Phanerozoic scale modulation of brachiopod longitudinal expansion fitness forced by plate tectonics

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Brachiopods are a phylum of Animalia which are characterized by a rich fossil record. But this record shows drastic decrease in brachiopod diversity and environmental occupancy through time. One set of explanations says that the decline is related to the state shifts in dominance after mass extinction events (usually P-Tr). Another explanatory set suggests that the dominant cause of brachiopod decline is competition with other functionally similar clades. The competition hypothesis predicts that there should be a monotonic decrease in some fitness metric at organismal or species level. Often overlooked is the influence of long-term tectonic processes which control size, geometry and topology of environments on the changes in dominance of brachiopods. Here we tested this hypothesis by analyzing the dynamics of longitudinal and latitudinal ranges of brachiopod genera in the post-Cambrian Phanerozoic using the Paleobiology Database global paleogeographic occurrence data. The major pattern revealed in the study is that while latitudinal ranges were approximately constant through the eon, the longitudinal ranges experienced long-term trend-like decline. In the beginning of the Phanerozoic and also during the Cretaceous-Cenozoic, average ranges of brachiopod genera were much more elliptic in the west-east direction, while in the middle of the Phanerozoic they become almost circular in their shape. The latitudinal ranges reflect average temperature tolerance of a genus, while the longitudinal ranges reflect capacity of a genus to expand in similar climatic conditions, thus reflecting its potential of expansion fitness. The scale by scale analysis of range shapes and continental fragmentation index found consistent scale independent positive correlation of ellipticity (in W-E direction) with higher fragmentation of continents. Therefore the analyses revealed statistically significant patterns that support the hypothesis of a strong tectonic control on the shapes and sizes of average geographic ranges of brachiopod genera. Smallest ranges with lowest ellipticity occurred in Triassic-Jurassic. Therefore, the loss of genus level expansion fitness due to tectonic amalgamation of Pangaea should have been an important factor which contributed to the failure of brachiopods to fully recover after P-Tr extinction event.