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Specialization and plasticity in a primitively social insect

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Biological systems not only have the remarkable capacity to build and maintain complex spatio-temporal structures in noisy environments, they can also rapidly break up and rebuild such structures. How such systems can simultaneously achieve both robust specialisation and plasticity is poorly understood. Here we use primitive societies of Polistes wasps as a model system where we experimentally perturb the social structure by removing the queen and follow the re-establishment of the social steady state over time. We use a unique experimental strategy correlating time-resolved measurements across vastly different scales of biological organisation at the level of individual insects, from video recordings to multi-modal sequencing of brain gene expression and DNA methylation profiles. In combination with a theoretical approach, here we show that Polistes integrates antagonistic processes on multiple scales of biological organisation to distinguish between intrinsic perturbations of molecular states and extrinsic cues affecting the society as a whole, and thereby achieves both robust specialisation and rapid plasticity. Furthermore, we show that the long-term stability of the social structure relies on dynamic DNA methylation which controls transcriptional noise. Such dynamics provide a general principle of how both specialization and plasticity can be achieved in biological systems.

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