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INSIDE JEB

Queen ants from other species smell different

A male (left) and a worker (right) *Odontomachus ruginodis* ant. Photo credit: Adrian Smith.

Communication is essential for any efficiently functioning community, and social ants are no different. 'Division of reproductive labour – with a queen who specialises in reproduction and female workers who do not reproduce – is a defining characteristic of insect societies', says Adrian Smith from the North Carolina Museum of Natural Sciences and North Carolina State University, USA. And this division of labour only works if the female workers can distinguish queens from fellow labourers. 'This is an essential communication task that all ants have to figure out', he says. But little is known about how most of the 14,000 ant species communicate their position in the hierarchy, although recent evidence had suggested that all social insects use the same specialised odour (pheromone) molecules. 'The problem was, this was based on comparing single, distantly related species', says Smith. So, he and Andrew Suarez from the University of Illinois at Urbana-Champaign, USA, decided to compare the aroma profiles of three species of closely related trap-jaw ants (*Odontomachus*) to find out whether all ant queens smell similar to each other.

Having dug ant colonies out of the ground and rotten logs in south Florida and Alabama, Smith had little trouble keeping the insects happy in the lab in artificial nests built from plaster-lined Petri dishes and tubes. 'They usually hunt live insects for food, so we gave them termites to hunt and feed to their larvae', Smith says. Then, he began painstakingly collecting samples of the wax odours coating the ants' bodies – from queens, female workers and male drones – ready for chemistry sleuth Jocelyn Millar, from the University of California Riverside, USA, to analyse by gas chromatography–mass spectrometry.

Comparing the chemical profiles of the queens' odours with those of workers of their own species, it was clear that the queens' odours differed significantly from the worker scents, although the monarchs and labourers shared some compounds. However, it was also evident that the profiles of the chemicals that contributed to the odours of the *O. ruginodis*, *O. relcitus* and *O. haematodus* queens were dramatically different too. Most surprisingly, *O. ruginodis* queens seemed to be sporting scent molecules – 2,5-dialkyltetrahydrofurans – that Smith had never seen before in a waxy ant coating; he recalls that Millar had to resort to some sophisticated chemistry to identify the molecule. However, when the duo analysed the odour profiles of the males from all three species, they found that the odours were much more similar to each other and the males all produced more pentacosadienes, pentacosenes and tricosanes to distinguish themselves from their females.

Puzzled by the intriguing composition of the *O. ruginodis* queen's aroma, Smith wondered whether the novel dialkyltetrahydrofurans molecules communicated a regal presence. Having first confirmed that worker ants recognised a queen ant and submissively withdrew their antennae when the queen was near, Smith bathed several queen ants in a solvent to collect their odour cocktail. Then, he separated the dialkyltetrahydrofurans (and other similar compounds) from the waxy components and checked the workers' reactions to each mixture individually. This time, neither the waxes nor the dialkyltetrahydrofurans produced a submissive response. So, the workers only recognised that the dialkyltetrahydrofurans were being produced by a queen when the molecules were in the context of the other background scents.

Having found that queens of different species do not use the same odour compounds to communicate their reproductive roles, Smith is keen to learn more about how the remaining 65 species of trap-jaw ants interpret scent communications to maintain their reproductive division of labour. 'There is a whole lot left to discover', he chuckles.

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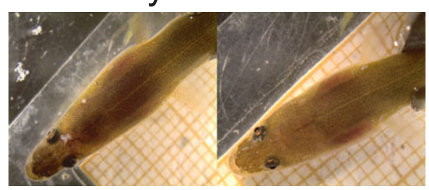
Smith, A. A., Millar, J. G. and Suarez, A. V. (2016). Comparative analysis of fertility signals and sex-specific cuticular chemical profiles of *Odontomachus* trap-jaw ants. *J. Exp. Biol.* **219**, 419-430.

Kathryn Knight

Eel heads shaped by what they eat



Elver eels with wide and narrow heads. Photo credit: Jens De Meyer.

Arriving at the mouths of northern Europe's cold rivers, minute eel larvae are on the verge of a major life transition. Jens De Meyer from Ghent University, Belgium, explains that when the tiny creatures leave the sea, they transform into transparent glass eels ready to embark on the tough journey upstream, where they spend the next 3–12 years and develop into sub-adult yellow eels. However, by the time they are fully grown and ready to begin the gruelling return journey to the Sargasso Sea, some of the eels have developed long narrow heads, while others have broad heads. 'It is very interesting to find out how and when this dimorphism develops during the eels' life cycle', says De Meyer. Speculating that the animals' head shapes could be influenced by their diet, De Meyer and Joachim Christiaens headed to sluice gates at the mouth of the Leopold Canal in Belgium to capture glass eels in order to find out how diet affects the animals' heads.

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Dividing the eels into three groups, the duo put each on a strict diet; one received hard food, the second had a soft diet and the third group received a mixture of the two. 'Selecting the diet was the most difficult part', recalls De Meyer, explaining that it had to be varied enough to give the animals on the hard diet a good workout whereas the eels on the soft diet would consume the same nutrients while having an easier time. After searching the literature, De Meyer and Dominique Adriaens selected several species for the animals to dine on: 'Then we observed their feeding behaviour', De Meyer recalls, adding, 'When they required biting or spinning behaviour, we considered it to be "hard food"; however, when the prey could be sucked in, we considered it "soft prey"'. Finally, they photographed the glass eels' heads once a month over 5 months and analysed the growth to see whether diet altered head development.

Amazingly, by the end of the test period, the team could see clear differences in the small eels' head shapes. The animals on the hard diet had wider heads that could accommodate larger jaw muscles for biting hard, while the eels that had been fed a soft diet had slender heads. 'We did not expect such a rapid and pronounced diversification in head shape', says De Meyer, adding that the differences had been thought to emerge after the animals had transformed into growing yellow eels. And when De Meyer investigated the eels that had been provided with a mixed diet, some of the animals had broad heads while others had narrow ones. 'This suggests that when eels are given the choice, some prefer hard prey and others soft. This difference in prey preference could decrease the competition for food in eels and thus increase their survival' he says.

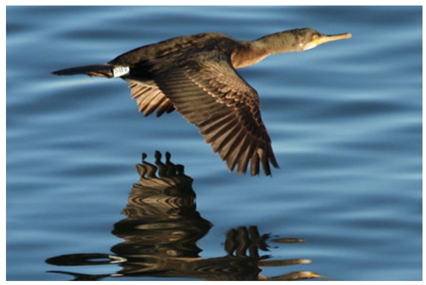
However, De Meyer adds that there are concerns for the welfare of eel populations in Europe's rivers and he warns that the broad-headed animals may be at greater risk from pollution than the narrow-headed animals, because they are further up the food chain and consume a diet that has already accumulated more pollutants. He says, 'Our study shows that this difference in the position in the food chain can be present very early in the eels' life cycle', and he hopes that a better understanding of how diet affects these animals could be vital in re-establishing eel populations in Europe's depleted rivers.

10.1242/jeb.137489

De Meyer, J., Christiaens, J. and Adriaens, D. (2016). Diet-induced phenotypic plasticity in European eel (*Anguilla anguilla*). *J. Exp. Biol.* **219**, 354-363.

Kathryn Knight

Shags take advantage of headwind to take off



Shag in flight. Photo credit: John Howard.

During the nesting season, the pressure is on for avian mums and dads to provide as much nourishment as possible for their chicks. For seabird parents, this can mean costly foraging trips across the waves. Katsufumi Sato from the University of Tokyo, Japan, explains that it was thought that seabirds may improve their flight cost efficiency by flying into headwinds to increase their air speed (the speed relative to the prevailing wind). However, it was not known whether birds actively choose to fly into the wind to reduce their costs and few studies had recorded seabird flights in enough detail to find out whether the seabirds take advantage of headwinds. So, Sato and his colleagues Yukihisa Kogure and Yutaka Watanuki added tiny accelerometers to the new generation of lightweight GPS tracking systems, which enabled them to use the equipment to follow foraging seabird flights with sufficient accuracy to assess whether the wind helps improve their efficiency.

Travelling to Scotland to work with long-term collaborators Francis Daunt and Sarah Wanless from the Centre for Ecology & Hydrology, UK, Sato and his colleagues were ready to track the flights of foraging European shags. Over three consecutive breeding seasons, the scientists caught the boat to the Isle of May off Scotland where they carefully attached accelerometers and GPS trackers to the necks and backs of 14 male shags before returning the birds to their nests. Then, having measured the wind speed at the highest point on the island and after successfully retrieving the data loggers, Sato and Kogure were faced with the gargantuan task of reconstructing the bird flight paths from thousands of GPS coordinates, in addition to measuring the birds' wing beat patterns from the acceleration traces, before calculating the birds' flight and air speeds.

Having analysed 147 flights, Sato and Kogure could see that the birds flapped their wings harder during take-off from the water than when cruising through the air, suggesting that they were expending more energy as they became airborne. Also, all of the birds took off into a headwind regardless of their final destination, to take advantage of the lift generated by the wind rushing towards them. And on two occasions – when the wind speed was in excess of 8 m s^{-1} – the birds were able to become airborne without the usual exertions by simply flapping their wings as if they were cruising.

However, once they were aloft, the wind direction seemed to have little effect on the shags' choice of course, with the birds flying in all possible directions. And when the team estimated the birds' air speed, by subtracting the wind speed from the ground speed, they found that it was relatively stable at around 15 m s^{-1}, unless the birds were flying into a strong headwind, when they flapped their wings harder and increased their air speed. The team suspects that instead of flying at the lowest power that allows them to remain aloft, European shags fly at a speed that allows them to travel the greatest distance for the least energy consumed during the flight. They also suggest that the birds are able to adjust their flight strategy to take the greatest advantage of any assistance that the wind can give them. However, they warn that the stronger winds that are predicted as a consequence of climate change could have beneficial and detrimental effects on foraging shags, giving the birds a helping hand to take off while hampering them as they battle headwinds once airborne.

10.1242/jeb.137497

Kogure, Y., Sato, K., Watanuki, Y., Wanless, S. and Daunt, F. (2016). European shags optimize their flight behavior according to wind conditions. *J. Exp. Biol.* **219**, 311-318.

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