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MODEL ORGANISMS

New tools, new insights — probing social behaviour in ants

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Eusocial insects display complex social behaviours, but the underlying molecular mechanisms are largely unknown. Now, a trio of papers in *Cell* decribe two genes (*orco* and *corazonin*) that control social behaviour in ants. Furthermore, two of the studies describe the first mutant lines in ants, which were generated by CRISPR–Cas9 genome editing.

Most social behaviours in ants are mediated by pheromones. An obvious difference between the chemosensory receptor repertoires of ants and non-social insects (such as *Drosophila* spp.) is that ants have a much greater number of olfactory receptors (ORs). To test whether ORs mediate the complex social behaviours that differentiate ants from non-social insects, two different groups of researchers used CRISPR–Cas9 genome editing to generate mutations in the *orco* gene, which encodes a highly conserved olfactory co-receptor that is essential for the function of all ORs. Until now, functional genetic studies have not been possible in ants because, by definition, only the queen can reproduce in eusocial species. Trible *et al.* bypassed this problem by generating *orco* mutant lines in *Ooceraea biroi*, a parthenogenetic ant species; germline modifications are transmitted to all progeny because they are maternal clones. By contrast, Yan *et al.* harnessed the unusual reproductive strategy of *Harpegnathos saltator* to increase the number of reproducing ants to enable them to establish *orco* mutant lines. In the absence of a queen, non-reproductive *H. saltator* workers can become 'gamergates', which lay fertilized eggs. This caste transition can be replicated in the lab simply by isolating workers.

Despite *O. biroi* and *H. saltator* having diverged 120 million years ago, both *orco* mutant lines had strikingly similar phenotypes. As expected, workers displayed a range of behavioural phenotypes consistent with a general loss of olfactory perception. However, unexpectedly, the number of glomeruli in the antennal lobes of the brain was dramatically reduced in *orco* mutant ants, as was the number of olfactory sensory neurons in the antennae. This dramatic neuroanatomical phenotype was consistent in both ant species but was not observed for *Drosophila melanogaster orco* mutants, which points to a possible role for *orco* in antennal lobe development and/or maintenance specifically in social insects.

In the third study, Gospocic *et al.* exploited the worker–gamergate transition of *H. saltator* to investigate the mechanisms regulating caste-specific behaviours. They identified *corazonin*, which encodes a neuropeptide, as a highly expressed worker-biased gene and showed that its caste-specific RNA expression is conserved in other insect species with different social systems. In ants undergoing the worker–gamergate transition, high corazonin peptide levels promoted worker-specific behaviour and inhibited behaviours associated with progression to the gamergate caste; as expected, short interfering RNA (siRNA) knockdown of the *corazonin receptor* (*CrzR*) gene had the opposite phenotypic effect. The researchers went on to identify the *vitellogenin* gene as a key regulatory target of corazonin; its expression is consistently downregulated in response to increased corazonin levels, suggesting that corazonin and vitellogenin have opposing effects on caste identity. Consistent with this hypothesis, siRNA knockdown of *vitellogenin* gene expression promoted worker-specific behaviours. Based on these observations, the authors propose that caste-specific behaviours and caste identity in *H. saltator*, and possibly other social insects, are regulated by a corazonin–vitellogenin axis.

The genetic uniformity of ant colonies, combined with the diverse social systems within ant species, makes them an excellent model for studying the molecular underpinnings of complex social behaviours. The development of functional genetic tools in two ant species further expands their utility as model organisms. *O. biroi* allows fast and efficient generation of multiple mutant lines, while *H. saltator* paves the way for future implementation of more sophisticated genetic tools that, for example, allow inducible gene expression.

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ORIGINAL ARTICLES Trible, W. *et al.* orco mutagenesis causes loss of antennal lobe glomeruli and impaired social behavior in ants. *Cell* **170**, 727–735.e10 (2017) | Yan, H. *et al.* An engineered orco mutation produces aberrant social behavior and defective neural development in ants. *Cell* **170**, 736–747.e9 (2017) | Gospocic, J. *et al.*The neuropeptide corazonin controls social behavior and caste identity in ants. *Cell* **170**, 748–759.e12 (2017)

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