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Reading #11

The effect of geographic range on extinction risk during background and mass extinction

Authors: Payne and Finnegan (2007)

Summary: This paper investigates geographic range size and its link to primarily “background” extinctions which receive much less attention than mass extinction events. The authors use a logistic regression to evaluate the selectivity of genus survivorship with respect to geographic range for benthic marine invertebrates from the Cambrian to Neogene periods using fossil data available from PBDB. The authors strongly rely on statistical methods for their approach, namely regression analyses (which I don’t fully understand). They employ the use of log-odds to correlate fossil occurrences not only with geographic range size, but also with species richness and global fossil occurrences to ensure that these are not influencing the results that they get that show the influence of geographic size. A positive log-odds values shows a positive relationship, a negative log-odds shows an inverse relationship, and a log-odds of 0 shows that there is no association between the two variables. Per-plate extinction was also a variable that was very important to this study as this represents the geographic range size. The authors, through odds-ratios, find that there is an inverse relationship between geographic range and extinction intensity. Extinction depends on geographic range when per-plate extinction intensity is low, that is, when there is not a large (mass) extinction. They also present a mathematical equation that explains this relationship. They conclude that geographic range is an important factor which determines the extinction risk of benthic marine organisms in the Phanerozoic. They also agree with previously stated ideas that mass extinctions result from pressures that are applied worldwide and could not be linked to only geographic range size but includes other geochemical or geological perturbations.

What I liked: Firstly, I really liked the amount of detail that this paper provides about the techniques that they used to estimate the effects of geographic range size. Even though I didn’t understand all of the math behind it, I think that the general concepts were explained well enough that I could understand what the diagrams meant. For example, the authors did a really good job of explaining regression and why they used this type of analysis as opposed to others. They also explained well the concept of log-odds which is central to their investigation. I also liked that they anticipated possible arguments that might be put forward against their methods. For example, they do acknowledge that the fossil record is very incomplete, but they note that for this type of analysis the effect of an incomplete record is greatly minimized compared to analyses which require an absolute measure of diversity or range. This paper also talks at length about the null-model. From what I understand, the null-model assumes that there are no other factors affecting the test variable, and this is done to ensure that only that specific variable is being manipulated. I thought it was interesting that they brought this up because just after they were done talking about plate extinction, I wondered how they knew from their model that only geographic range size was to blame. After they explained the null-model I realized that this was a simplified assumption they were making, not counting things such as habitat or feeding preferences that may also contribute to extinction risk.

What I disliked: There is literally nothing I disliked about this paper. I learned a lot from reading it and any questions that I had were addressed directly in the paper. I really appreciated the end where they gave more details about data and methods, logistic regression, and metrics of record quality. I think more papers should do this but I would think that maybe this is usually included in “Supplementary Materials” of other papers. However, it was very short and directly to the point for this paper and it was great that they could include everything.

Diagrams: Figure 1 shows the trends for the Phanerozoic of the geographic range size of genus survivorship. It explains and shows very clearly the positive, negative, and 0 relationships of the log-odds technique that was explained earlier. The points of major extinctions have also been clearly marked and show a positive relationship (positive log-odds) between geographic range and extinction risk. Figure 2 shows geographic range selectivity (log-odds) plotted against extinction selectivity for the Mesozoic-Cenozoic, Post-Ordovician-Paleozoic and Cambrian-Ordovician periods with the five major extinctions marked. I like this diagram because (dumb reason) the shapes and colours make it really easy to distinguish the different data sets and more clearly see the relationship. Figure 3 shows what range versus selectivity would look like if extinctions were independent across plates. The paper says that the weak association with geographic range exhibited by the K-T, P-T and T-J mass extinctions show that per-plate extinction risk varied considerably among genera. What I take away from all of this is that the regular background extinctions (which do show strong correlations to range) have stronger per-plate extinction risks and that this does rely on the geographic range size. Background extinctions are more strongly influenced by range size while for mass extinctions the range size does not matter (the mass extinction occurs regardless).