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The evolution of complexity in social organization—A model using dominance-subordinate behavior in two social wasp species

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HIGHLIGHTS

- ▶ Varying complexities in two eusocial wasp species *R. marginata* and *R. cyathiformis*.
- ▶ Dominance patterns vary differently across species w.r.t. hierarchical ranks.
- ▶ A model suggesting a common interaction pattern with simple changes in strategies.
- ▶ The model could give rise to the observed patterns in both the species.
- ▶ A possible pathway for the evolution of complex societies from simpler ones.

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ABSTRACT

Dominance and subordinate behaviors are important ingredients in the social organizations of group living animals. Behavioral observations on the two eusocial species *Ropalidia marginata* and *Ropalidia cyathiformis* suggest varying complexities in their social systems. The queen of *R. cyathiformis* is an aggressive individual who usually holds the top position in the dominance hierarchy although she does not necessarily show the maximum number of acts of dominance, while the *R. marginata* queen rarely shows aggression and usually does not hold the top position in the dominance hierarchy of her colony. In *R. marginata*, more workers are involved in dominance-subordinate interactions as compared to *R. cyathiformis*. These differences are reflected in the distribution of dominance-subordinate interactions among the hierarchically ranked individuals in both the species. The percentage of dominance interactions decreases gradually with hierarchical ranks in *R. marginata* while in *R. cyathiformis* it first increases and then decreases. We use an agent-based model to investigate the underlying mechanism that could give rise to the observed patterns for both the species. The model assumes, besides some non-interacting individuals, the interaction probabilities of the agents depend on their pre-differentiated winning abilities. Our simulations show that if the queen takes up a strategy of being involved in a moderate number of dominance interactions, one could get the pattern similar to *R. cyathiformis*, while taking up the strategy of very low interactions by the queen could lead to the pattern of *R. marginata*. We infer that both the species follow a common interaction pattern, while the differences in their social organization are due to the slight changes in queen as well as worker strategies. These changes in strategies are expected to accompany the evolution of more complex societies from simpler ones.

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1. Introduction

Group living animals display fascinating diversity in their social systems. Even within the class of the 'truly' social or eusocial species, there exists a considerable degree of variation

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in their social development. Eusociality, which is characterized by reproductive division of labor, cooperative brood care and overlap of generations, is mainly seen in ants, bees, wasps and termites (Wilson, 1971). The presence or absence of morphologically distinguishable reproductive and non-reproductive castes is used to further subdivide eusocial species into highly and primitively eusocial respectively (Wilson, 1971). Honeybees and many species of ants are examples of advanced or highly eusocial societies; their colonies are usually large, consisting of thousands of