his work on the insecticide pymetrozine, Wolf was keen to discover the insecticide's target in the locust's control circuitry. Confident that pymetrozine would also inactivate a component of the central nervous system, the team began probing the insect's middle leg control circuitry, and were astonished to find that the chemical targeted sensory cells instead (p. 4451).

Wolf explains that pymetrozine is a widely used insecticide that destroys plant sucking aphids and white flies. As soon as the pests are exposed to the insecticide, the insects are unable to continue feeding. The insecticide has a similar effect on locusts, while also forcing the middle leg to extend slowly as the insecticide takes effect. Given that the insecticide has such a dramatic effect on the well understood control system in the insect's middle leg joint, Wolf decided to study the insecticide's effects on locusts to see if he could pinpoint the toxin's target.

Jessica Ausborn and Wolfgang Mader began systematically testing components of the middle leg's femur-tibia joint control system to see which were affected by a dose of pymetrozine, expecting to find that the central nervous system was the target. But they were amazed when they tested the first component in the control system, the chorodontal organ, that they need look no further; '[it] turned out to be the primary site of pymetrozine action' says Wolf. The insecticide was affecting mechanosensory cells that detect the joint's position and movement, and not a component of the central nervous system. Wolf remembers telling colleagues about this unexpected discovery at a journal club meeting later the same day; 'no one believed it' he says. Wolf needed more proof.

Undertaking an extensive battery of control experiments to check the insecticide's effects throughout the joint control circuit, Ausborn finally convinced Wolf that the chorodontal cells, and no other mechanosensors, were the target when she tested the chorodontal organ directly and found that it stopped responding after a dose of pymetrozine; 'That's when we opened the bottle of champagne' Wolf says.

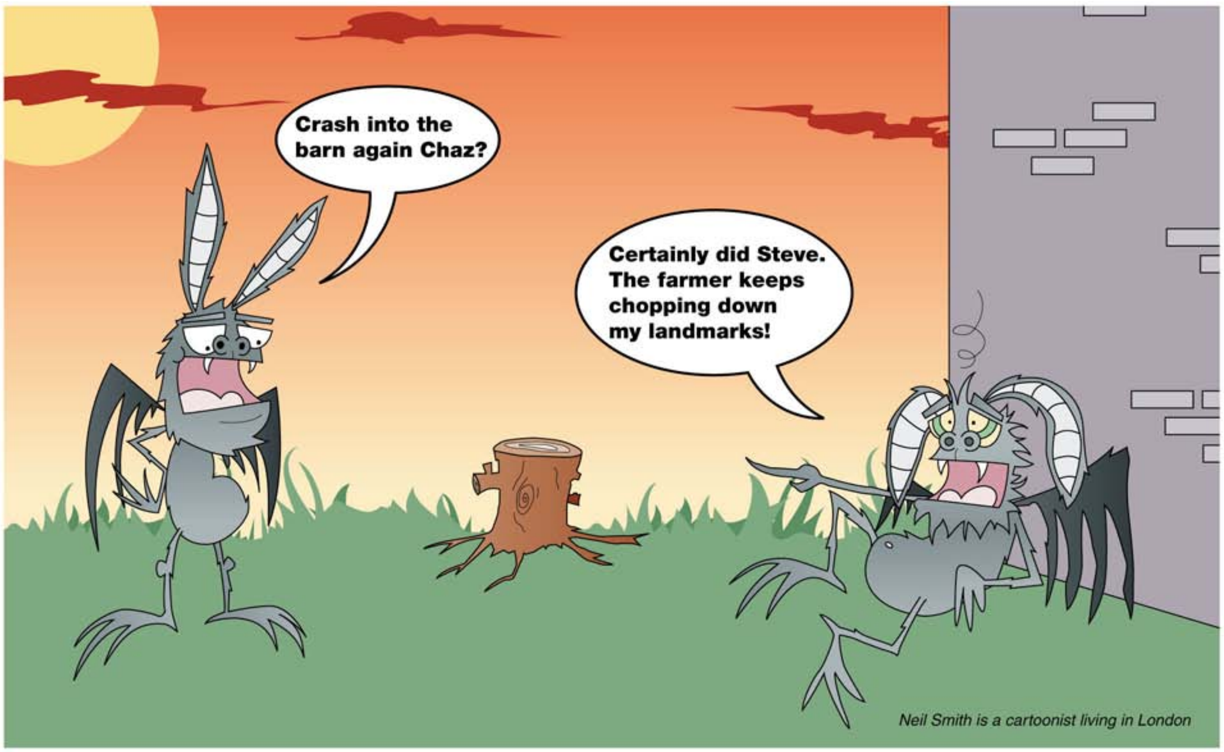
Having satisfied himself that pymetrozine targets chorodontal sensory cells Wolf is excited that pymetrozine could prove to be a powerful tool in the neurophysiologist's experimental arsenal, offering the potential to knock out the function of a single class of sensory receptors, the chorodontal mechanoreceptors, without surgical intervention. Of course he can't rule out the chance that pymetrozine may also target other tissues throughout the insect's body, but it's certainly effective on the locust chorodontal organ. Wolf is also keen to identify the molecular target of this unconventional insecticide, which could prove essential for the development of new insecticides, but he admits that this could be a long way down the line.

10.1242/jeb.01953

Ausborn, J., Wolf, H., Mader, W. and Kayser, H. (2005). The insecticide pymetrozine selectively affects chordotonal mechanoreceptors. *J. Exp. Biol.* **208**, 4451-4466.

Kathryn Phillips

ECHO-ORIENTATION



Bats zooming through the air at dusk know where they're going, despite flying in near darkness; they detect their ultrasound calls bouncing off objects and use these echoes to find their way around. Marianne Jensen, Cynthia Moss and Annemarie Surlykke decided to see which of these numerous echoes bats rely on for orientation (p. 4399).

Collecting big brown bats from attics in America and a colony in Canada, the team trained the animals to fly through a hole in a large net suspended across a dark room, rewarding them with a juicy mealworm. They placed a camera tripod next to the hole for the bats to use as an 'acoustic landmark' that reflects their calls. To reconstruct the bats' flight path as the animals tried to locate their dinner, the team filmed them with high-speed cameras. They recorded the bats' calls to correlate these with their flight behaviour. When the team placed the tripod near the hole in the net, the bats had no trouble finding the hole. But when the team moved the tripod to another position, the bats crashed into the net next to the tripod and inspected the area of the net where the hole should have been; they clearly ignored the net's faint echoes and used the tripod as an acoustic landmark. When the team took the tripod out of the room, the frustrated bats spent even longer desperately searching for the net opening. The team concludes that bats can learn to rely on a single echo-reflecting object to figure out where to go.

10.1242/jeb.01954

Jensen, M. E., Moss, C. F. and Surlykke, A. (2005). Echolocating bats can use acoustic landmarks for spatial orientation. *J. Exp. Biol.* **208**, 4399-4410.

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