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INSIDE JEB

Mini-ants manage vision miniaturisation

A seed harvesting ant worker (*Pheidole* species) standing on the eye of a bull ant, *Myrmecia tarsata*. Photo credit: Ajay Narendra.

Miniaturisation doesn't seem to be a problem for Ant-Man when he climbs into his suit and shrinks, but the mini-superhero could face challenges he hadn't bargained for. For example, water and air become super sticky at microscopic scales and tiny creatures lose heat faster than bulkier bodies. But what effect does being small have on vision and the way that mini-beasts see the world? Does shrinking the eye affect how much detail an animal can see and how well objects stand out from the background? Intrigued by the question, Ajay Narendra from Macquarie University, Australia, turned to Ant-Man's namesakes. 'Quantifying this in ants was really a no-brainer', he chuckles, pointing out that ants rely heavily on vision and they vary enormously in size. But, most importantly, there were hordes of different species right on Narendra's doorstep.

Choosing to investigate the vision of ants ranging in size from massive bull ants (*Myrmecia tarsata*) to medium-sized jack jumpers (*Myrmecia nigrocincta*), and tiny spiny ants (*Polyrhachis nr aurea*) and *Rhytidoponera inornata*, Ravindra Palavalli-Nettimi and Yuri Ogawa braved the insects' vicious stings, bringing a handful back to the lab. Cautiously painting clear nail varnish over the insects' eyes, Palavalli-Nettimi and Ogawa produced almost perfect minute casts of the structures to measure the lens size and number. Not surprisingly, the eyes of the biggest bull ants had the largest (∼22 µm wide) – and highest number of (∼2627) – lenses, while the middle-sized jack jumpers squeezed a similar number (∼2483) of smaller lenses into their eyes. Meanwhile, both of the smaller ant species had far fewer lenses, with the eyes of the tiny *R. inornata* containing only ∼227 minute lenses, averaging 12.75 µm across. But how well could the ants see in practice?

Knowing that Laura Ryan and Nathan Hart had recently developed a technique that allowed them to assess how clearly sharks see – by measuring minute voltage changes in the eye – Palavalli-Nettimi and Ogawa adapted the method to record how well the ants could see flickering black and white bars as the duo varied the bar thickness and how well they stood out from the background. 'The most challenging task was to obtain a good signal-to-noise ratio in the smallest ant', says Palavalli-Nettimi, who resorted to shielding the delicate ant eyes from stray electric and magnetic fields with a Faraday cage so he could record the weak voltages.

Amazingly, when the team eventually compared the ants' eyesight, the minute *R. inornata* could see almost as clearly as the heftiest *M. tarsata* bull ants. 'The smallest ants had only 8% of the facets [lenses] of the largest ants, but had 80% of their spatial resolution', says Narendra. And, when the team compared how well objects stand out for the differently sized insects, the heavyweight bull ants had the upper hand, able to pick out faint objects that were only 6.4% brighter than their background, in contrast to the diminutive *R. inornata* ants, which could only distinguish objects that were 74.1% brighter. 'This shows that smaller ants place more emphasis on spatial resolving power than contrast sensitivity', says Narendra. However, when the team compared how long the insects' eyes took to respond when a light flicked on, the smaller ants response time was ∼260 ms, in contrast the bull ants' speedy ∼106 ms, 'which may allow them [*R. inornata*] to improve their contrast sensitivity', says Narendra.

So, the eyesight of mini-ants is poorer than that of their outsized cousins, but not as weak as their size difference might suggest, and Narendra is keen to see how other insect species deal with the challenge of miniaturisation.

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