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GSA Proposal – Final

Latitudinal diversity gradients of Phanerozoic bivalves

Statement of the Problem

(839/1000)

Marine invertebrates are widely studied because not only are many diverse species well-preserved in the rock record, but distinct speciation patterns can be easily identified (Hallam, 1989). Given the robustness of the marine record, a large amount of research has been dedicated to investigating latitudinal diversity patterns of invertebrates. While there is increasing work which explores these relationships, many previous studies have relied on fossil occurrences as reported in the literature (Orzechowski et al., 2015). In this study I will use more comprehensive data from the Paleobiology Database to study the habitat preferences of benthic bivalves with respect to latitude using a regression model. I hypothesize that, at increasingly lower latitudes, one mode of life (tiering) of bivalves will be favored over the other.

Justification:

(2496/2500)

Modeling the relationships of fauna and ecology by using diversity gradients is essential to predicting speciation or extinction risks of species in a world dominated by anthropogenic-driven changes to climate and geographic range size (Orzechowski et al., 2015). A useful way to study ecological relationships is by looking at the fossil record which preserves important information about faunal response to both biotic and abiotic factors over a long time (Jablonski et al., 2013). The marine molluscan record provides a good way to do this since not only are bivalves diverse in their ecological habits and well-represented in the fossil record, but they are also sensitive to changes in sea-levels and ocean chemistry which in turn reflect overall variations in climate and tectonics. Bivalves demonstrate diverse niches such as tiering or preferential location in the sediment column, feeding habits including suspension feeders, deposit feeders, carnivores and more, and motility which is the organism's locomotion and includes cemented forms, attached forms, recliners, and fully motile forms (Mondal et al., 2016). The wide range of niches that bivalves can fill, therefore, makes this taxa a good candidate for modeling niche preference with latitude.

Latitudinal biodiversity gradients of the natural world show a strong pattern of species richness that is pronounced at the equator and dwindles at the polar low latitudes (Mittelbach et al., 2007). Such gradients have been well-established for terrestrial biomes but gradients for the marine realm remain open to question (Roy et al., 2000). Thorson (1957) suggested that a latitudinal gradient would be almost non-existent for infaunal bivalves which burrow into

sediment because they need fewer adaptations than epifaunals which are exposed to the water column. However, Roy et al. (1999) showed through the use of literature-gathered data that diversity gradients for infaunals were just as strong as they were for epifaunals. Part of the difficulty in making these estimates lay in the fact that mostly local, or alpha, diversity was measured (Roy et al., 1999) and it was suggested that as beta diversity, or the quantitative difference in diversity among regions, increases, sampling should take place at a more regional scale in order to be truly representative (Harrison et al., 1992). This study will include four latitudinal regions and will aim to provide a broad understanding of how latitude predicts tiering in bivalves.

Research Plan:

2302/2500

The selectivity patterns of molluscan fauna will be modeled from the Ordovician to the Holocene to uncover trends in diversity and habitat preference with respect to latitude. Molluscan fossil occurrences will be downloaded using the Paleobiology Database (PBDB) and organisms will be separated based on their preferred mode of life or tiering, namely epifaunal, or bivalves that grow at or above the sediment-water interface, and infaunal, or bivalves that live within the sediment itself. Epifaunal species will include erect epifaunal bivalves that grow vertically into the water column, as well as surficial epifaunals, which live in contact with sediment but do not extend high into the water column (Mondal et al., 2016). Infaunal bivalves will include shallow-burrowers (<6 cm) and deep-burrowers (>6cm) (Mondal et al., 2016). Semi-infaunal organisms will not be considered, and the study will take place at the genera level in order to include as many organisms as possible. Data from the PBDB will be essential to this study and all fossil occurrences of bivalves will be downloaded spanning most of the Phanerozoic and beginning at the Ordovician when they first appeared (Stanley, 1968). The data will be cleaned and culled for outlier occurrences to exclude fossils with an occurrence of less than 2. Organisms will then be separated based on mode of life, age, and latitudinal region using R programming language. Shannon's Entropy, a diversity index which is used to mathematically quantify species diversity in a particular region based on richness (number of species) and abundance (number of individuals per species), will be calculated for each region studied. Next, the PBDB data will be used to perform a logistic regression analysis which will model the relationship between bivalve tiering and latitude. This will essentially predict the tiering preferences (infaunal or epifaunal) of bivalves at different latitudes, and high or low probability values from the regression will reflect the probability of an infaunal or epifaunal species occurring at a particular latitude. Finally, for this comparison, four main latitudinal regions will be considered: tropical, sub-tropical, Antarctic, and sub-Antarctic islands.

Citations:

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