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CENTRE FOR THE SYNTHESIS AND ANALYSIS OF BIODIVERSITY

Project summary

FUNCTIONALWEBS

The functional diversity of food webs: linking ecology, physiology and biogeography

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Trait-based ecology recasts community ecology's central question about species coexistence as: which processes determine the functional trait composition of ecological communities? Spatial scale is implicit in this question, as different processes are expected to act at different scales.

Context and objectives

Community ecology has struggled to provide predictive models that link environmental drivers with the structure of biological communities. Greater progress could be made by focussing on the functional traits of species (their physiological, biological and ecological attributes), rather than on their identities. We are specifically missing analyses of trait diversity at large spatial scales where dispersal between sites is rare, so that we cannot determine if functional diversity in general is constrained local resources or limited by dispersal, evolution, or biogeography. Our focal system (the invertebrates inhabiting water-filled bromeliad leaves) has been sampled from 22 neotropical locations, and the dataset (850 taxa; 1750 bromeliads; 12 traits; environmental variables) has been collated in an SQL database. Our fundamental question is: which processes determine functional community structure at different spatial scales? We ask 3 sub-questions: (i) Are invertebrate communities in a single bromeliad non-randomly assembled in terms of functional traits? (ii) Within a site, does the distribution of functional traits change predictably over environmental gradients? and (iii) Is there convergence in the functional structure of communities over a broad biogeographic range ; alternatively, does functional community structure primarily depend on biogeographic regions?

Methods and approaches used for the project

We have documented twelve nominal traits with a number of modalities, or states, using a fuzzy-coding technique. Principal Component Analysis was used to reduce trait dimensionality to significant axes of trait variation, and the proportion of potential trait space that was actually occupied by all taxa was compared to null model expectations. Permutational Analyses of Variance were used to test whether trait combinations are clade-dependent. We mostly used mixed effect models and structural equations models to test trait-environment and trait-niche relationships, and null models to control for statistical artifacts.

Principal conclusions

The ecological strategies of species aligned with their position on the evolutionary tree of life, suggesting that the evolution of novel trait combinations is very slow. Hence, taxonomically diverse communities may have only limited numbers of ecological strategies to cope with environmental change. Not only evolutionary constraints shape functional community structure, the particular responses of the community to local environmental resources changed with bioclimatic conditions. Neither a universal trait hypothesis (structuring of communities by niche processes, so trait-environment relationships are consistent across geographic regions despite taxonomic turnover) nor a biogeographic dependence hypothesis (trait-environment relationships change between regions due to large changes in species pools) were strongly supported by our results. Niche processes appeared to play a weak role for small-scale environmental heterogeneity, and a stronger role at scales characterizing elevational gradients, meaning that similar environmental gradients create different challenges for invertebrates at different sites.

Anticipated (or actual) impact of these results for science, society, and public and private decision making

Our approach of explicitly examining functional trait diversity across multiple trophic levels and spatial scales provides an important template for the emerging field of functional biogeography, a branch of ecology that posits that species

functional traits provide a powerful currency of investigation to predict the impact of environmental change on ecosystem functions based on different levels of biological organization and across biogeographic regions and habitat types. Because our compiled database is remarkable in its trophic and spatial extents - individual abundance and functional traits for ca. 850 neotropical invertebrate taxa distributed from 19°N to 29°S and across environmental gradients – we also created a valuable resource for future research.

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