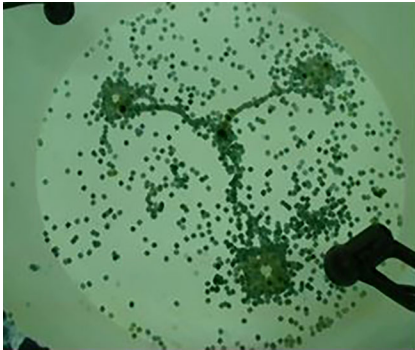


INSIDE JEB

Ants prune to prime transport networks



Ants foraging from three feeders arranged in a triangle.

Since the invention of the internal combustion engine, traffic jams have become an inevitable part of life. ‘One of the problems faced by any transportation system is dealing with changes in traffic congestion’, says Tanya Latty, from the University of Sydney, Australia. ‘Sometimes there are simply more cars on the road than the system can handle’, she explains. And ants frequently face the same dilemma as they scurry along well-established odour superhighways that are continually reinforced by use as they forage. However, Latty explains, ‘Food resources can change in quality’, causing congestion as the determined insects have to respond to a change in circumstances. Knowing that the creatures of habit are almost as wedded to their tried and tested routes as we are to tarmac, Latty and Madeleine Beekman wondered whether Argentine ants can track changes in food quality and, if so, whether they could adjust their transport networks to make the most of changes in their circumstances.

Providing mini ant colonies with a choice of three feeders arranged at the apexes of either a small or a large triangle – one feeder was stocked with a sticky (1 mol l^{-1}) sucrose treat, while the other two provided a more dilute (0.5 mol l^{-1}) food supply – Latty filmed the ants’ antics as they scampered between their nest and each of the reservoirs. Then, Latty systematically switched the location of the tempting concentrated sucrose solution to the position of each of the two other weaker

feeders to find out how the ants responded. ‘The hardest thing in the study was coming up with a rigorous, unbiased way to define “trails”’, admits Latty, who recalls with a chuckle, ‘We initially tried to do this by eye, but we quickly realised that the human brain is very good at seeing patterns, even when they don’t exist’. However, after teaming up with Michael Holmes and James Makinson to investigate the ants’ preferences, patterns eventually began to emerge.

‘In the first few minutes of the experiment, the ants built many trails’, says Latty, adding that the feeder that was filled with the strongest sugar solution rapidly acquired the largest number of trails: the colonies allocated more than 60% of their foragers to plunder the sticky treat. However, when she moved the location of the concentrated sucrose feeder to one of the other feeder sites, Latty was impressed to see that the ants were able to adapt to the changes. Also, instead of constructing new trails from scratch, the ants reinforced existing trails that had previously been underused, while cutting the number of trails leading to the newly diluted feeder. ‘There were enough trails built early in the process for most of the network adaptation to be driven by pruning alone’, she says, explaining that pheromone trails that had been heavily used in their heyday were lost when they fell into disuse and the guiding scents faded.

‘The ants have a remarkable capacity to deal with the various constraints and trade-offs inherent in building a transportation system’, says Latty, who admits that she was surprised by the ants’ versatility. And, having discovered that ant transport networks are significantly more flexible than previously thought, she is eager to learn about the roles of individual ants in shaping their transportation networks and how their memories may help the industrious insects forge new transportation networks as their fortunes change.

10.1242/jeb.156349

Latty, T., Holmes, M. J., Makinson, J. C. and Beekman, M. (2017). Argentine ants (*Linepithema humile*) use adaptable transportation networks to track changes in resource quality. *J. Exp. Biol.* **220**, 686-694.

Kathryn Knight

Exercise protects mosquitofish from UV-B rays



Mosquitofish (*Gambusia holbrooki*) female and male. Photo credit: etrusko25 [CC BY-SA 2.0], via Wikimedia Commons.

From human couch potatoes to captive salmon and even our pets, adopting an active lifestyle can extend life expectancy and improve health. Releasing protective compounds (antioxidants) and enzymes into our bodies that protect against the ill effects of the toxins (reactive oxygen species) that are naturally produced by metabolism, exercise can even reduce the incidence of cancer and the effects of ageing. Knowing this, Frank Seebacher (University of Sydney, Australia) and Craig Franklin (University of Queensland, Australia) wondered whether exercise may also protect animals from the damage caused by a dose of sun. Seebacher explains that exposure to UV-B, one of the wavelengths that causes sunburn, also produces the reactive oxygen by-products that are so damaging to our tissues. So could exercise protect animals from the harmful effects of sun exposure too?

Introduced from the US into Australian river systems with the intention of controlling mosquito populations, the controversial mosquitofish (*Gambusia holbrooki*) seemed like the ideal species with which to test Seebacher’s theory. After collecting the invasive fish from the Manly Dam near Sydney, Seebacher and Ensiyeh Ghanizadeh-Kazerouni kept the fish in tanks of flowing or still

water, and exposed some of the fish to several hours of mild UV-B light each day. Having kept up the different treatments for 2 weeks, Ghanizadeh-Kazerouni then checked the fish's fitness by recording the swim speed at which they became exhausted and their oxygen consumption while swimming steadily. Next, Ghanizadeh-Kazerouni measured the fish's antioxidant capacity and the amount of damage to their muscle caused by reactive oxygen species produced by the UV-B exposure.

Needless to say, the fish that had been training in flowing water were better swimmers than the fish that had had an easy time in the still water, although the exercise did not improve their metabolism – their oxygen consumption was essentially the same as that of the untrained fish. However, the exercise did seem to protect the fish from the damaging effects of UV-B exposure. While the muscles of the unexercised fish were clearly suffering the effects of increased exposure to the reactive oxygen species produced by the UV-B exposure, the exercised fish had lower levels of oxidative damage after receiving the same dose of UV-B rays. And when Ghanizadeh-Kazerouni analysed the strength of the fish's protective antioxidant response, the fish that had been swimming against a current were significantly better protected from damage from reactive oxygen species by a protein (catalase) that neutralises the toxins and a scavenger compound (glutathione).

So it seems that in addition to improving physical fitness, exercise can also provide some protection from the damaging effects of UV-B exposure. However, Seebacher and Franklin are concerned that alterations in rainfall patterns and human activity such as dam building could make fish increasingly vulnerable to the harmful effects of the sun's rays as flow in rivers declines and the fish work out less just to stay still.

10.1242/jeb.156323

Ghanizadeh-Kazerouni, E., Franklin, C. E. and Seebacher, F. (2017). Living in flowing water increases resistance to ultraviolet-B radiation. *J. Exp. Biol.* **220**, 582–587.

Kathryn Knight

Chilean loco snail at risk in future climate scenarios



An adult *Concholepas concholepas* in mussel beds on the Chilean shore. Photo credit: Patricio Manríquez.

The ecological consequences of a predator going on the blink can be catastrophic. Single species can rampage out of control with their natural checks and balances removed, even if the predator is just a snail. Paolo Domenici, from CNR-IAMC, Italy, and Patricio Manríquez, from CEAZA, Chile, explain that the large marine snail *Concholepas concholepas*, a Chilean delicacy known as 'loco', resides along the length of the rocky Pacific coast of Chile and Peru where it dines on several species of mussel, including *Semimytilus algosus*, ensuring that the mussel does not exclude other species. In addition to maintaining biodiversity along the shoreline, the snail is prized by small-scale fisheries, making it vital that we understand the potential impact of rising sea temperatures and CO₂ levels on this species as we continue pumping greenhouse gases into the atmosphere. Because elevated CO₂ levels in water can affect the behaviour of predator and prey alike, Domenici, Manríquez and their colleague Rodrigo Torres decided to find out more about the impact of future climate scenarios on this key Chilean species.

As the lateralization (handedness) of some animals – the direction that they prefer when turning – can alter as CO₂ levels rise, Domenici and Manríquez measured the turning preferences of 40 juvenile locos that had experienced modern-day CO₂ levels and temperatures by tempting them through a T-shaped maze with a delicious morsel of *S. algosus* placed behind a Plexiglas wall. At the end of the channel, the snails were forced to turn either left or right before circumnavigating the obstruction to receive their reward. After filming the snail's painstakingly slow progress eight times, Manríquez then

measured whether the snail turned left exclusively, was right handed, had a slight preference for one or the other direction, or was 'ambidextrous'. Then, Manríquez and Torres began the arduous task of maintaining each of the snails in their own individual mini biodomes for 6 months, setting the temperature at either 15°C or 19°C and the CO₂ level at either 500 μatm (current levels) or 1400 μatm (future levels), before retesting their handedness.

While the snails that had been residing in modern (500 μatm CO₂) mild and warm climate scenarios had retained their handedness, preferring to turn to the side that they had favoured 6 months earlier, the snails that had experienced the future (1400 μatm CO₂) mild and warm climate scenarios had lost their earlier preference and now had a completely different turning behaviour. And when Domenici analysed the snails' overall performances, it was clear that the snails that had been reared in warm future climate conditions were slower when they negotiated the maze, and both groups of future CO₂ snails took longer to decide which direction to turn. The higher CO₂ climate also seemed to impair the ability of the snails to follow their noses and avoid the barrier, often colliding with the obstruction as they attempted to manoeuvre around it, while the snails that had been kept in a lower CO₂ environment negotiated the barrier without impediment.

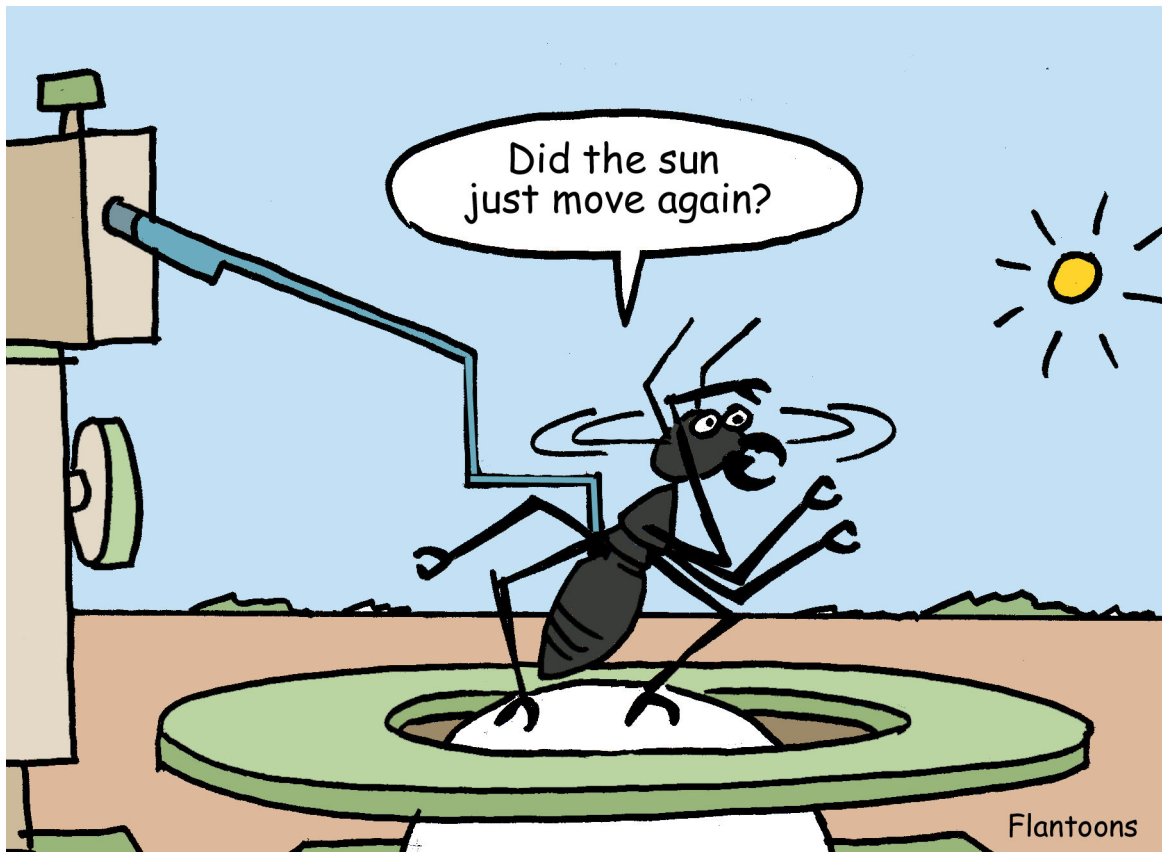
Increases in CO₂ levels similar to those that are predicted to occur by the end of the century had clearly changed the behaviour of this key predator on the rocky Chilean coast and affected the ability of the animals to repeat behaviours that were previously hard-wired. And Domenici is concerned about the effect that future change may have on this delicate ecosystem, saying, 'The negative effects of ocean acidification on locomotion traits associated with prey-finding may cause cascading effects beyond those described at the individual level, such as predator-prey population dynamics and community structure'.

10.1242/jeb.156356

Domenici, P., Torres, R. and Manríquez, P. H. (2017). Effects of elevated carbon dioxide and temperature on locomotion and the repeatability of lateralization in a keystone marine mollusc. *J. Exp. Biol.* **220**, 667–676.

Kathryn Knight

Super-sensitive treadmill reveals details of dainty ant footwork



Keeping things simple is never easy in the real world, and for scientists who want to understand how *Cataglyphis* desert ants exploit their arsenal of navigation tools as they find their way home, it is almost impossible to control every feature of the environment while recording the insects' footwork as they scamper across the desert. Although spherical treadmills, which can track animals' helter-skelter movements, have been available since the late 1960s, none was nimble enough to record every fleet-footed detail of an ant's home run until Matthias Wittlinger, from the University of Freiburg, Germany, teamed up with Hansjürgen Dahmen and Hanspeter Mallot, at the University of Tübingen, Germany, to update the equipment. Redesigning the treadmill with a lightweight hollow Styrofoam ball – suspended on an airbed – that could be manoeuvred by the leggy insects with ease, while tracking the sphere's responses with modified optical mouse sensors, Dahmen was able to successfully

track each twist and turn as ants attempted to find their way home.

However, Wittlinger, Verena Wahl and Sarah Pfeffer needed convincing that ants perched on top of the frictionless sphere were homing as naturally as if they were scurrying across the desert. Relocating the portable treadmill to Tunisia – complete with battery-operated air pump, plastic bottle air reservoir and laptop – Wittlinger, Wahl and Pfeffer trapped ants that had successfully located a feeder stocked with biscuit crumbs in the desert, swiftly attached a pin to each insect's back and tethered it on the treadmill sphere before recording the ant's route home. The ants soldiered directly to the location where they expected to find the nest, before slowing and beginning a meandering search for their missing home. Impressively, the treadmill successfully recorded the minute step-size difference between the outer and inner legs as the ant scoured the surface of the

treadmill for its misplaced nest. And when the trio tricked the ants' navigational compass by rotating the treadmill through 90 deg – in an attempt to send the ants off at a tangent – the insects obliged by switching direction according to the now-shifted position of the sun.

'The possibility to investigate the orientation behaviour of animals mounted on top of the sphere... allows us to analyse complex behaviour in great detail', says Wittlinger, who is keen to begin altering the ants' surroundings to learn more about their homing strategy.

10.1242/jeb.156331

Dahmen, H., Wahl, V. L., Pfeffer, S. E., Mallot, H. A. and Wittlinger, M. (2017). Naturalistic path integration of *Cataglyphis* desert ants on an air-cushioned lightweight spherical treadmill. *J. Exp. Biol.* **220**, 634-644.

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