Comparison of Genus and Species-level Compilations of Metabolic Rate through Time

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Abstract

Metabolism is the basis of fundamental principles of biology and sustains life through vital processes such as growth and reproduction. Brown et al. (2004) showed that metabolism is central to our understanding of patterns and dynamics at all levels of biological organization. Often, paleontologists use the holotypes of type species to represent genera in global analyses, but they rarely test how representative the type specimen is of the genus as a whole. Through my analyses, I compared genus and species-level compilations through time by computing the mean metabolic rate of each genus to the metabolic rate of the type species to see if using this representative provided effective data when conducting genus-level analyses. To achieve these objectives, I used sizes collected from Catalogue of Ostracoda and Treatise on Invertebrate Paleontology. The range of the type species’ metabolic rate varied, but there is no systematic bias towards higher or lower metabolic rates. Therefore, using type species in genus analyses is effective when looking for general trends, but the absolute values based on the holotype of type species have some bias to them and are not as accurate.

Background

Ostracods are small, microscopic organisms, usually less than a millimeter long, but are one of the most successful orders of all crustaceans, with more than 6000 extant species. They also have the most complete fossil record of any crustacean, which is one reason it is advantageous to use them in data collection. In my analyses, I used data included the metabolic rate of those ostracods. I chose metabolic rate because it is an easily understandable yet important concept that I am able to observe firsthand. I would like to see whether this applies to invertebrates like ostracods and how it may vary over time. I also want to compare mean metabolic rates of genera to metabolic rates calculated using a type species because in many genus-level analyses, the holotypes of type species have been and are used, but there have not been many analyses addressing how effective using a type species is in representing a genus.

Methods

For my analyses, I used data collected by the History of Life interns from volumes of Catalogue of Ostracoda (Ellis and Moosa) and Treatise on Invertebrate Paleontology (Moore and Pitrat) to calculate the metabolic rate using the equation:

\[ \text{Metabolic Rate} = \frac{M}{e^k} \]

where \( M \) is the body mass, \( e \) is the base of the natural logarithm, and \( k \) is the apparent activation energy for biochemical reactions, both in Kelvin. I used the statistical computer language R to make calculations and graphs, including the ones below.

Results

Metabolic rate of ostracods overall has decreased over time. This surprised me, because while the body size of the type species (and the mean or pattern found) was the metabolic rate of the type specimens decreases in some genera. However, the metabolic rate of the type specimen itself is not surprising, although some have slightly more or less species than others.

![Figure 1: This graph shows how the metabolic rate of ostracodes has changed over time. Points were found with the mean of species from each time period. The red line shows the metabolic rate using individual species to form the mean, whereas the black line shows metabolic rate using type specimens as holotypes to find the mean. While they have relatively similar metabolic rates, those with individual species are more precise.](image1.png)

![Figure 2: This graph shows percentage of the type species falls in the holotype for 5% quantiles, which include the smaller outliers (lower 25%), the middle range of metabolic rate (50%), and the larger extremes (upper 25%). You can see the distribution fairly equally, although some have slightly more or less species than others.](image2.png)

![Figure 3: This graph shows the average metabolic rate of the type species for each genus, and the larger extremes (upper 25%). You can see the distribution fairly equally, although some have slightly more or less species than others.](image3.png)

![Figure 4: This graph shows the confidence interval of several genera. The red line shows the metabolic rate of the type species. As you can see, the overlap is small, and thus it is within the average range, other times, it is not useful. This shows that using a type species as a representative of a genus means to work much harder than is not always reliable.](image4.png)

Conclusions

Metabolic rate of ostracods overall has decreased over time. This surprised me, because while the metabolic rate of the type species (and the mean or pattern found) decreases in some genera, the metabolic rate of the type specimen itself is not surprising, although some have slightly more or less species than others.

![Figure 5: This graph shows the mean metabolic rates of all species within a genus plotted on the y-axis and the metabolic rate taken from the holotype of the type species shown on the y-axis. As you can see, the difference in value is varied—some genera have type specimens and means that match up very closely, while others do not match up quite as closely.](image5.png)

References


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