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Reevaluating the assumptions of organism-based paleoenvironmental inference models: A case study from an ostracod metacommunity on San Salvador Island, Bahamas

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Organism-based calibration data sets have the potential to produce detailed, high-resolution records of past environments. One way of producing such records is through transfer functions, which use changing abundances of microfossils through time to reconstruct a single environmental variable.

Transfer functions are constructed by understanding the correlation between modern communities and the abiotic environment. This correlation is then applied to preserved microfossil assemblages to produce a quantitative record of past abiotic factors. However, organism-based paleoenvironmental inference models have been criticized as producing spurious results when the underlying ecology is misunderstood.

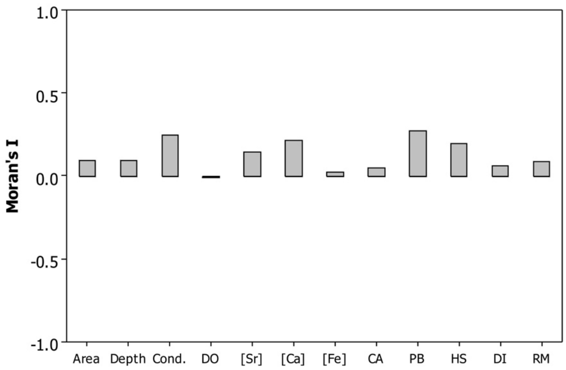

Fig. 1: Moran's I of selected environmental factors and species percent abundances. Cond. indicates conductivity, DO indicates dissolved oxygen, CA indicates *Cyprideis americana*, PB indicates *Perissocytheridea bicelliforma*, HS indicates *Hemicyprideis setipunctata*, DI indicates *Dolerocypris inopinata*, RM indicates *Reticulocythereis multicarinata*.

Specifically, ecological processes such as dispersal limitation of species, neutral processes of community assembly, or physical factors like spatial autocorrelation of the abiotic environment can lead to overestimation of the precision of transfer functions. We sampled thirty-two lakes on San Salvador Island, Bahamas for ostracod communities and nineteen abiotic factors in order to investigate whether this metacommunity would be suitable for a transfer function.

Individual abiotic factors (Fig. 1), species percent abundances (Fig. 1), and changes in assemblage composition (Fig. 2) were not spatially autocorrelated at the scale of the island. Thus, in this metacommunity, there exists no ecological or physical obstacle to the establishment of a transfer function.

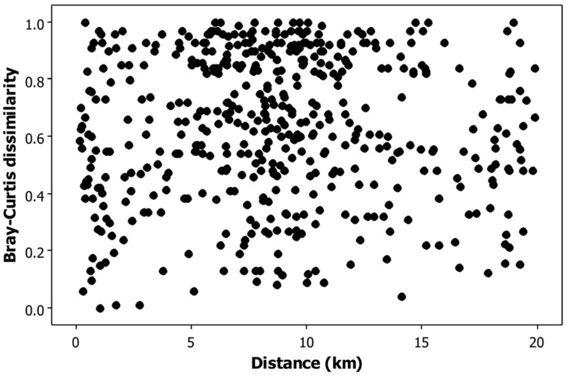

Fig. 2: Scatter plot of Bray-Curtis dissimilarity matrix of species assemblages and distances between lakes. Each point represents a comparison between 2 lakes. There are 496 possible pairwise comparisons among 32 lakes.

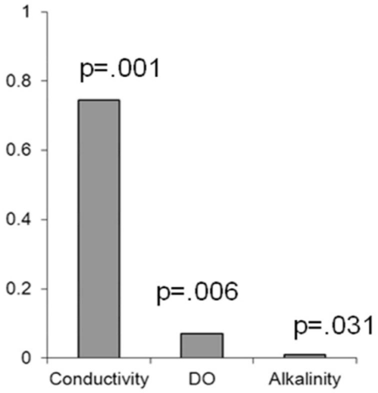

Fig. 3: Effect sizes of correlation between environmental factors and ostracod assemblages. Figure 3 represents the results of a multivariate fuzzy set ordination of ostracod assemblages and 19 associated environmental factors. Conductivity, dissolved oxygen (DO) and alkalinity were the only factors that significantly correlate with ostracod assemblages. The y-axis is the incremental increase in Pearson's correlation (r) between the Bray-Curtis dissimilarity matrix of species assemblages and the indicated environmental factor resulting from its addition to a forward selection model. The final, 3-variable model correlates strongly ($r = 0.86$) to changes in species assemblages.

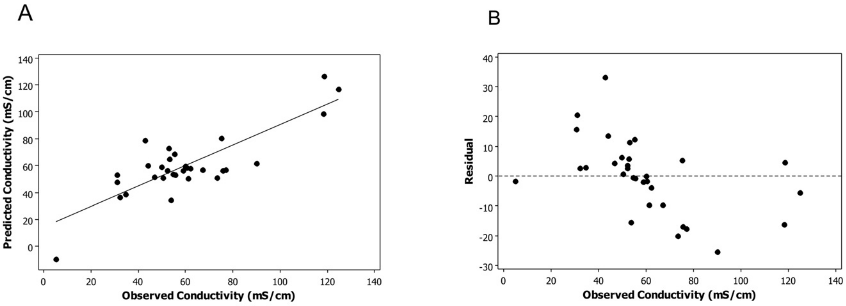

Fig. 4: Performance of ostracod-based transfer function for conductivity on San Salvador Island, Bahamas. 4A measures the performance of the transfer function by jackknifing. Jackknifing is a process whereby N multiple regression models are created by leaving one data point out and using all N-1 other data points to predict the conductivity of the left out data point. This predicted conductivity is then plotted against the measured conductivity; a line of best fit is displayed ($R^2 = 0.68$). $N = 32$ for this data set. 4B plots the residuals of the transfer function model created with all 32 data points plotted against measured conductivity.

Multivariate fuzzy set ordination reveals that β-diversity of ostracods is correlated with: conductivity, dissolved oxygen, and alkalinity (Fig. 3). A transfer function for conductivity was then constructed since past conductivity can be linked to regional changes in climate and sea level (Fig. 4). This study shows that the limits to organism-based paleoenvironmental inference-models are not insurmountable and suggests techniques to overcome them.

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