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Locust navigation centre tracks sun and polarisation

Locust head, focusing on the eyes. Photo credit: Uta Pegel and Uwe Homberg.

Many creatures that embark on their inaugural migration benefit from the guidance of more experienced voyagers, but this is not so for novice locusts. The parents of these intrepid voyagers will never have ventured along the same route: 'It is usually different generations that complete a seasonal migration in the course of a year', says Uwe Homberg from Philipps-University, Germany. Many navigating insects depend on the pattern of polarised light in the sky (generated by air molecules scattering light) and the shifting pattern of colours as the sun passes over from dawn to dusk for orientation. With this in mind, Homberg and his colleagues, Uta Pegel and Keram Pfeiffer, wondered whether the neurons that sense polarised light also respond to other features in the sky. However, measuring the responses of individual neurons in the brain is challenging in the insects' natural environment. Instead, Pfeiffer built a system of lights where the team could simulate various effects of the sun moving across the sky as they measured the electrical signals generated in locust brains to learn more about the insects' sense of direction.

'Locusts have a long history of being a subject in studies on the nervous system… therefore, we know a lot about the organisation of their nervous system', says Homberg, who decided to focus on the central complex, a region of the brain that is known to be involved in navigation and the detection of polarised light in several migratory species. Pegel recorded the response of selected neurons from this brain region to polarised light that was gently rotated above the locust's head and confirmed that the neurons respond to polarised light when they fired off electrical signals with increasing frequency as the polarisation angle varied.

Then the duo positioned a light (either green or UV) at an angle of 45 deg above the insect's head and moved it in a circle around the locust while recording the electrical signals in the same neurons. 'We reasoned that green light might be interpreted as being the sun, while UV light could have been interpreted as being somewhere in the hemisphere of the sky opposite to the position of the sun', says Homberg. Again, the neurons' response increased strongly as the light approached one location on its circuit around the locust's head and decreased after passing through. 'The brightest light in the desert is most likely the sun', says Homberg, suggesting that these neurons probably register the position of the sun as it sweeps from east to west during the day.

However, having hoped that the locusts would be able to extract additional orientation information from different colour features in the sky, Homberg and Pegel were surprised that the neurons did not distinguish between green and UV shades. 'It was hard to figure out that this finding was not related to the configuration of the setup or the rearing of the animals', says Homberg, who even raised some of the insects outside in the sun to make sure that the neurons' insensitivity to colour was genuine.

Having systematically recorded how the insects' brains responded to different forms of light, Homberg concludes, 'The neurons of the central complex that code for the plane of polarisation additionally respond to the azimuth (the horizontal position) of an unpolarised light spot', allowing the insect to navigate according to the position of the sun. And he is now hoping to take his study outside to investigate how the insect's brain responds to real visual features in the sky.

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Kathryn Knight
kathryn.knight@biologists.com

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