

Mutualistic networks emerge from the interplay of abundance, behaviour and spatial constraints

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Abstract-

Mutualistic interactions between species form complex networks that shape evolutionary and ecological processes. Traditionally, these networks have been studied at the species level, with species abundance and traits proposed as key structuring mechanisms. However, such approaches often fail to explain commonly observed network structural patterns, which have consequences for community stability and functioning.

This limitation may stem from overlooking fine-scale interactions between individuals, the actual network building blocks. By shifting the focus from species to individuals, here we aim to better understand the mechanisms shaping mutualistic networks using plant–pollinator assemblages. To do so, we combined field data on pollinator visitation to individual plants and agent-based models (ABMs) within a Bayesian framework.

We found that explaining a key network structural pattern, the pollinator community degree distributions, required accounting for species abundances, distinct pollinator behaviours, and plant spatial configurations. These factors determined the probability of interactions between individuals and altogether explained a substantial portion of the degree distribution variation even without including specific trait-matching mechanisms. Nevertheless, our predictive ability varied across different flowering stages, highlighting that distinct mechanisms operate across time.

By integrating empirical data with individual-based modelling, we were able to capture details of interactions occurring in the real world, revealing how fine-scale processes shape community-wide network structure and offering new insights into the emergence of complex ecological networks.

Index Terms- agent-based models, complex networks, individual-based modelling, mutualism, network topology, plant–pollinator interactions, pollination, spatially explicit networks

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Citation:

Arroyo-Correa, B.; Bartomeus, I.; Castro, M.; Galeano, J. "Mutualistic networks emerge from the interplay of abundance, behaviour and spatial constraints", *Journal of Animal Ecology*, , .