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.

HOW NON-STICK BUGS EVADE NATURAL FLY PAPER


Picture by Dagmar Voigt

There are few things more irritating than a fly buzzing around the house. South Africans have an unconventional solution to the problem. They hang up a bunch of *Roridula gorgonias* leaves. Attracted to the shiny adhesive droplets on the leaves' hairs the hapless pest is soon trapped by the natural flypaper. However, this is not the end of the story. Each *R. gorgonias* plant is home to a population of *Pameridea roridulae* (mirid bugs), which dine on the trapped insects. Yet the mirid bugs successfully evade their host's sticky clutches (p. 2647). Curious to find out how, Dagmar Voigt and Stanislav Gorb from the Max-Planck Institute for Metals Research, Germany, decided to take a look at the apparently non-stick bugs to see how they elude *R. gorgonias*' grasp.

But how could the team get their hands on *R. gorgonias* plants complete with their own private mirid bug colony so far from the plant's home? 'Fortunately there are a few *R. gorgonias* enthusiasts in Germany' says Voigt, and after contacting Klaus Keller in Augsburg, he agreed to supply the team with the hairy plants and their residents.

Back in their Stuttgart lab, Voigt and Gorb decided to test how non-stick mirid bugs really are. Wrapping a bug in a leaf the team were amazed when they unrolled it and 'the bug jumped up and ran away!' says Voigt. The bug was completely non-stick. Next the team checked the mirid bug's surface by pressing a bug against a glass slide and looking at the slide under a microscope to see if they were covered in a special glue-proof coating. The bugs seemed to be coated in a greasy fluid. Voigt explains that all bugs are covered in a greasy layer, so what made the mirid bug's surface more non-stick than other insect coatings?

Flash freezing the bugs to –120°C, Voigt and Gorb took a high-resolution look at the insect's coating with a cryo-scanning electron microscope (cryo-SEM). The mirid bug's coating was 30 times thicker than the blowfly they compared it with. But how was this extra thick coating protecting the mirid bugs? Did it come loose when contacted by adhesive? Or was the greasy coating somehow disrupting the glue's adhesive powers?

Touching a sticky hair against a piece of mirid bug cuticle and looking at it with cryo-SEM, the team could see that the glue seemed to run like a fluid over the thick greasy surface. However when they looked at a *R. gorgonias* hair in contact with a section of blowfly cuticle, the glue formed a discrete blob that looked like a gel with well-defined edges. The mirid bug's greasy coating seems to disrupt the glue in some way, preventing it from adhering to the insect's surface.

Finally, the duo measured how strongly the glue became attached to various insects' surfaces. Having removed the mirid bug's protective layer by washing in cold chloroform, the team found that the glue stuck as strongly to the mirid bugs as to other insects, with the glue stretching to produce filaments as long as 5 cm. But when they successfully attached glue droplets to unwashed mirid bug cuticles, the cuticles easily broke free from the glue, rarely forming filaments more than 1.5 cm long. Voigt suspects that insect victims eventually exhaust themselves, fighting against the adhesive filaments.

Voigt and Gorb are keen to understand more about the mechanism that keeps *P. roridulae* roaming free, while other insects succumb to the glue that mirid bugs simply shrug off.

10.1242/jeb.022939

Voigt, D. and Gorb, S. (2008). An insect trap functioning as a habitat: a cohesion-failure mechanism prevents adhesion of *Pameridea roridulae* bugs to the sticky surface of the plant *Roridula gorgonias*. *J. Exp. Biol.* **211**, 2647-2657.

BEETLES 'HEAR' HEAT THROUGH PRESSURE VESSELS

For most creatures, fire is a complete disaster. It is hard to see how anything benefits when an inferno sweeps through a forest: except for the fire beetles, *Melanophila acuminata*. They are the first to occupy a scorched site, converging in their millions from distances of up to 10 km. Free of predators, they gorge on roast remains and mate, depositing their eggs beneath the bark of burned trees. But how do these tiny insects sense a blaze over such great distances?

Helmut Schmitz from the University of Bonn in Germany explains that *Melanophila* beetles are equipped with exquisitely sensitive infrared receptors that may detect blazes. But unlike most infrared receptors, which sense temperature with thermosensitive neurons, the fire beetle's


Picture by Helmut Schmitz

infrared receptors are modified hair sensors that originally detected subtle movements. So how do the insects convert heat into mechanical stimuli? Schmitz explains that the receptors contain fluid that he suspects expands as it heats up and presses against a motion-sensitive nerve cell deep in the receptor; 'the beetles could be described as hearing heat,' says Schmitz. But for the mechanism to work, the fluid must be contained in a pressure vessel that does not expand when heated. Schmitz and his PhD student Martin Müller decided to investigate the material properties of *Melanophila* infrared receptors to see if they are hard enough to stand the pressure (p. 2576).

But first the team had to find some fire beetles. Knowing that forest fires had swept through Spain in the summer of 2006, Schmitz and Müller set off 9 months later to collect charred tree trunks infested with beetle larvae from a burned forest near Cardona. Returning to their Bonn laboratory, Schmitz waited for the larvae to metamorphose into beetles before he could begin investigating the sensor's mechanical properties.

Dying thin dried sections of the cuticle with Mallory trichrome stain, Müller could clearly see that the cuticle around the dome-like receptor structure was composed of three layers; the external exocuticle, reinforced with onion-like chitin layers; the mesocuticle, encasing the pressure-transducing fluid; and the endocuticle, beneath the receptor. But how hard were each of these materials? The duo needed a sophisticated technique to measure the cuticle's mechanical properties on a nanoscale.

Striking up a collaboration with materials scientists Maciej Olek and Michael Giersig at the nearby Forschungszentrum caesar, Müller used nanoindentation to measure the cuticle hardness and stiffness inside the infrared receptor. Schmitz explains that this groundbreaking technique has only recently been used on biological samples, and the receptor's internal structures could only be analysed by cutting ultrathin sections from dehydrated receptors embedded in resin, identifying different regions in the receptor before selectively probing them with a nanoindenter. After months of painstaking analysis, Müller found that the external exocuticle was twice as hard, and 1.5 times as stiff, as the spongy mesocuticle. The exocuticle is tough enough to act as a pressure vessel, allowing the beetle to convert the fluid expansion caused by heat into a mechanical sensation.

Schmitz suspects that the differences in the hardness of the cuticle materials will be even greater in natural hydrated samples, and is keen to measure the native receptor's material properties with freezing techniques. Ultimately he hopes to accurately model the expansions and pressures generated in the insects' extraordinary infrared receptors and build fire beetle-inspired infrared detectors. But until then, fire beetles will remain one of the few creatures that 'hear' heat.

10.1242/jeb.022947

Müller, M., Olek, M., Giersig, M. and Schmitz, H. (2008). Micromechanical properties of consecutive layers in specialized insect cuticle: the gula of *Pachnoda marginata* (Coleoptera, Scarabaeidae) and the infrared sensilla of *Melanophila acuminata* (Coleoptera, Buprestidae). *J. Exp. Biol.* **211**, 2576-2583.

TURTLES DIVE DEEP FOR DINNER


Picture by Jonathan Houghton

Sporting a deep-diver's physiology when you spend most of your time paddling near the surface seems a little extravagant. But leatherback turtles are equipped with myoglobin-rich blood, which provides the oxygen storage capacity required to allow them to dive to impressive depths, sometimes exceeding 1 km. Near their breeding sites in the Caribbean the turtles perform deep dives very occasionally, which has puzzled researchers for decades; why bother going to such great depths when all of the turtles' needs can be met nearer the surface? So when satellite relay data loggers became available to record dives, Jonathan Houghton, Graeme Hays and colleagues at the University of Swansea, UK, decided to study the turtles' diving behaviour during the long voyages from their breeding grounds to discover the reason for these rare extreme dives (p. 2566).

The team equipped 13 turtles with the data loggers before letting the animals roam free. 'We tie them on after the turtles finish laying eggs, when they flick sand around to cover the nest. They stay completely still during handling,' Houghton says. The device, which records location, temperature, dive depth and duration, collects data as soon as it is submerged in saltwater and transmits the information to satellites when the turtle returns to the surface. Using this system, Houghton recorded over 26,000 dives, spanning the entire North Atlantic Ocean. He discovered that extraordinarily deep dives were always rare. Only 95 of the dives, 0.4%, went to depths beyond 300 m.

Why might turtles dive deep? According to one idea, they do it to escape predators. But the data loggers revealed that the reptile's diving speed remained normal during deep dives, suggesting that they were in no hurry to escape. Moreover, they spent several hours at the surface both before a deep dive – probably to slow their metabolism for increased oxygen efficiency – and afterwards, presumably to repay the oxygen debt created by anaerobic conditions during the dive. 'Hanging out at the surface would be a daft strategy for avoiding predators, because that's where they can spot your silhouette,' says Houghton.

A second hypothesis speculates that deep dives help turtles cool down. But water temperatures only decrease marginally beyond 350 m, which fails to explain why turtles would bother diving deeper.

This left Houghton with a third hypothesis; that turtles dive deep searching for food. Leatherbacks like to eat surface-dwelling jellyfish, which are common only in northern waters. However, during the months spent travelling from their tropical breeding grounds the turtles rely on other jellyfish-like animals that form long colonies and spend their days at depths around 600 m, only coming to the surface at night. Houghton's data show that most deep dives occurred around midday during this transit period, often just before a turtle settled for a few days or weeks in the same area. From this he suspects that the turtles dive deep to locate prey during daylight hours, harvesting the animals later when they come to the surface at night. If the turtles have identified a particularly rich site, they may stay a while after a deep dive to replenish their energy reserves before moving on.

So leatherback turtles probably use deep dives to find their next feeding station when travelling where jellyfish swarms are sparse.

10.1242/jeb.023010

Houghton, J. D. R., Doyle, T. K., Davenport, J., Wilson, R. P. and Hays, G. C. (2008). The role of infrequent and extraordinary deep dives in leatherback turtles (*Dermochelys coriacea*). *J. Exp. Biol.* **211**, 2566-2575.

Nora Schulz

FEMALE FROGS PREFER DEEP CROAKS

Neil Smith is an illustrator living in Salisbury

When it comes to picking a mate, it's important to make the right choice. And the choice is even tougher when nearby closely related species are sending out similar messages. Females have to identify not only an attractive male, but also a male of the same species. Carl Gerhardt from the University of Missouri explains that the frequency spectra of closely related Cope's gray treefrogs and gray treefrogs are very similar, with peaks around 1 kHz and 2 kHz. However the croaks differ in one crucial detail. Cope's gray treefrogs trill at 35–70 pulses s^{-1} while gray treefrogs trill at 10–35 pulses s^{-1}. Curious to know which frequency is the best carrier for crucial mate choice messages, Gerhardt offered fertile female frogs a choice between two simplified croaks; the first trill matched to the real male's time pattern and tuned to one of the frequency peaks in the male's croak and the second at the same pitch, but with a modified time pattern. Then he monitored the females to see which call they preferred and hopped towards (p. 2609).

Gerhardt found that both species more often correctly identified the trill that resembled the real male's trill when it was at a deep pitch than when it was high pitched. The Cope's gray tree frogs were also more accurate than the gray treefrogs, correctly identifying real male-like croaks over a wider volume range at both pitches more often than the gray treefrogs. So croak frequency does affect both species' responses to the croak pulse rate, and Gerhardt suspects that the differences 'may reflect the different ways in which females of the two species assess trains of pulses, and could have broad implications for understanding the underlying auditory mechanisms'.

10.1242/jeb.023002

Gerhardt, H. C. (2008). Phonotactic selectivity in two cryptic species of gray treefrogs: effects of differences in pulse rate, carrier frequency and playback level. *J. Exp. Biol.* **211**, 2609-2616.

Kathryn Phillips
kathryn@biologists.com