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Convergent phenotypes but non-convergent genomes in simple social insect societies

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Convergent evolution generates remarkable phenotypic similarities in organisms with contrasting evolutionary histories. Does evolution use the same molecular pathways to generate the same phenotypes in different lineages? Social insect castes include some the most impressive examples of convergent phenotypic evolution. We address this question using two sympatric species of social insect: the dinosaur ant *Dinoponera quadriceps* and the paper wasp *Polistes canadensis*. At the behavioural level, both species exhibit similar within-caste behaviours, and a simple social structure. At the evolutionary level, however, they have contrasting histories: *Dinoponera* evolved from a highly eusocial ancestor, representing a reversion to simple sociality. *Polistes* are ancestrally primitively eusocial, representing the early stages of caste evolution. Here we present the first genome sequences for these species, and compare individual-level caste-specific transcription, methylation and microRNAs at the gene, functional-group, and modular (network) level. At the broad-scale, behavioural phenotypes in both species show convergent genomic properties: less than 5% of the genome is caste-biased; there is an extreme asymmetry in caste-biased transcriptional investment, but very little functional enrichment. Conversely, gene identities, functional enrichment, methylation and microRNAs associated with castes in the two species were largely non-convergent. Exceptions included a small number of 'toolkit' genes, and some shared functional enrichment among the reproductive phenotypes. In each species, a substantial proportion of differentially expressed genes were novel, putatively non-coding, genes. These data reveal broad-scale molecular hallmarks underlying simple behavioural castes that are common to phenotypes at the origin of sociality (*Polistes*) and secondarily derived (*Dinoponera*). However, they also suggest that the role of conserved genes and regulatory processes in convergent phenotypes is not as important as previously thought. It appears there has been substantial molecular re-wiring in eusocial evolution, as expected if non-social traits are lost, and new social traits evolved in the evolution of complex eusociality.