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Inside JEB

SWIMMING HELPS SIMULATED TURTLES STAY ON COURSE


Ken Lohmann

Pitched against the mighty North Atlantic, it would seem that newly hatched loggerhead turtles would stand little chance of influencing their destiny. Perceived wisdom held that after swimming from their home beach the youngsters got picked up by the powerful currents circulating in the North Atlantic, where they could spend as much as the next 15 years being carried around the ocean. However, Nathan Putman and Ken Lohmann from the University of North Carolina, USA, were less sure. Together with other colleagues, they had already shown that simulations of the magnetic field from various locations in the North Atlantic affected the tiny animals' choice of direction, with the minute migrants selecting the best orientation to keep them in the circulating current. However, many ecologists did not believe that the hatchlings' efforts could influence their North Atlantic odyssey. Intrigued, Putman and Lohmann decided to take a computational approach; they set millions of cyber-turtles loose in a simulated North Atlantic to find out how much they affect their own course (p. 1863).

'We wanted an ocean model that would depict weather events that were forced using wind, so getting a model that was very fine scale was important for those fine scale little animals', says Putman. So, the duo teamed up with oceanographer Thomas Shay from the University of North Carolina, USA, to simulate 5 years of ocean circulation. Then, having successfully constructed their cyber-ocean, they had to figure out how to simulate the turtle voyagers. 'We came across Philippe Verley, who devised this wonderful software that was called ICTHYOP that was designed to study the movement of fish larvae', explains Putman. Visiting Verley at the Laboratoire de Physique des Océans in France, Putman and Verely discussed how they could convert the fish simulations into turtles migrating through the ocean. After a number of modifications to the software, Putman was ready to set hundreds of thousands of simulated turtle hatchlings loose in the cyber-ocean.

Setting the youngsters to swim for 1, 2 or 3 h per day at 0.2 m s^{-1}, the program allowed the turtles to drift with the current for the remainder of the day. Then, when the turtles entered specified regions of the ocean, the program allocated them a swimming direction in roughly the same orientation that the young turtles had selected in the laboratory. 'We were interested in modelling realistic navigation behaviour so we wanted a wide spread of around 80 deg around the directions that the hatchlings had picked', explains Putman.

After months of computation and analysis, the duo realised that even the most minimal amount of swimming had affected the simulated hatchlings' trajectories. Comparing the swimming turtles with simulations of turtles that drifted exclusively, the duo could see that the courses of the swimming turtles were less dispersed than those of the turtles that had been cast purely to the sea. 'The swimming behaviour seemed to be compensating for the tendency of dispersion. It's like the turtles were swimming to make the currents approximate what we see in the textbooks', says Putman.

Having found that swimming for even a tiny fraction of a day could help the simulated turtles stay on course, the duo is keen to track the progress of recently embarked hatchlings to find out how much of an impact swimming makes in practice. 'The plan is to put tiny little tags on turtles. We'll know where the turtle goes, but it won't tell us if they are swimming or drifting, so we'll look at the ocean circulation models along the turtles' paths and subtract the current velocity to determine when they are swimming', explains Putman.

10.1242/jeb.074278

Putman, N. F., Verley, P., Shay, T. J. and Lohmann, K. J. (2012). Simulating transoceanic migrations of young loggerhead sea turtles: merging magnetic navigation behavior with an ocean circulation model. *J. Exp. Biol.* **215**, 1863-1870.

Kathryn Knight

TADPOLE MADTOM VENOM KEEPS PREDATORS AT BAY

Some fish are sitting ducks, waiting to be snapped up by the next passing predator: but not tadpole madtoms. Armed with frills of spines along their dorsal and pectoral fins, and noxious venom glands, these catfish are well prepared for encounters with hungry predators. Jeremy Wright from the University of Michigan, USA, explains that although the venom glands had been assumed to protect their owners from predators, no one had directly tested this

Ohio Department of Natural Resources

idea, because the glands are usually accompanied by the spiky spines, making it impossible to untangle the contributions of each deterrent. So, Wright decided to find out how largemouth bass coped with mouthfulls of tadpole madtom, with and without their spines and venom glands (p. 1816).

Isolating a ravenous largemouth bass with either an intact tadpole madtom – complete with spines and venom glands – or tadpole madtoms that had lost their spines or their venom glands, Wright watched the predator for an hour to find out whether or not it could consume the catfish. Not surprisingly, almost all of the intact madtoms survive unscathed – the largemouth bass only succeeded in consuming one fish during the entire course of the experiment – although the predator didn't give up trying, spitting out the painful prickly mouthful each time. However, the madtoms that had lost their spines or venom glands did not fare as well. The spineless madtoms usually succumbed to the bass within one or two attacks, while the madtoms that had retained their spines but lost their venom glands came under repeated attack. The hungry bass even continued consuming the non-toxic catfish when impaled by their snack's spines.

So it seems that the catfish's venom glands are a significant deterrent to predators, as the largemouth bass were prepared to have a go at spiky tadpole madtoms that had lost their venom glands. Wright says, 'The results imply that in the case of catfish, predator sensitisation and avoidance are disproportionately influenced by the presence of venom glands, rather than the spine itself'.

Identifying the key component in the tadpole madtom's venom that makes them more toxic than other catfish he has investigated, Wright says that this protein may, 'be responsible for providing the significant selective advantage observed in this species' – providing better protection for tadpole madtoms than spines alone.

10.1242/jeb.074286

Wright, J. J. (2012). Adaptive significance of venom glands in the tadpole madtom *Noturus gyrinus* (Siluriformes: Ictaluridae). *J. Exp. Biol.* **215**, 1816-1823.

Kathryn Knight

RECIPE FOR A SUCCESSFUL TOUCH DOWN: FLY STYLE

Floris van Breugel

Landing is tricky at the best of times, but imagine trying to bring down a light aircraft safely without a speedometer or altimeter. That is effectively what a fly does every time it alights. What is more, in order to pull off a successful landing, a fly has to override its instincts. Floris van Breugel from The California Institute of Technology, USA, says, 'The fly's natural response is to turn away from looming objects, but for some reason in this case it decides to land and so we can study how the landing process works and learn how the visual system works'. Intrigued by the insect's graceful manoeuvres, van Breugel and his thesis advisor Michael Dickinson decided to film fruit flies during their final approach and landing to identify the strategy for a successful set down (p. 1783).

Building a flight arena equipped with six 100 frame s^{-1} cameras and a 1.9 cm wide central landing post, van Breugel filmed 12 hungry flies overnight as they buzzed around and alighted on the post. Adding a high-speed camera with a tracking system and automated focus, activated when a fly neared the post, van Breugel was able to capture the final descent in fine, 5000 frame s^{-1}, detail.

Identifying 177 successful landings and 1065 non-landings when the fly veered off, van Breugel then had to work out how to analyse the data. 'There wasn't much to go off in terms of previous papers that looked at things in a similar way', says van Breugel. 'At first I was trying to see if I could understand how the image of the post on the fly eye was influencing its flight', he recalls, but then van Breugel hit upon the idea of analysing the trajectory from the point when the insects began to decelerate.

'We found that they follow a pattern where both their flight speed and distance from the post were important', says van Breugel, adding, 'The flies that were flying really fast slowed down further from the post and the flies that were flying slowly slowed down when they were closer to the post'. But what could this tell van Breugel and Dickinson about how the insects controlled their final approach?

Analysing the fly's eye view of the post as it closed in, the duo realised that the insects were matching the way that the image expanded across the retina with its visual size, forcing fast flies to decelerate more abruptly than more pedestrian insects. The duo also realised that the flies only extended their legs ready for landing when they were almost upon the landing post. Explaining that the flies extended their legs when the image of the post on the fly's retina was 60 deg wide, van Breugel adds, 'The time to touch down after leg extension is on average 50 ms'. However, this is too fast for the final approach to be under visual control, suggesting that the flies switch to autopilot. Describing the final contact, van Breugel says, 'They extend their legs in a stereotypical way, then the front legs stick out, touch the post and then they grab on and swing towards it and land'.

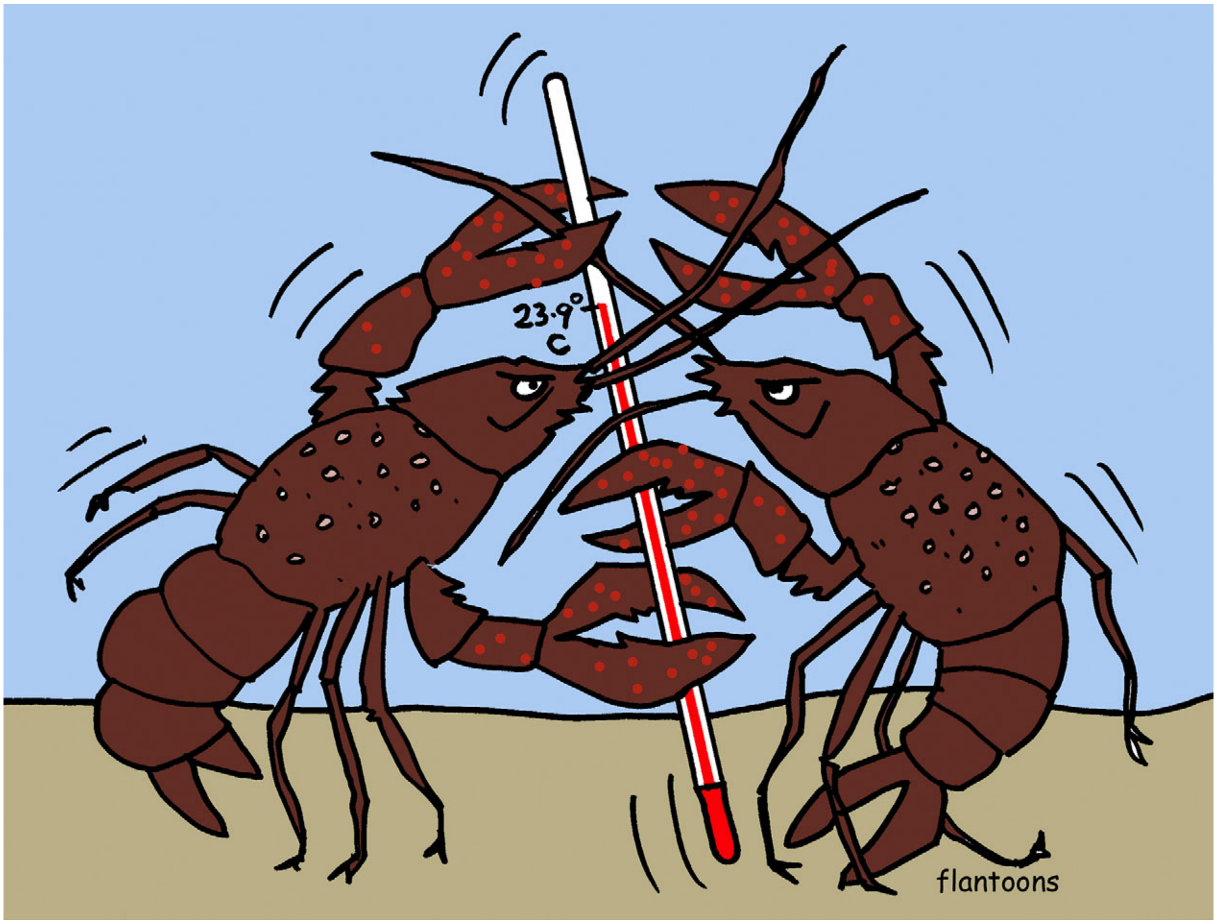
Having identified the fly's landing strategy, van Breugel and Dickinson were curious to find out when the insects that pulled out of a landing aborted the manoeuvre and realised that they took evasive action when the pole landing site was 30 deg wide on the insect's retina. They also investigated the factors that led to less graceful landings and found that the flies that crash landed had not decelerated sufficiently before attempting touch down.

10.1242/jeb.074294

van Breugel, F. and Dickinson, M. H. (2012). The visual control of landing and obstacle avoidance in the fruit fly, *Drosophila melanogaster. J. Exp. Biol.* **215**, 1783-1798.

Kathryn Knight

CRAYFISH COMPETE FOR COMFORTABLE TEMPERATURE



For most creatures, survival depends on the battle for resources; whether it's food, shelter or territory. But could temperature be another resource that cold-blooded (ectothermic) creatures are prepared to compete over? At high temperatures the metabolism of warm ectotherms runs faster, allowing them to be more active while requiring more fuel, whereas less active cooler ectotherms will dine less but may have more energy to devote to growth. Well known for their aggression and for establishing dominance hierarchies, crayfish depend on their surroundings to maintain their body temperature, so scientists from Brock University, Canada, led by Glenn Tattersall and Joffre Mercier, decided to find out whether crayfish were prepared to fight over a location that provides the optimal temperature (p. 1892).

Building a crayfish arena divided into two halves, where each half could be maintained at a different temperature by its own computer-controlled coffee machine, Tattersall teamed up with Joshua Luebbert and Kiel Ormerod to test the crustaceans' temperature preferences. First, they established the crayfish's preferred temperature by slowly altering the temperature in one chamber and allowing individuals to move between the arena chambers to select their preferred temperature. Next, they paired juvenile crayfish together for 3 days to establish and cement their relationship. Then, they offered the crustaceans a choice between a chamber at their preferred temperature and a second chamber that was well outside their comfort zone and either 4°C warmer or cooler than the first.

Monitoring the crayfish, the duo realised that there were hardly any aggressive interactions between the two animals. On occasions, the crayfish managed to share the preferred temperature chamber; however, the dominant animal established itself in possession of the comfortable chamber almost half of the time with the subordinate crayfish readily backing down to make do with the hot or cold alternative. 'The established hierarchy did not exhibit conflict over the preferred temperature', says Tattersall.

However, when Tattersall and Olivia LePine repeated the experiments with crayfish that had only just been introduced to one another, it was a different story. This time, despite establishing their relative status within half an hour, the subordinate crayfish continued challenging the dominant inhabitant for access to the preferred temperature chamber.

So, crayfish are prepared to fight to gain access to locations where the temperature best matches their lifestyle and they resolve their battles differently, depending on their social history. Tattersall says, 'Being too warm appears to be a condition that forces them to fight more during shared bouts at their preferred temperature. Likely, the warm temperatures are perceived as thermally more stressful than cold temperatures'.

10.1242/jeb.074302

Tattersall, G. J., Luebbert, J. P., LePine, O. K., Ormerod, K. G. and Mercier, A. J. (2012). Thermal games in crayfish depend on establishment of social hierarchies. *J. Exp. Biol.* **215**, 1892-1904.

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