How thorny devils tap damp sand to slake thirst

Thorny devil, in the reptile house at Alice Springs Desert Park, Australia. Stu's Images [CC BY-SA 4.0], via Wikimedia Commons.

Thorny devils scampering across the baking red Australian sand in search of an ant dinner look almost invincible in their coat of spikey armour, but their choice of diet may make survival even more challenging in the harsh environment. Philipp Comanns from RWTH Aachen University, Germany, explains that the lizards' mouths are so well adapted to consuming ants that they are unable to lick water to drink. However, the resourceful animals have a remarkable alternative strategy to overcome the drinking challenge: they have effectively turned the entire surface of their skin into a drinking straw.

Comanns describes how the reptile's skin is covered with microscopic channels that take up water by capillary action. The lizards then suck the water through the channels into their mouths: 'It is very cool seeing these lizards standing in a puddle and finally start to move their mouths as they drink', he says. However, it wasn't clear how thorny devils and other so-called 'rain harvesters' access water in one of the most arid environments in the world. They rarely encounter puddles and the dew that falls at sunrise only dampens the ground. Fascinated by the lizard's ability to extract water from the most parched locations, Comanns arranged to visit Philip Withers – who originally discovered the skin phenomenon – at the University of Western Australia, to find out more about how the mysterious creatures extract water from their desiccated surroundings.

Working with six thorny devils that had been caught in the bush by Graham Thompson, Comanns recalls that the animals were content to have their feet immersed in a puddle of room temperature water for an hour. Some even began opening and closing their mouths to drink within 10 s of being dipped into the water. Having weighed the lizards before they began drinking, an hour later (when they had drunk their fill and their skins were fully charged) and then an hour after that (when the skins had dried and any additional mass accounted for the water consumed), Comanns discovered that the 40 g reptiles opened and closed their mouths almost 2500 times during an hour-long drinking session and downed as much as 1.28 g of water (3.3% of body weight) in 0.7 µl sips. Meanwhile, the channels on the surface of the skin could hold an additional 1.32 g of water.

But Comanns was still none the wiser about which water sources that the animals depend on. Were they extracting water from damp sand, or could they gather enough dew on their chilly bodies from air warming in the early morning to slake their thirst? After allowing the lizards to stand in the damp sand and measuring how much water wicked up into the skin, Comanns found that even the wettest sand (22% water content) only saturated 59% of the capillaries and although Comanns assumes that this could be sufficient to satisfy the lizards, he never saw them drink. However, the animals like to cover their backs in damp sand and he suspects that this may allow them to extract more water. Also, when he cooled the lizards to 22°C and placed them in a warm humid room, the condensation that formed on the lizards' bodies was only sufficient to wet the surface of the skin and not enough to charge the water capillaries.

So, thorny devils can extract significant quantities of water from soggy sand but not enough from dew at sunrise and Comanns suggests that the lizards and other animals that resort to capillary action to get water shots should be rechristened moisture harvesters, 'Because it is not always about rain', he says.

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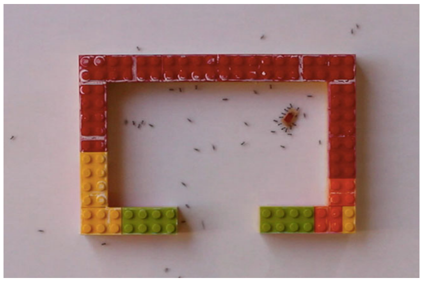
Kathryn Knight

Cooperative ants are more than the sum of their parts



Ants cooperating to negotiate the cul-de-sac obstacle. Photo credit: Helen McCreery.

Moving house is a rite of passage that can test even the strongest relationships, requiring teams of people to cooperate to heave heavy sofas and large boxes up and down stairs. But we are not alone in our ability to pull together to tackle a sizeable challenge; dragging a hefty insect carcass to the nest is probably the closest equivalent of negotiating a tight turn in the stairs for a team of ants. 'We have to talk to the other person constantly to figure out how to solve the problem', says Helen McCreery from the University of Colorado, Boulder, USA, so how does a crowd of determined ants carrying a large morsel respond when they encounter an impediment to their mission? 'They suddenly have to make a choice when it is not clear that one option is better than any other', says McCreery; and the busy creatures appear to achieve this without discussion. Intrigued, McCreery, her advisor Michael Breed and computer scientist Radhika Nagpal from Harvard University, USA, decided to find out how hindered ant crews cooperate to negotiate unexpected obstructions.

As a band of burdened ants could use an almost unlimited range of strategies to navigate their way around an obstacle, the team designed three obstructions to test

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how the insects responded in practice. Constructing a Lego brick wall, a three-sided cul-de-sac and a completely enclosed corral coated in slippery Fluon® – to prevent the ants from escaping over the top – McCreery and Zachary Dix placed each one in the path of a crew of longhorn crazy ants (*Paratrechina longicornis*) as they attempted to heft chunks of tuna home, and then filmed the ants' tactics.

Analysing the ants' manoeuvres when they encountered the wall, the team saw that the obstructed ants simply moved to and fro along the wall until they reached the end and resumed their homeward course. 'Ants are really good at knowing the direction of the nest', says McCreery, explaining that the ants needed little information other than the direction of home to implement this strategy. However, using the same tactic when faced with a cul-de-sac would be doomed to failure. Realising that the strategy for escaping a blind alley must be more sophisticated, the team watched as the ants zig-zagged to and fro across the front wall of the obstruction – as they had when trying to navigate around the wall. However, as time passed, they began randomly moving backwards, away from the nest, until eventually they encountered the exit and were able to go on their way again. The ants' strategy of using random movements allowed them to maintain a consensus while being flexible and robust enough to get them out of most tight corners, although the route that they took was not always the most efficient.

However, McCreery admits that she was surprised at how quickly the ants gave up and abandoned their precious piece of tuna when they found themselves trapped in the corral. 'We really expected their behaviour in the trap to look a lot like the cul-de-sac, at least at the beginning. But as soon as we closed the door, the speed and group size started to drop', she recalls, suggesting that the ants might have given up sooner than expected because they were cut off from incoming ants. And, having discovered how ants deal with being stuck in a blind alley, Nagpal is keen to apply these strategies to teach teams of robots how to cooperate to solve problems in environments that they are unfamiliar with.

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Kathryn Knight

Drag has not shaped mantis shrimp weapons

A male *Odontodactylus scyllarus* mantis shrimp smashing a common periwinkle. Photo credit. Roy Caldwell.

Whether pulverising their victims with a powerful single blow or impaling them with a lethal harpoon, feisty mantis shrimps more than live up to their Australian nickname of 'thumb splitter'. Their blows can be so forceful that a thump from one of their appendages can even tear water apart, producing a distinctive flash of light as the resulting bubble implodes. How the weapons of different mantis shrimp species have been moulded by their watery environment is a puzzle that fascinates Sheila Patek from Duke University, USA. With a long history of investigating the predatory crustaceans, Patek has now turned her attention to try to understand how the drag forces experienced by the stomatopods' limbs have shaped the design of their weapons.

Having already analysed the motions of several hammer-wielding mantis shrimps (*Neogonodactylus bredini*, *Odontodactylus scyllarus*, *Gonodactylus smithii*) and harpooners (*Lysiosquillina maculata* and *Alachosquilla vicina*), Patek teamed up with undergraduate David Matthews at the University of Massachusetts, USA, to add another spearer to the list: *Coronis scolopendra*. Filming the action of the medium-sized new recruit at 15,000 frames s^{-1} and comparing its performance with that of the other species, Patek could see that the smallest animals hurled their weapons faster than the larger animals. However, the high-speed movies could not tell her about the drag acting on the differently shaped and sized appendages, so Patek collaborated with Adam Summers from the University of Washington, USA, to produce scaled up models of the appendages of all six species, which Philip Anderson then tested in a horizontally flowing flume to measure the drag that they experienced. As the final segment of the limb, the dactyl, swings out during the early stage of the flicking motion, Anderson measured the drag on the limbs and found little difference between the different designs. However, the drag on the smashers' limbs increased when the limb was fully extended, while the harpooners were no more impaired by drag when the limb was fully extended.

However, Patek explains that when the armoured limbs are launched during an attack, they do not move in a straight trajectory. Instead, the mantis shrimps swing their hammers and harpoons in an arc, and this can dramatically alter the drag forces that they experience. So Patek collaborated with two colleagues, Sam Van Wassenbergh from the University of Antwerp, Belgium, and Matt McHenry from the University of California, Irvine, USA, to test two different types of drag simulation to find out how well they agreed on the impact of drag on the differently sized and shaped limbs. Explaining that one of the simulation techniques (computational fluid dynamics) is known to be extremely precise but extraordinarily time consuming, while the second (blade element analysis) takes a more simplified approach but is speedier, the team compared the results of the calculations and found that McHenry's blade element analysis was remarkably accurate, despite its simplicity; 'This study demonstrates the utility of simple mathematical modelling for comparative analyses', says Patek.

Considering the implications of the calculations, which showed that drag has a minor impact on the weapon shape, Patek says, 'This suggests that drag forces have not stymied the spectacular diversification of mantis shrimp appendage shapes, including hatchets, spears and hammers, that are used for impaling and crushing prey'. So, while drag can have a significant effect on body shape for motion, other factors – such as robustness and making an easy catch – probably have more of an impact on weapon design when the next meal is at stake.

10.1242/jeb.151415

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Chestnut-crowned babblers huddle for comfort

Some species are notorious huddlers, from bats that nestle together for warmth to enigmatic emperor penguins braced against the harsh Antarctic winter. Yet others, such as chestnut-crowned babblers from southeastern Australia, continue huddling even when the nights are mild. Mark Chappell from the University of California, Riverside, USA, and colleagues William Buttemer at the University of Wollongong, Australia, and Andrew Russell from the University of Exeter, UK, explain that little was known about the interplay between factors such as environmental temperature and breeding habits that drive roosting, so the trio began investigating how the chestnut-crowned babblers' sociable lifestyle affects their metabolism.

After carefully capturing birds at the University of New South Wales Research Station at Fowlers Gap, the team measured the metabolic rates of individual unsheltered birds and groups of birds (up to 9) sheltered in nests. Conducting the trials overnight, the trio initially set the temperature at a chilly 5°C (typical of the early breeding season) as they recorded the birds' oxygen consumption, before raising the temperature to 14°C, and then completing the measurements several hours later at the warmer temperatures (28°C) that the birds encounter late in the breeding season.

Not surprisingly, the individual birds had to work harder to stay warm in the chilly conditions, consuming 112% more energy at 5°C than they did at 28°C. And when the scientists moved the solitary animals into nests, their metabolic rates fell by between 11% and 15%, depending on the temperature. However, the birds' metabolic rates plummeted when the number of nest mates increased, with large groups of birds in the coldest nests consuming 50–60% less energy than the solitary birds at the same temperature.

The team also noticed that the metabolic rates of the individual birds were extremely variable and their resting metabolic rates were 15% higher than those of birds huddling in a nest at temperatures where it should not have been necessary for them to resort to shivering for warmth, which may suggest that nesting alone is stressful. Chappell and colleagues also suggest that this could account for the relatively high mortality rates suffered by chestnut-crowned babbler mothers as the females roost alone while rearing their young, and the additional expense incurred when nesting in the chilly early breeding season could place them at significant risk.

10.1242/jeb.151423

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