Differences in the Mandibular Centroid Size of Squirrels in the Family Sciuridae

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**Introduction**

A black and white drawing of a hand holding a chain

Description automatically generated with low confidence Squirrels are the small animals found in the trees of many forests. They are part of the Sciuridae family. Squirrels can be different sizes and colors. Not only can squirrels bodies be different shapes and sizes, but their jaws can differ in shape and size as well. Many factors can determine the size of a squirrel’s jaw including their body size and diet. There are other factors that can affect the size and shape of a squirrel’s jaw. The mandible is used to process food, but depending on the size and shape the process can differ. A study done by Swiderski and Zelditch examined how the differences in food processing effects the mandible shape. There are two diet groups, the granivores and the folivores. The granivores are individuals that eat nuts, seeds, and sometimes plant parts. The folivores eat mainly leaves and sometimes seeds (Swiderski & Zelditch, 2022). It would be much easier for an individual to process grass than to chew up a nut or seed. This would mean the granivores would have differently shaped mandibles than the folivores due to their diets. An article written by Casanova-Vilar and van Dam suggested that the size of the mandible is inherited and passed down in species. Closely related species may have more related jaw sizes than those that are very distantly related (Casanovas-Vilar & van Dam, 2013). This means if you randomly pick two species from a phylogenetic tree, there is a chance they could be closely related and have very similar structures, but the chance is small. Genetics could play a big role in this research because the size and shape of the mandible could be passed down from parent to offspring. However, inherited traits can adapt and evolve to the environment for survival purposes. The article written by Zelditch et. al compared how the different diets between species can affect the mandibular centroid size. They categorized their data into squirrels that eat nuts, hard nuts, bark, seeds, grass, soft, browse1, and browse2. They hypothesized that the optimal size of the squirrel’s jaw would be dependent upon the diet, but the shape for that diet would be dependent on the size (Zelditch et al., 2017). Niche partitioning could also be a factor in this study because if different species of squirrels eat different types of food in the same population, this can cause the mandible shape and size to change to the diet. Louise Roth proposed that the differences could be in individual parts of the bone rather than the mandible or the skull as a whole. She found that the mandible and skull differed in covariance but there was no clear line separating the skull into subunits (Roth, 1996). A study done by Mazzamuto et. al looked at how migration into new environments can cause changes in the mandible shape and size in different squirrel species. The study found that there was no significant difference between males and females, and the variation in size was similar between the populations. However, the authors found a small divergence in the closely related species (Mazzamuto et al., 2021). This article examined the centroid size in different species of squirrels to identify if there is a statistically significant difference between the genera.

Figure : Landmarks and semi-landmarks of a squirrel mandible. Retrieved from Zelditch et. al, 2017

**Methods**

The data used in this research was collected from an article by Zelditch et.al. The data was downloaded from dryad and uploaded to RStudio for analysis. Using the dryad data provided from their research, a plot showing the average centroid sizes of each species as well as a graph showing the frequencies of the average centroid sizes was created using Microsoft Excel. For statistical analysis, a Kruskal-Wallis Rank Sum test was completed in RStudio. This test will show if there are statistically significant differences between two or more groups of independent variables. There were 1677 squirrels measured for the study from 184 genera. For this paper the variables are the species and the mandibular centroid size.

**Results**

The Kruskal-Wallis Rank Sum test showed that the p-value was <2.2e-16 which is roughly 0.00000000000000022. Since this is below 0.05 the test shows there is a statistically significant difference between genera in the mandibular centroid size. Table 1 shows the average centroid sizes for all squirrel species that were gathered from Zelditch’s paper (Zelditch et al., 2017).

Table 1: Average mandibular centroid size in each of the squirrel species

Table 2 shows the frequencies of different centroid sizes. The majority of the sizes fall into the 58.516mm to 138.516mm size range. Most of the data falls into the 78.516mm to 98.516mm range. There were very few species that had an average centroid size above 178.516mm.

Chart type: Histogram. Frequency of 'CS(Average)'

Description automatically generated

Table 2: Frequencies of the average centroid size

**Discussion**

The data showed that there was a statistically significant difference in centroid sizes between the genera. The are many factors that could have swayed the results. One that was very prevalent in this data set was inadequate sample sizes. There were many species that had only one or two data points to examine however, there were some species that had ten or more. This could drastically affect the results of the study. Casanovas-Vilar and van Dam proposed that the reason for these differences could be an adaptation to the environment or a specific function it needs to perform and not just the diet of the squirrel (Casanovas-Vilar & van Dam, 2013). This could mean that the squirrel is changing its jaw shape or size because it has to change the way it performs certain functions in the environment. The environment may not be hospitable, and the species may have to move to a new area causing it to change its eating habits to a new food type which could change the shape and size. The results from the Zelditch study showed that only 40% of the variance in the data could be explained by the different diets of the squirrels meaning there has to be more than just diet to explain the differences (Zelditch et al., 2017). Swiderski and Zelditch found that the diet of the squirrel does affect the size and shape of the mandible. They also found that the difference in function and muscles for processing the different diets is the mechanical difference in the jaw shape for each species (Swiderski & Zelditch, 2022). Mazzamuto found that invasive species going into new populations can cause the species to adapt to the new environment. They also found that environmental stress such as not being able to find specific food types could cause the differentiation as well as genetic drift. Another reason given to explain the variation is an independent origin (Mazzamuto et al., 2021). If the differences have an independent origin of each other, the species will show different shapes and sizes because there would be multiple origins of those shapes and sizes.

**Conclusion**

Many factors can affect and change the mandibular shape and size in a squirrel’s jaw. In this study there was a statistically significant difference in the mandibular centroid size in the genera of squirrels from the family Sciuridae. One factor is the diet of the squirrel. The diet can affect how the food is mechanically processed which can use different muscles and require the mandible to be a different shape than other diets. Other factors can include inheritance of specific mandible shapes and sizes. Genetics can be an important factor because if a specific jaw shape and size is passed down, the squirrel will have to keep the same diet as the parent, or the offspring will have to adapt its jaw to a different diet. The size and shape could simply have different origins in different species. There is not one factor causing the difference between genera or species, but a combination of multiple factors.

**References**

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