**The Effects of Elevation on Weight in *Acanthis flammea* malesfrom 1992-2007**

Tyler Meador

Student of West Virginia University Institute of Technology

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**INTRODUCTION**

The *Acanthis flammea*, also known as redpolls, have a very large range of latitudinal variations which may influence the way that they have adapted over time (Pohl and West 1976). Residing in different latitudes and elevations may not only temporarily (during migratory seasons) change circadian rhythms but may also show to influence changes to their genetics (Pohl and West 1976). It has been found that the conditions of our environment heavily influence the physical features of many different organisms, such as size and shape, which serves as an explanation for the evolutionary changes of many species (Youngflesh et al. 2022). These environmental factors may include temperature and/or elevation. Temperature has been shown to have a positive correlation with body size across different species. Research involving size vs. environment is necessary due to global warming and other factors continually changing the environment; it is also essential when studying the evolution/adaptation of species (Youngflesh et al. 2022).

Though multiple studies (Blackburn and Ruggiero 2001, Pohl and West 1976, and Youngflesh et al. 2022) show that elevation and other environmental factors influence body size and weight, it would not be accurate to assume that this is the only driver in the evolutionary changes that have taken place. It is important to keep in mind that while elevation and body size may have a positive correlation, this does neither prove nor disprove that elevation is the driving force behind body size and mass as there are many forces driving evolutionary changes that occur (Blackburn and Ruggiero 2001).

Research shows that elevation gradients, along with any other evolutionary force, select for trade-offs (Balasubramaniam and Rotenberry 2016). Higher elevation has been shown to cause smaller nests size, number of eggs laid, but allows the eggs to be larger. Another trade-off, which is favorable, is less predation in higher elevations causing their survival rate to be much higher. High elevation causes many of these changes due to increased solar insolation and lower atmospheric pressures. The lower atmospheric pressures cause a much greater egg water loss, which leads to an increase in the beginning amount of water in the eggs causing the eggs to become larger (Balasubramaniam and Rotenberry 2016). Despite these findings an article written by Balasubramaniam & Rotenberry (2016) concluded that elevation and body mass of 135 galliform bird species had no correlation, but this could be evidence to show how environmental factors affect species differently since redpolls are passeriform bird species. However, their findings do not align with those of other researchers, Blackburn and Ruggiero (2001), Pohl and West (1976), and Youngflesh et al. (2022), which all suggests that elevation does affect the body mass of bird species.

I hypothesize that higher elevation is positively correlated with lower overall weight of male, *Acanthis flammea*, redpolls, bird species. As elevation increases weight will decrease, which will help to serve as an explanation for how migration and different environments influence evolutionary changes and adaptations. As species have been separated by migration or the formation of some boundary, such as a river, it is possible that this separation causes them to begin adapting in different ways. Natural selection will begin favoring one characteristic in one population that it does not favor in the other, an example of this would be the favoring of smaller bird weights at higher elevations. I also hypothesize that the average elevation in which redpolls have been sighted has decreased from 1992-2007, and because of this reduction we will see an increase in their average weight across these years.

**MATERIALS AND METHODS**

*Data Collection*

All data used within this research paper was collected from a research article titled *Abiotic conditions shape spatial and temporal morphological variation in North American birds*, which was written by Casey Youngflesh, James F. Saracco, Rodney B. Siegel, and Morgan W. Tingley. The writers of this paper collected their data of 105 species of North American birds from 1989-2018 from over 250,000 birds as part of the Monitoring Avian Productivity and Survivorship (MAPS) program (Youngflesh et al. 2022). They collected their data from 1,124 banding stations, which each contained 6-20 mist nets, here they collected information such as species, year, station, latitude, longitude, elevation, wing length, and weight. For this specific study wing length was defined as the distance measured in millimeters between the carpal joint and wing tip, bird mass was measured in grams. All data points involve only male birds, because the mass of female birds fluctuate during seasonal changes. Elevation for each station was collected using a 30-arcsecond resolution Global Multi-resolution Terrain Elevation Data product (Youngflesh et al. 2022). Only the data collected on *Acanthis flammea* bird species was used for analysis of my hypothesis, data collection for this bird species did not span the entirety of the research for this paper but was only collected from 1992-2007.

*Data Analysis*

Using the elevation, year, and weight of the *Acanthis flammea* data, which is 2,697 data points, graphs were made in RStudio (version 2022.02.1+461). Each year has varying numbers of bird data represented because the number of captures per year varied. Figure 1 shows elevation versus weight for all data points. Figure 2 plots average elevation against the average weight for each year in which data were collected for *Acanthis flammea*. Figure 3 demonstrates the fluctuations in elevation for each year and Figure 4 shows the changes in weight for each year. Three Pearson correlation tests were also conducted in RStudio for elevation and weight, year and elevation, and year and weight using a 95% confidence interval (Equation 1).

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*Equation 1: Pearson's Correlation Formula*

**RESULTS**

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Figure 1: Elevation vs. weight from 1992-2007

Pearson correlation test for elevation and weight gave a value of -0.06. For year and elevation, the Pearson correlation test gave a value of -0.17. For year and weight, the Pearson correlation test gave a value of 0.13. Figure 1 appears to display no significant relationship between the two variables.

Figure 2: Average elevation and average weight for each year.

Figure 2 displays the average elevation and average weight for each year, beginning in 1992 at the far left of each and moving to 2007 at the far right. Weight does not appear to fluctuate as Elevation does.

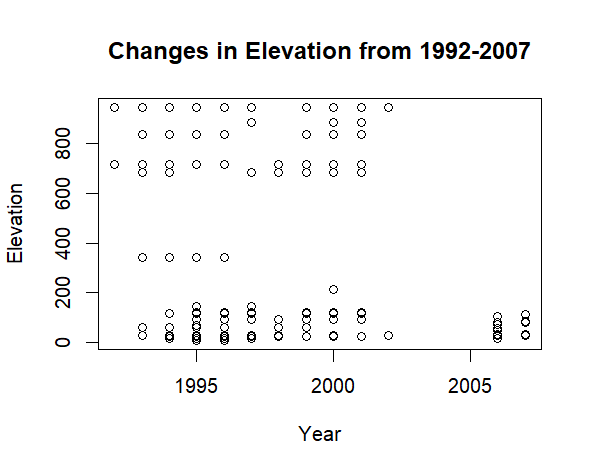


Figure 3: Fluctuation in elevation from 1992-2007.

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Figure 4: Fluctuation in Weight from 1992-2007.

**DISCUSSION**

The following results show a couple of things. For one, the correlation tests for both elevation and weight, and year and elevation, show negative correlation tests. These negative results indicate an inverse proportion, as elevation increases, weight decreases and vice versa. The same can be said for the correlation results for year and elevation. There was, however, a positive correlation value for year and weight, meaning as the years “increased”, weight increased.

These results indicate that the elevation in which redpolls are found has fluctuated across the years but overall has decreased over time, while the weight has increased. Though the three Pearson’s correlation tests resulted in relatively low values, indicating weak relationships, they were however in support of my hypothesis. However, because these values are so low there is not a strong enough correlation to assume that they are completely dependent upon one another. For example, if temperature and weight were tested and we found that there was a much stronger correlation between the two it could mean that temperature was the driving force behind the changes in weight.

The graphs and the correlation tests indicate my hypothesis was supported by the data given, though only weakly supported. Within the *Acanthis flammea* male population species, there was a negative correlation between weight and elevation. The data supports that over time, the male redpolls have evolved evolutionarily due to environmental factors of elevation, or indirectly connected to elevation. As said, while the latitudinal variations for the birds are quite large, overall, it was found that while elevation increases, weight will decrease (Pohl and West 1976).

Studying how the environment affects evolutionary changes is important, because environments continually change due to many factors such as climate change (Hoffman and Sgrò 2011). Geographical distributions are changing among different species because of climate change. Change in geographical distribution, which could mean a change in elevation, may save many species from extinction. Evolutionary adaptations will begin occurring in many populations as the climate continues to change. Many of these changes could occur through plasticity, which means that the change is solely determined by the environment and not by genetics. Evolutionary changes in bird populations have often been found to be due to plastic contributions, which is in support of the idea that elevation affects the weight of bird species ((Hoffman and Sgrò 2011).

**LITERATURE CITED**

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