

Coral assemblages and neutral theory

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Abstract

Neutral theory explains patterns of biodiversity based solely on speciation, demographic stochasticity, and dispersal limitation. The validation of this controversial theory depends on empirical support and it has been largely untested in marine communities. Coral assemblages have been repeatedly invoked as the animal communities most likely to conform to the assumptions of neutral theory. This thesis tested the hypothesis that neutral theory explains the macroecological structure of coral assemblages.

Firstly, I assessed whether neutral models can accurately characterise coral species abundance distributions across multiple scales. Simulation-based and analytical neutral models were fitted to a hierarchical dataset of coral species abundance distributions from across the Indo-Pacific gradient of biodiversity. The dataset has three replicate habitats (slope, crest and flat), and three spatial scales (site, island and region). Both models exhibit significant lack of fit to empirical data at the site and island scales, but not at the region scale. The neutral model consistently underestimates the number of rare species, and overestimates the number of common species. Additionally, the neutral model fits coral abundance distributions less accurately than the poisson-lognormal at all scales. Using two formulations of neutral theory, and two goodness-of-fit tests, along with comparisons with the lognormal distribution, ensures that the inferences about coral assemblages and neutral dynamics are robust. Neutral model predictions are consistently and significantly different from observed coral species abundance distributions.

Secondly, I developed a novel test of neutral theory that examines variability between communities of species relative abundances. In neutral communities, species

relative abundances are determined by demographic stochasticity or “ecological drift”. Thus, communities diverge through time, and are expected to have low community similarity. In contrast, niche apportionment mechanisms have been invoked to argue that higher levels of community similarity should be observed under niche assembly than under neutral dynamics. These contrasting predictions provide an ideal opportunity to test neutral models against empirical data. Relative abundances of species across local communities differ markedly from neutral theory predictions: coral communities exhibit community similarity values that are far more variable, and lower on average, than neutral theory can predict. Surprisingly, empirical community similarities deviate from the neutral model in a direction opposite to that suggested in previous critiques of neutral theory. Instead, the results support spatio-temporal environmental stochasticity as a major driver of community structure at the macroecological scale.

Thirdly, I unveiled a coral local community species abundance distribution. Community structure patterns are notoriously sensitive to sampling issues, and a comprehensive characterization of such patterns requires extremely large sample sizes. Consequently, the fit of biodiversity models to species abundance distributions, and parameter estimates in particular may be sensitive to sample size. To address these questions, over 44,000 corals were counted and identified to species at an exposed crest in Lizard Island, Great Barrier Reef. A neutral model was fitted to the species abundance distribution of the total dataset, and to sub-samples of various sizes. Parameter estimates and fit of the neutral model at different sample sizes were compared. The unveiled species abundance distribution appears to be multimodal. Parameter estimates are not affected by sample size.

These results strongly indicate that the limited suite of ecological and evolutionary processes included in neutral theory do not suffice to explain diversity patterns in coral assemblages. In combination, the three approaches included in this thesis suggest that neutral theory is most useful as a null model for community structure. Furthermore, the thesis highlights differences in species' responses to environmental fluctuations as a potential major driver of species abundance patterns.

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