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.

SWARM DECISIONS BASED ON WAGGLE DANCE VIGOUR


Picture by Tom Seeley

We all make decisions every day, but are only rarely involved in ‘group-level’ decisions, such as voting for a politician. When a bee swarm decides to move house, they also make a group decision, but Thomas Seeley, from Cornell University, explains that only a few hundred honeybees are actively involved in the process. Seeley and Kirk Visscher, from the University of California, are fascinated by the ways that insect societies organise themselves and they wondered how bees make the decision where to move next. The pair already knew that scout bees are the first to go off in search of promising nest sites. Having discovered a potential home, the successful bee returns to the swarm and communicates the location with a waggle dance to encourage other scouts to take a look before making the decision. But how do scouts communicate a potential nest site’s desirability? Curious to know which aspects of a waggle dance encoded the crucial information, Seeley and Visscher set off for Cornell University’s Appledore Island to find the differences between scout bee dances that report desirable residences and those that report cramped conditions (p. 3691).

Arriving with a team of student observers at the isolated island, Seeley and Visscher prepared a swarm to go house hunting. Offering the insects a choice between a desirable (40 l) and a mediocre (15 l) nesting box, each situated within 250 m of the homeless insects, Seeley and Visscher filmed the scout bees’ waggle dances when they returned to the swarm. Meanwhile, a pair of observers, each armed with paint and data loggers, waited patiently to mark individual scout bees as they arrived at each nest box and recorded the insects’ arrivals and departures.

After filming scout bees from four swarms, Seeley and Visscher analysed the insects’ antics and found that the first scout to find a site almost always danced vigorously, no matter how good or poor the site was. Seeley explains that this is a critical stage of the decision-making process. If the bee doesn’t announce her discovery to other scouts, then the site won’t be entered in the bees’ ‘debate’. So a bee discovering a site nearly always danced for it, regardless of its quality.

They also found that bees that visited the larger nest box tended to perform more cycles of the waggle dance than scouts that visited the smaller box; so the number of waggle dance cycles seemed to be the key factor in communicating which was the better of the two sites.

However, this wasn’t always the case; sometimes bees performed a large number of waggle dance cycles even when they had only found the small box. Seeley explains that mistakes such as this aren’t a problem for the bees, because so many scouts visit the site that the ‘noise’ generated by the odd bee getting it wrong eventually averages out. The team also noticed that with each subsequent return to the nest site, the bees performed fewer and fewer waggle cycles until they eventually stopped waggle dancing altogether, naturally limiting the influence that individual bees have on the decision-making process.

According to Seeley, the bee swarm’s decision-making process is much like that of monkey brains: both accumulate evidence for multiple alternatives until the evidence for one reaches a critical level, when it becomes the chosen alternative. He explains that the bees do this by recruiting scout bees to visit each potential site until the number of scouts at a site exceeds a threshold. The decision is made when the bees sense the ‘quorum’ at the site and return to the swarm to spread the good news.

10.1242/jeb.026765

Seeley, T. D. and Visscher, P. K. (2008). Sensory coding of nest-site value in honeybee swarms. *J. Exp. Biol.* **211**, 3691-3697.

BEES RELATE SUN MAP TO PANORAMA

Knowing the sun’s position is crucial for honeybee communication. Without this knowledge it is impossible for hive members to interpret their nest mate’s famous waggle dance, where the angle that the dancing insects walk relative to vertical is the same angle that the foragers must fly relative to the sun’s position to find nectar. But how do bees communicate when the sun is out of sight? According to William Towne from Kutztown University of Pennsylvania, the insects memorize the sun’s position over the day, and they fall back on this memory when the weather is overcast. But for this memorized sun map to mean anything, the insects must have learned the sun's position relative to some aspect of their world that they can refer to. Towne explains that Fred Dyer first showed that bees orient their memory of the sun's position relative to their local landscape in the 1980s. Since then, most people had taken Dyer's results to mean that bees learn the sun's movements in relation to the entire landscape, until Tom Collett of Sussex University reminded Towne that there were other possibilities; such as the bees using a familiar flight path as their reference. Towne decided to retest the insects' sun maps, to see if he could tie the matter up (p. 3729).

First he had to be sure that the insects couldn't relate their sun map to any other cues, such as their flight path, so Towne and student Heather Moscrip set up a hive in a field next to a tree-lined corner. They placed a feeder adjacent to the hive so that the foragers' flight path was too short to provide a realistic reference frame for the insects' sun map. Then the duo waited for an overcast day while the bees set about learning their sun map. As soon as the clouds closed in, Towne and Moscrip picked up the hive and transported it to a field that looked identical to the first, but this time the corner was facing in the opposite direction; a mirror image. The sun was in a completely different position relative to the tree-lined corner, but the bees couldn't see it behind the clouds. After moving the feeder away from the hive until it was far enough for the insects to start waggle dancing, Towne began recording their waggle dances.

Analyzing the dance directions back in the lab, Towne quickly realised that the bees had got the feeder's position completely wrong. Thinking that they were still at the first site, the bees were dancing as if the sun was over the original field. The insects were remembering the sun's position relative to the first tree-lined corner, and not relating their dances to the sun's true position over the mirror image field. And when Towne and Moscrip repeated the experiment while moving the feeder along different compass bearings, the bees danced again as if they were in the original field. They were definitely referring their sun map to the local landscape panorama, and not to a more limited reference, such as a familiar flight path

Towne admits that he is delighted to have confirmed Dyer's original hypothesis of more than 20 years ago. Meanwhile the bees remain unphased; they knew where the sun was all along.

10.1242/jeb.026757

Towne, W. F. and Moscrip, H. (2008). The connection between landscapes and the solar ephemeris in honeybees. *J. Exp. Biol.* **211**, 3729-3736.

HOW GIBBONS WALK ON FLOPPY FEET

Picture by Evie Vereecke

The human foot is a miracle of evolution. We can keep striding for miles on our well-sprung feet. There is nothing else like them, not even amongst our closest living relatives. According to Evie Vereecke, from the University of Liverpool, the modern human foot first appeared about 1.8 million years ago, but our ape-like ancestors probably took to walking several million years earlier, even though their feet were more 'floppy' and ape like than ours. Vereecke explains that modern ape feet have a flexible joint midway along the foot (we retain this joint, but have lost the flexibility), which made her wonder how well our predecessors may have walked on two feet. Lacking a time machine, Vereecke and Peter Aerts from the University of Antwerp decided to look at the flexible feet of modern gibbons to find out more about how they walk (p. 3661).

But working with gibbons is notoriously hard. 'You can't touch them and you can't work with them in the lab' says Vereecke. Fortunately she and Aerts had access to a troop of the semi-wild apes just down the road at Belgium's Wild Animal Park of Planckendael. Having set up her camera outside the animals' enclosure at foot height, Vereecke simply had to sit and wait for the animals to walk past, hoping that the camera would capture a few footfalls. Eventually after several weeks of patience, Vereecke had enough film footage to begin digitalising the animals' foot movements and build a computer model to find out how they walk.

The first thing that Vereecke noticed was that the animals don't hit the ground with their heels at the start of a stride. They move more like ballerinas, landing on their toes before the heel touches the ground. Analysing the gibbon foot computer model, Vereecke realised that by landing on the toes first they were stretching the toes' tendons and storing energy in them. According to Vereecke, this is quite different from the way that energy is stored in the human foot. She explains that our feet are built like sprung arches spanned by an elastic tendon (aponeurosis) along the sole of the foot. When we put weight on our feet, the arch stretches the aponeurosis, storing elastic energy to power the push off at the end of a stride.

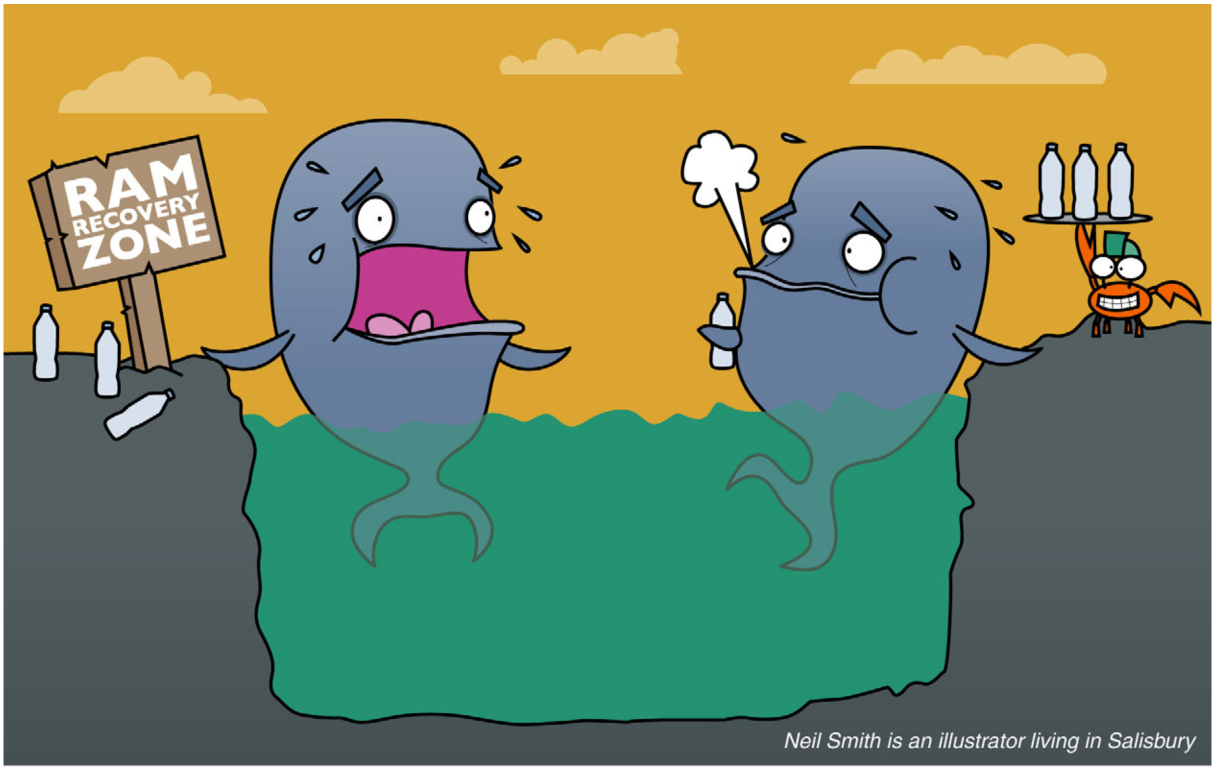
And there were more differences between the gibbon and human walking patterns at the end of a stride. Instead of lifting the foot as one long lever, the gibbon lifted its heel first, effectively bending the foot in two to form an upward-turned arch, stretching the toes' tendons even further and storing more elastic energy ready for release as the foot eventually pushes off.

So what does all this mean for our ape-like ancestors? Vereecke is keen to point out that gibbons are not a perfect model for the ways that early humans may have walked; there are marked differences between modern gibbons and the fossilised remains of early humans. However, modern gibbons live in trees and walk on two flexible feet, just like our ancestors. Her work shows that it is possible to walk quite efficiently with a relatively bendy foot and that our ancestors may have used energy storage mechanisms that are similar to ours, despite their dramatically different foot shapes.

10.1242/jeb.026781

Vereecke, E. E. and Aerts, P. (2008). The mechanics of the gibbon foot and its potential for elastic energy storage during bipedalism. *J. Exp. Biol.* **211**, 3661-3670.

RAM FEEDING COSTS WHALES DEAR



Neil Smith is an illustrator living in Salisbury

Filtering tiny zooplankton from the sea, baleen whales have three options for getting a good mouthful of water. They can slurp it up, swim continually with their mouths open or lung forward intermittently. Jeremy Goldbogen from The University of British Columbia explains that humpback whales and other rorqual species have adopted the lunging approach to feeding. However, their foraging dives are much shorter than the foraging dives of whales that continually filter the sea, which suggests that the energetic cost of lunging is significantly greater than the cost of constant filtering. Curious to know whether lunge-feeding whales breathed harder as a result of their exertions, Goldbogen and colleagues successfully tagged two humpback whales off the California coast to record their foraging lunges and the number breaths they took after returning to the surface (p. 3712).

Analysing the results, the team found that the animals take longer dives when they lunge more. The animals also take more breaths when they return to the surface after a long dive than they do when they surface after shorter dives.

So surfacing humpback whales breath more heavily after a series of lunges, but this doesn't necessarily mean that lunge diving is more energetically costly than simply sitting beneath the surface and not exercising, such as when singing. Comparing dive lengths between lunging and singing whales, Goldbogen found that the singing whales could remain submerged for twice as long, and that lunging whales breathed three times harder when they returned to the surface. So lunge feeding is certainly an energetically costly alternative to other more sedate feeding styles.

10.1242/jeb.026773

Goldbogen, J. A., Calambokidis, J., Croll, D. A., Harvey, J. T., Newton, K. M., Oleson, E. M., Schorr, G. and Shadwick, R. E. (2008). Foraging behavior of humpback whales: kinematic and respiratory patterns suggest a high cost for a lunge. *J. Exp. Biol.* **211**, 3712-3719.

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