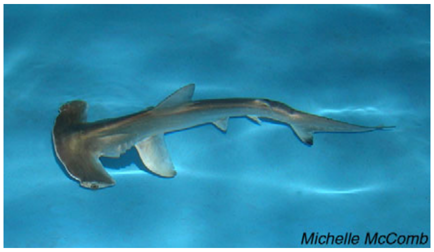
Inside JEB highlights the key developments in *The Journal of Experimental Biology*. Written by science journalists, the short reports give the inside view of the science in JEB.

HAMMERHEADS' WIDE HEADS GIVE IMPRESSIVE STEREO VIEW


Michelle McComb

Hammerhead sharks are some of the Ocean's most distinctive residents. 'Everyone wants to understand why they have this strange head shape,' says Michelle McComb from Florida Atlantic University. One possible reason is the shark's vision. 'Perhaps their visual field has been enhanced by their weird head shape,' says McComb, giving the sharks excellent stereovision and depth perception. However, according to McComb, there were two schools of thought on this theory. In 1942, G. Walls speculated that the sharks couldn't possibly have binocular vision because their eyes were stuck out on the sides of their heads. However, in 1984, Leonard Campagno suggested that the sharks would have excellent depth perception because their eyes are so widely separated. 'In fact one of the things they say on TV shows is that hammerheads have better vision than other sharks,' says McComb, 'but no one had ever tested this'. Teaming up with Stephen Kajiura and Timothy Tricas, the trio decided to find out how wide a hammerhead's field of view is and whether they could have binocular vision (p. 4010).

Hammerheads come in all shapes and sizes so McComb and Kajiura, opted to work with species with heads ranging from the narrowest to the widest. Fishing for juvenile scalloped hammerheads off Hawaii and bonnethead sharks in the waters around Florida, the team successfully landed the fish and quickly transported them back to local labs to test the fish's eyesight.

The team tested the field of view in individual shark's eyes by sweeping a weak light in horizontal and vertical arcs around each eye and recorded the eye's electrical activity. Comparing the hammerheads with pointy nosed species, the team found that the scalloped hammerheads had the largest monocular visual field, at an amazing 182 deg., and the bonnethead had a 176 deg. visual field, which was bigger than that of the pointy nosed blacknose and lemon sharks, at 172 deg. and 159 deg., respectively.

Having collected the animals' monocular visual fields, the team plotted the visual fields of both eyes on a chart of each fish's head to see whether they overlapped. Amazingly, they did. The scalloped hammerhead had a massive binocular overlap of 32 deg. in front of their heads (three times the overlap in the pointy nosed species) while the bonnet head had a respectable 13 deg. overlap. And when the team measured the binocular overlap of the shark with the widest hammerhead, the winghead shark, it was a colossal 48 deg. The hammerheads' wide heads certainly improved their binocular vision and depth perception.

Finally, the team factored in the sharks' eye and head movements and found that the forward binocular overlaps rocketed to an impressive 69 deg. for the scalloped hammerheads and 52 deg. for the bonnetheads. Even more surprisingly, the team realised that the bonnethead and scalloped hammerheads have an excellent stereo rear-view: they have a full 360 deg. view of the world.

'When we first started the project we didn't think that the hammerhead would have binocular vision at all. We thought no way; we were out there to dispel the myth,' says McComb. But despite their preconceptions, the team have shown that the sharks not only have outstanding forward stereovision and depth perception, but a respectable stereo rear view too, which is even better than the TV shows would have us believe.

10.1242/jeb.040709

McComb, D. M., Tricas, T. C. and Kajiura, S. M. (2009). Enhanced visual fields in hammerhead sharks. *J. Exp. Biol.* **212**, 4010-4018.

TOUGH FLEXIBLE ANTLER IDEAL FOR DEER DUALS

Prized for their impressive antlers, red deer have been caught in the hunters' sights for generations. But a deer's antlers are much more than decorative. They are lethal weapons that stags crash together when duelling. John Currey, from The University of York, UK, has been intrigued by the mechanical properties of bone for over half a century and has become fascinated by the mechanical properties of antler through a long-standing collaboration with Tomas Landete-Castillejos at the Universidad de Castilla-La Mancha. 'Antlers look as if they are dry,' says Currey, 'but no one knew if they really are dry when used in contests'. Curious to find out whether red deer antlers are used wet or dry when duelling, and how this affects the antlers' mechanical properties, Currey headed south to La Mancha to test the mechanical properties of red deer antlers (p. 3985).

But before the team could begin testing the antler's strength, they needed to find out how dry the bones were. Collecting freshly cut antlers from the university farm and a local game estate just after the stags had shed their antler's protective velvet, Currey, Landete-Castillejos, José Estevez and their colleagues weighed the antlers each week to find out how much they dried. Amazingly, over the first 2 weeks, the antlers lost a colossal 8% of their weight, compared with 1% weight loss if they were cut at other times of the year. Eventually the weight loss stabilised and the antler's humidity was in balance with that of the surrounding air. It was clear that the antlers were dry when the stags began duelling.

But how did this water loss affect the bone's material properties in comparison with those of normal bones, which function internally and are always wet? Would the dry antler make a better weapon than wet bone?

The team prepared 40 mm long blocks of dry antler and wet deer femur and measured the amount of force needed to bend the blocks to find out how flexible the materials were. Even though most bones are relatively brittle and inflexible when dry, the team found that the dry antlers are almost as stiff as wet bone: which is ideal for weapons that have to survive a lengthy pushing contest after the initial clash.

But how 'tough' was the antler? How much energy could it absorb in the initial crash? Applying a force to the middle of the blocks of bone and gently increasing it until the bone broke, the team plotted a curve of the bending force against the amount that the bone bent. Calculating the amount of energy that the antler could absorb before shattering, Currey found that the tissue was incredibly tough: 2.4 times tougher than normal wet bone. And when Currey measured the amount of energy that the dry antler could absorb in an impact, he was surprised and pleased to see that it could survive impacts 6 times greater than the impacts that shattered wet femur. The dry antler was tougher than wet bone and ideally suited to survive the stags' initial clash.

So dry deer antlers are simultaneously stiff, yet tough, making them perfectly suited to their role as a weapon. And the deer seem to have solved a problem that has puzzled engineers for decades. 'It is very difficult to make anything that is both stiff and tough,' says Currey, but it seems that duelling deer solved the problem eons ago.

10.1242/jeb.040717

Currey, J. D., Landete-Castillejos, T., Estevez, J., Ceacero, F., Olguin, A., Garcia, A. and Gallego, L. (2009). The mechanical properties of red deer antler bone when used in fighting. *J. Exp. Biol.* **212**, 3985-3993.

CATERPILLARS MIMIC ANTS DESPITE SIZE DIFFERENCE

Ants are well known for their social lifestyle and communication is key for their survival. However, some creatures take advantage of the ants' communal existence to hitch a free ride. Kartsen Schönrogge from the Centre for Ecology and Hydrology, UK, explains that the caterpillars of some *Maculinea* butterflies parasitise red ant nests. According to Schönrogge, some *Maculinea* species treat their hosts as a larder, raiding and consuming the ants' brood, while other species mimic ant larvae to trick the workers into feeding them, just like cuckoos. But the relationship between the butterflies and their hosts is extremely close: *Maculinea rebeli* caterpillars depend entirely on *Myrmica schencki* ants while *Maculinea arion* are only nurtured by *Myrmica sabuleti*: caterpillars that arrive in the wrong species' nests are slaughtered. Efficient communication between the ants and their lodgers is essential.

Curious to find out more about the systems that the caterpillars and their hosts use to communicate, Schönrogge and his colleagues Jeremy Thomas, Emilio Balletto, Francesca Barbero and Simona Bonelli began listening to the ants (p. 4084). But why turn to the sense of hearing, when insects mainly communicate through smell? Schönrogge explains that *Maculinea* butterflies and the *Myrmica* ants produce sounds, which were mainly thought to provide information about the sender's location, and when *M. rebeli* caterpillars make sounds like an *M. schencki* queen, the ants behave like her courtiers, even though she isn't there. According to Schönrogge, *M. rebeli* caterpillars are such convincing mimics that they are able to trick ants into believing that they are larvae so that worker ants rescue the caterpillars before they rescue their own young when under attack. Curious to know whether the cuckoo caterpillars are better acoustic mimics of their hosts than predator caterpillars that simply consume brood, Schönrogge and his colleagues decided to analyse the sounds produced by all four species.

Digging up ants' nests in Italy and the UK and collecting butterfly eggs to grow into caterpillars, Barbero travelled to Schönrogge's UK lab to use his custom built ant-recording studio to listen to the insects. Focusing on workers and queens of both ant species, and larvae and pupae from both butterflies, Barbero recorded the insects' frequency (pitch), pulse length and pulse repetition frequency.

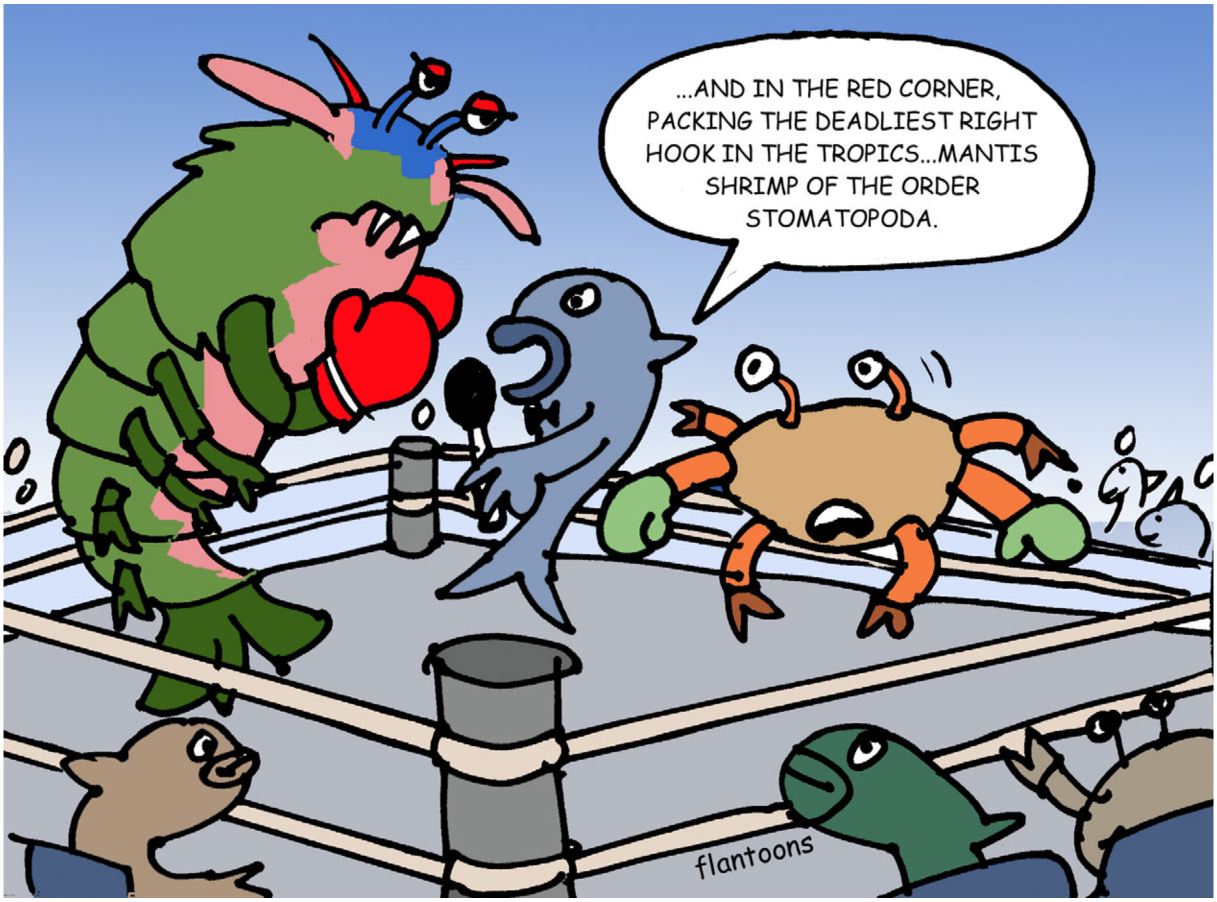
Analysing the recordings, the team could see that the main difference between the worker and queen ants' buzzes was their pitch. Workers have a high-pitched buzz, around 1400 Hz, while the queens buzz at 800 Hz (regardless of species) and the butterfly pupae all buzz at 800 Hz. The pupae were mimicking the queens to raise their status in the worker ants' eyes and ensure that they get fed first. The team analysed the pupae's buzzes and found that the predatory *M. arion* pupae were as good at mimicking the ants as the cuckoo-like *M. rebeli* pupae, although both caterpillars pulsed more slowly than their ant hosts.

Schönrogge admits that he is surprised that there are not more differences between the caterpillars' buzzes given that *M. rebeli* have to inspire more cooperation from their ant host than the predatory *M. arion* pupae. He adds that it is even more surprising that the ants and insects are able to produce such similar buzzes given their differences in size and the instruments that they use. 'That is the part that most people find amazing,' says Schönrogge.

10.1242/jeb.040683

Barbero, F., Bonelli, S., Thomas, J. A., Balletto, E. and Schönrogge, K. (2009). Acoustical mimicry in a predatory social parasite of ants. *J. Exp. Biol.* **212**, 4084-4090.

ELASTIC ENERGY POWERS MANTIS SHRIMP PUNCH



When a lurking mantis shrimp strikes, the victim rarely knows what hit it. Uncoiling its raptorial appendages in less than 2 ms, mantis shrimp dispatch their prey quickly. Sheila Patek, Travis Zack and Thomas Claverie explain that the shrimp's explosive strikes are powered by energy stored in spring structures in the shrimp's exoskeleton, 'but little is known about the dynamics and location of elastic energy storage structures in this system,' they explain. Curious to find out more about how the crustaceans strike, the team used computed tomography to get inside mantis shrimp's skeletons and measured the force required to compress raptorial appendage structures that could launch a lunge (p. 4002).

Calculating the energy stored in the merus region of the appendage, the team realised that it must be stored in highly mineralised internal bar structures in the limb. And when the team cut the bars, they found that it was impossible to store energy in the system: the bars are the elastic structures that store the shrimp's phenomenal power. The team also modelled energy storage in the bar structures, and realised that the structures were behaving just like conventional springs: they store energy provided by the extensor muscle as the muscle contracts, and release the energy explosively when the latches release.

'The spring acts as a power amplifier,' Patek explains, and she estimates that by storing energy in the compressed spring, the tiny 97 mg extensor muscle could amplify its power output more than 27 times.

10.1242/jeb.040691

Zack, T. I., Claverie, T. and Patek, S. N. (2009). Elastic energy storage in the mantis shrimp's fast predatory strike. *J. Exp. Biol.* **212**, 4002-4009.

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