Project 1: Using Python to Reproduce Figures from Biological Research Paper

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Paper

Bergmann's rule Rules body size in an ectotherm: Heat conservation in a Lizard along A 2200-metre Elevational gradient (Zamora-Camacho et al.)

Introduction

Bergmann's rule in biology states that, within a taxonomic group, populations of larger size exist in colder environments, with the reverse being true in warmer environments. The explanation given by Bergmann for this body size – temperature relationship is based on the ratio of surface area to volume. Larger animals have a lower surface area to volume ratio, and therefore lose less heat per unit of mass, which is beneficial for life in cold climates. In reverse, body heat is lost more quickly by animals with a high surface area to volume ratio, which explains the trend for smaller body sizes warm climates.

Originally applied to endotherms, which are capable of internally regulating their body temperature, it is unclear if Bergmann's rule is equally applicable to ectotherms, which rely on their external environment for body temperature regulation. In the study chosen for this project, the researchers hypothesized that Bergmann's rule would be applicable to ectotherms when the benefits of a higher heat conservation due to a larger body size outweigh the decreased heating capacity. The hypothesis was tested on the lizard species *Psammodromus algirus*, which has been found to have increased body sizes in higher elevations in Sierra Nevada. Data collected for this study included the body sizes, and body temperatures of lizards from different elevations, from 300 to 2500 m above sea level.

Methods

The researchers graphed the body size and temperature data to obtain heating rates and cooling rates for the lizards. The heating and cooling rates obtained in this manner were then used in further analysis reflected in figures 2 – 7 in the paper. I chose to replicate figures 2 and 3, which show the relationship between body mass and altitude, and the relationships between body mass and heating and cooling rates, respectively. Data from the paper was stored in an excel file.

To replicate the chosen figures, I imported pandas, matplotlib.pyplot, numpy, and statsmodels libraries. To process the data, I read the data from the excel file into a pandas dataframe. The first step in replicating figure 2 from the paper was to compute necessary values such as means, standard deviations, and standard errors for the body masses measured at each altitude. In addition, 95% confidence intervals were calculated for the figure. The next portion of code dealt with the necessary steps to display the figure, such as plotting the points, adding error bars to reflect the 95% confidence interval, and labeling the points with sample sizes.

To replicate figure 3, I first removed all null values from the dataframe. Because this figure involved an ordinary least squares regression, the statsmodels library was used for adding a constant term and performing the regression. From the resulting summary table, the coefficients of the constant and x terms were substituted into the equation y = mx + b to plot the regression line.

Results

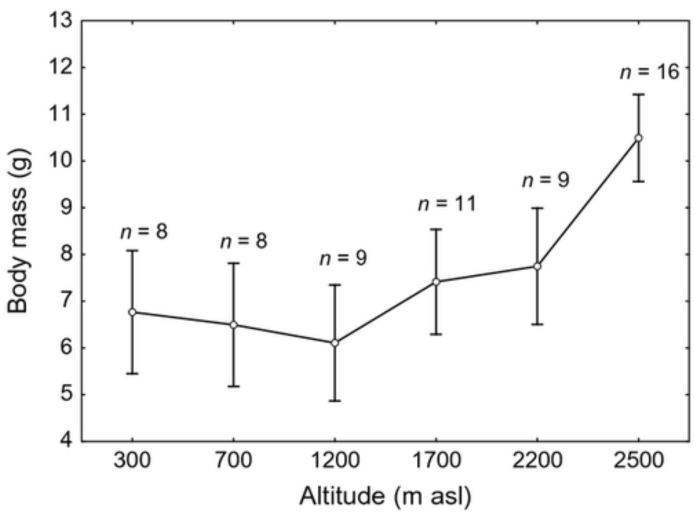


Figure 2 from paper

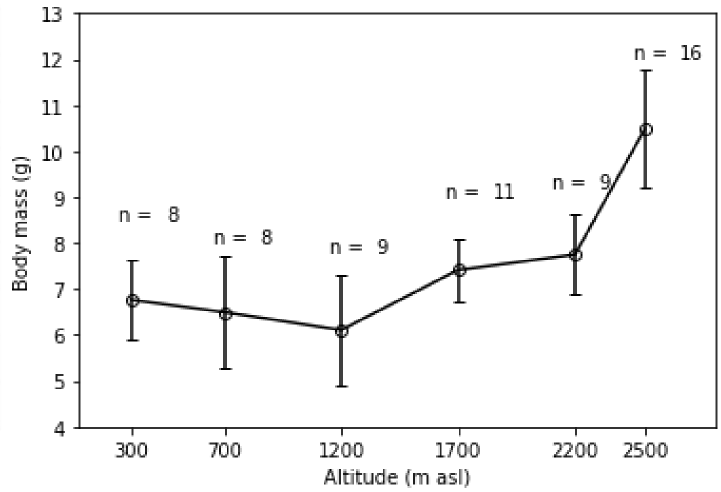
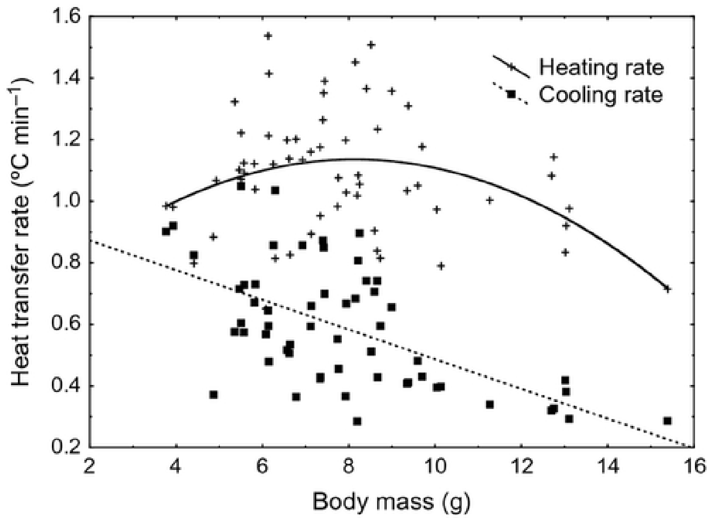


Figure 2 replicated

Figure 2 shows the relationship between body mass and altitude, with sample sizes labeled above the data points, and bars denoting 95% confidence interval. In this figure, it can be seen that larger body masses are found at higher elevation, which is consistent with Bergmann's Rule. This is evidence that Bergmann's rule can be applied to ectotherms.



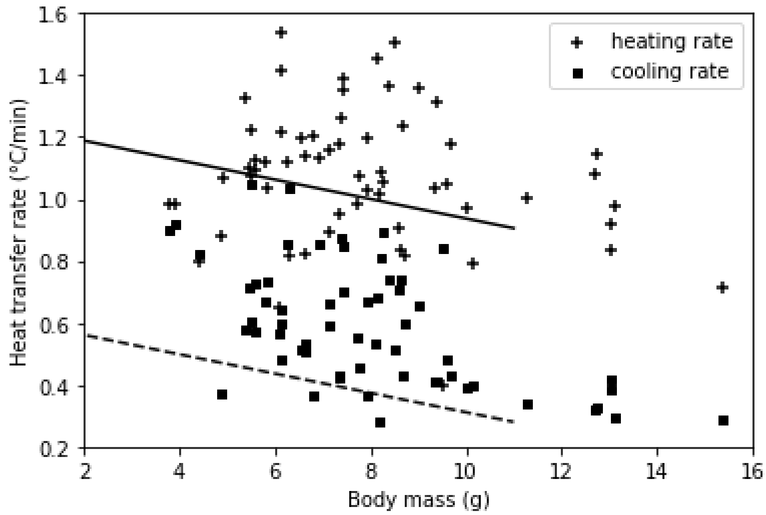


Figure 3 from paper

Figure 3 replicated

Figure 3 shows the ordinary least squares regression of heating rate and cooling rate over body mass. The figure from the paper had a curved line showing heating rate over body mass, while the figure I produced had a straight line. Despite this discrepancy, both versions of figure 3 show a negative relationship between both heating rate and body mass, and cooling rate and body mass. However, in the figure from the paper, the slope of the cooling rate over body mass appears steeper, which is relevant to the study's heat conservation hypothesis.

The results of the study indicated that larger lizards have an adaptive advantage over smaller lizards in cold habitats. This explains the relationship between elevation level and body mass found in the study. The findings support the hypothesis Bergmann's rule applies to ectotherms when the benefits of a higher heat conservation due to a larger body size outweigh the decreased heating capacity.

Reference

Zamora-Camacho, F. J., Reguera, S., & Moreno-Rueda, G. (2014). Bergmann's rule Rules body size in an ectotherm: Heat conservation in a Lizard along A 2200-metre Elevational gradient. *Journal of Evolutionary Biology*, *27*(12), 2820-2828. doi:10.1111/jeb.12546