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

## ANGELFISH TAKE SPONGE REEFS BY STORM


Great Barrier Reef Marine Park Authority image

When Nicolai Konow flew to Australia to begin his PhD with David Bellwood at James Cook University, he was planning to work on butterflyfish. But once he saw his first angelfish, there was no turning back. Swimming with these colourful reef fish, he realised that ‘they do things with their jaws that no other fish do!’ Puzzled by their peculiar mouths, Konow set out to unravel angelfish’s biomechanical secrets (p. 1421).

There is astounding variety in fish dining habits, but researchers have helpfully shunted feeding techniques into two large groups. The first group, ram-suction feeders, include fish that envelop their unsuspecting prey, or suck tasty floating morsels into their mouths. Fish in the second group, which includes angelfish, are biters. But how do bulky angelfish munch on sturdily attached prey like sponges and tunicates, which are normally tucked away and well-protected?

To find out how angelfish attack their prey, Konow decided to examine angelfish during mealtimes. Luckily, the sponge reefs that angelfish call home are right on his doorstep. The real problem was catching the feisty fish; he discovered that angelfish are remarkably agile escape artists. ‘You herd them like cows,’ Konow says, ‘but then they bolt!’ Eventually, he managed to catch six fine specimens. The next hurdle presented itself almost immediately. ‘Back in the lab, I discovered that angelfish are really fussy eaters,’ Konow recalls, ‘and it took a while to find the juicy stuff they like to eat.’ Fortunately, he noticed layers of untouched marine fauna growing on local harbour pylons, which he soon realised was a limitless supply of gourmet angelfish food.

Finally, he was ready to examine angelfish jaw movements as they chomped on their victims. Sticking small reflective dots on various joints and bones of angelfish jaws, he set up a high-speed camera and recorded the fish as they gorged on the feast he provided. With special software used to analyse high-speed motion during car crash testing, Konow tracked how the reflective dots moved relative to each other and the prey. He noticed that the tip of the angelfish’s lower jaw rotates relative to the rest of the jaw. But what really surprised Konow was that this jaw rotation has very unusual timing. Angelfish snap their protruded jaws shut *before* pulling them back with the prey securely lodged between their teeth, making sure that they don’t bite off more than they can chew. ‘We know of no other fish with such a mechanism dedicated to closing the jaws before retracting them,’ Konow says.

How do angelfish manage this feeding feat? Taking a closer look at angelfish jaws, Konow saw that they have a unique feature that enables what he has dubbed the ‘grab and tear’ technique. An extra joint in their lower jaw allows them to snap their jaws shut while they still jut out. Once their jaws are closed, angelfish pull them back with exceptional speed. Konow is amazed at the ‘terrific pulling power’ of this novel feeding technique. Thanks to their lower jaw’s extra joint and speedy retreat, angelfish can feast on prey in the reef’s hard-to-reach places.

10.1242/jeb.01599

**Konow, N. and Bellwood, D. R.** (2005). Prey-capture in *Pomacanthus semicirculatus* (Teleostei, Pomacanthidae): functional implications of intramandibular joints in marine angelfishes. *J. Exp. Biol.* **208**, 1421-1433.

## TRUDGING TORTOISES


Picture provided by Peter Zani

When Darwin made his historic *HMS Beagle* voyage, one animal in particular caught his eye: the giant Galápagos tortoise, plodding along at a leisurely 0.16 metres per second. Intrigued by the hefty reptile’s painfully slow pace, Peter Zani and colleagues at the University of Colorado, Boulder, decided to put giant tortoises through their paces (p. 1489).

Zani wondered whether tortoises, just like many other animals, use a mechanism known as the inverted pendulum to conserve mechanical energy as they amble along. He explains that as you walk, the potential energy that is associated with the height of your centre of mass changes into kinetic energy. When your foot touches the ground, lifting your centre of mass, this kinetic energy is converted back to potential energy. 'Throughout this energy exchange, your centre of mass rises and falls in the shape of an inverted pendulum,' Zani says. It's an efficient mechanism to recover energy, but do giant Galápagos tortoises use it?

According to Zani, 'two conditions have to be met to show that the inverted pendulum mechanism is at work.' First, kinetic and potential energy should be out of phase – as kinetic energy rises, potential energy falls. Second, fluctuations in kinetic and potential energy must be of equal magnitude and shape. Since kinetic energy is the energy of motion, and giant tortoises are so slow, they are likely to have very small kinetic energy fluctuations. Teaming up with Rodger Kram, Zani calculated that if tortoises use the inverted pendulum mechanism, their modest kinetic energy should raise their centre of mass vertically by only 0.5 mm. But tortoises sway as they walk, so Zani and Kram suspected that they don't use the inverted pendulum mechanism.

To test this, they needed to analyse the mechanical energy patterns of travelling tortoises. Zani widened and strengthened a traditional force plate walkway to cope with the bulk of the giant creatures. If he could convince tortoises to walk across it, he'd be able to convert its force measurements into mechanical energy values. Jinger Gottschall joined Zani and Kram as they loaded the modified walkway into a trailer and drove to the Oklahoma City Zoo. Once there, they were faced with the challenge of luring five giant Galápagos tortoises up a ramp onto the walkway. Zani soon found that 'you can't force a 200 kg animal to do what you want!' But tempting the creatures with juicy apples and carrots seemed to do the trick, and the team videotaped them as they lumbered across the walkway to get their treat.

Analysing the force plate measurements and video footage with Gottschall, Zani could see that the tortoises didn't meet the two conditions. Their kinetic and potential energies fluctuated randomly – sometimes they were in phase, sometimes they were out of phase. 'There was certainly no systematic exchange of energy,' he says. They also saw that a giant tortoise's centre of mass rises about 1.5 cm as it walks, much more than the 0.5 mm predicted if they use the energy-conserving mechanism. As the team had suspected, giant Galápagos tortoises do not use the inverted pendulum mechanism. Yet despite their inefficient pace, Zani notes that giant tortoises don't have to work harder than other animals to travel the same distance.

10.1242/jeb.01600

**Zani, P. A., Gottschall, J. S. and Kram, R.** (2005). Giant Galápagos tortoises walk without inverted pendulum mechanical-energy exchange. *J. Exp. Biol.* **208**, 1489-1494.

## MOLE CRICKETS' AMPLIFIED LOVE CALLS


Picture by Tom Walker

When the sun sets, male mole crickets settle down in their carefully constructed calling burrows and begin serenading the females passing overhead. Cricket veteran Henry Bennet-Clark wondered if male trills are amplified by the burrow's horn-shaped opening, which looks rather like an old-fashioned hearing aid. Do burrows really improve sound production efficiency? To find out, Ken Prestwich developed a unique method to measure the singing efficiency of two mole cricket species (p. 1495).

As Prestwich explains, the efficiency of sound production is the ratio of acoustic power (output) to metabolic power (input). But the traditional method to measure metabolic rate – placing a creature in a small enclosed space to record its $O_2$ consumption and $CO_2$ production – makes it difficult to measure acoustic power at the same time. Since mole crickets only sing inside their burrows, Prestwich came up with an unusual set-up to measure acoustic and metabolic power at the same time; he decided to use the burrows as masks to measure the breathing of singing mole crickets.

To try his novel idea, Prestwich rounded up some mole crickets. Roaming around Florida at dusk, he listened for mole cricket calls and dug the males out of their burrows. Back in the lab, the crickets industriously dug burrows in sand-filled buckets. Rigging up an artificial sunset, Prestwich was relieved to find that the males were happy to call from their new homes. To measure the insects' metabolic rate as they sang, he pushed a tube through the sand into the bulb, a dead-end in the burrow in front of the males' faces, turning the bulb into a mask. He then set up a stream of air past the insects into the bulb and up into $CO_2$ and $O_2$ analysers. But there was a problem. 'My own breathing was messing up the gas measurements,' Prestwich says. The solution was simple; whenever he was in the lab, he breathed into a large plastic bag. At the same time, he determined mole crickets' acoustic power by placing a wire hemisphere (the shape of mole crickets' sound fields) over the burrow opening and detecting sound pressure levels with a microphone at various points on the frame.

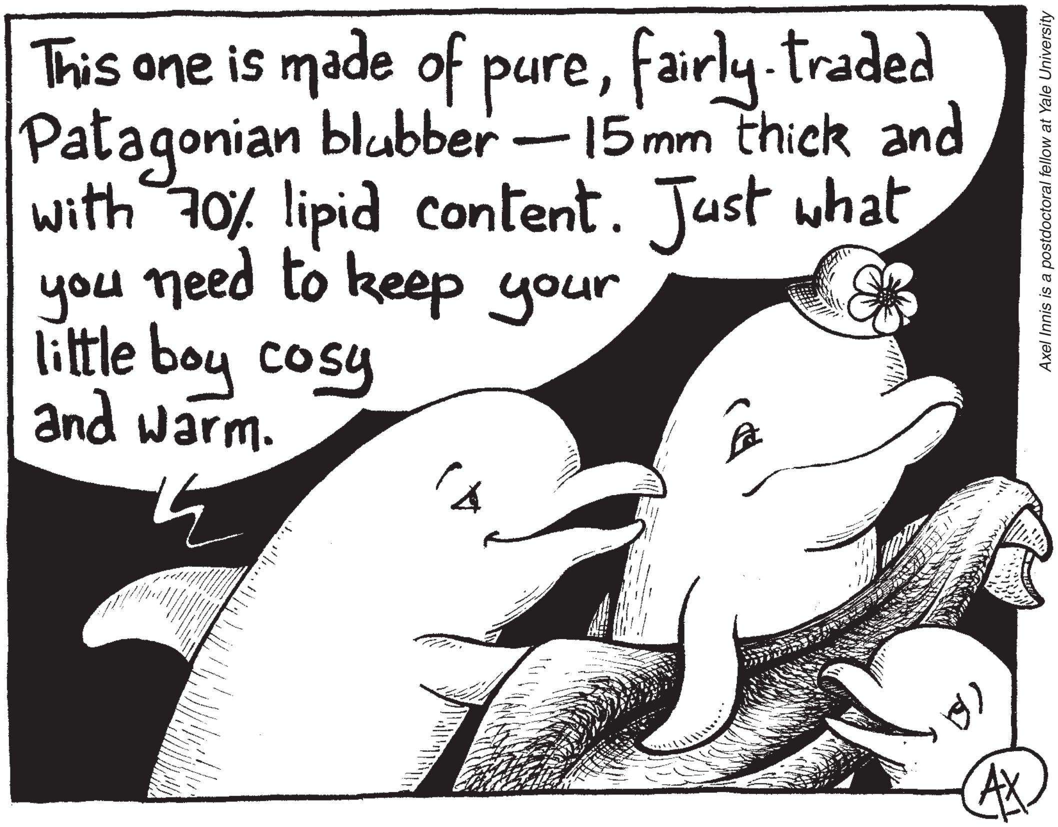
The new approach really paid off; Prestwich now has the first concurrent measurements of the metabolic cost of calling and acoustic power. But when he calculated mole crickets' song production efficiency, he was in for a surprise. The two species sang with 0.23% and 0.03% efficiency, 'which is remarkably low,' says Prestwich. Maybe the burrows don't improve efficiency after all?

But there may be another explanation for the lab crickets' poor efficiency. Field workers have long suspected that air between sand grains in dry burrows dissipates sound and damps crickets' songs. To see if this was true for his crickets, Prestwich sprinkled water over the lab burrows. Sure enough, their songs grew louder, but the crickets' metabolic rates didn't change; the wet burrow was enhancing the sound, not the crickets pumping up their metabolic power. Which means that damp lodgings near ponds and lakes are hot property as far as mole crickets are concerned.

10.1242/jeb.01598

**Prestwich, K. N. and O'Sullivan, K.** (2005). Simultaneous measurement of metabolic and acoustic power and the efficiency of sound production in two mole cricket species (Orthoptera: Gryllotalpidae). *J. Exp. Biol.* **208**, 1495-1512.

## CHUBBY CALVES COMBAT THE COLD



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Like us, dolphin infants face the challenge of staying warm after leaving the comfort of the womb. But baby dolphins are much more vulnerable to cold than muffled-up human babies; dolphins are born in water, which conducts heat away from their bodies 25 times faster than air. Suspecting that the youngsters may have special adaptations to combat heat loss, Robin Dunkin and her colleagues at the University of North Carolina at Wilmington wondered whether newborn dolphins' blubber insulates better than that of older dolphins (p. 1469).

The team already knew that the thickness and fat content of Atlantic bottlenose dolphins' blubber changes as the marine mammals grow up, so they set out to see how this affects blubber's thermal properties. Collecting blubber samples from unfortunate dolphins that had not survived stranding on North Carolina's beaches, the team compared blubber's thermal conductivity (how well heat moves through it) and insulation (how well it limits heat loss) among dolphins of different ages. They discovered a threefold increase in thermal insulation as dolphins developed from a tiny foetus to a plump juvenile, due to a continuous increase in blubber's thickness and fat content over this growth period. Since the calves' blubber layer keeps on growing after birth, the team conclude that newborn blubber is not specially adapted to provide extra insulation. But while dolphin calves reap the thermal benefits of their expanding blubber, adults suffer a decline in their blubber's fat content. Luckily, this isn't a problem; adults have a thicker blubber layer than calves. Clearly, dining on their mothers' fatty milk allows young dolphins to stay podgy and warm, while adults with their copious amounts of blubber can pare down their blubber's quality and still enjoy the same level of insulation as their babies.

10.1242/jeb.01601

**Dunkin, R. C., McLellan, W. A., Blum, J. E. and Pabst, D. A.** (2005). The ontogenetic changes in the thermal properties of Atlantic bottlenose dolphin blubber *Tursiops truncates*. *J. Exp. Biol.* **208**, 1469-1480.

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