The Effects of Cranial Asymmetry on Bite Force in the Green Anole (*Anolis carolinensis*)

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Introduction

Anole lizards are a model group for understanding evolutionary change and adaptive radiation due to their morphological plasticity and repeated instances of morphological and ecological convergence as they invade new habitats. The green anole lizard (*Anolis carolinensis*) is a native species to the southeastern part of the United States. Among anoles, the green anole has been suggested to be a model organism as it has been widely studied for the past 100 years granting an in-depth understanding of its natural history, it is readily kept and studied in the lab, and it has a diversity of behaviors relevant to a variety of evolutionary mechanisms. Fluctuating asymmetry in bilaterally symmetric organisms is random right-left asymmetry and arises from genetic and environmental forces during development. Although the root causes of fluctuating asymmetry are broadly understood, its effect on functional performance is not yet clear. Previous studies have demonstrated decreased asymmetry in more functionally important structures relative to less functionally important structures (e.g., more symmetric shells in aquatic turtles than in terrestrial turtles). We utilized a large sample of green anole crania to determine the relationship between performance (specifically, bite force) and magnitudes of fluctuating asymmetry.

QUESTION 1:
How do the asymmetrical features of cranial morphology in the green anole affect its bite force?

QUESTION 2:
Does the magnitude of asymmetry change due to the size of the anole?

Methods

microCT Scan

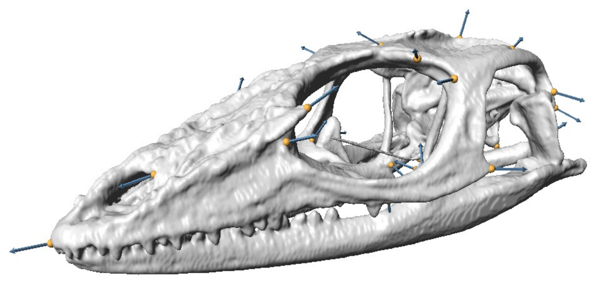
Micro-Computed Tomography
To generate high resolution surface models

SEGMENTATION

Avizo®

Three separate thresholding values were used to determine whether the processes used to generate skull surface models impacted our study.

LANDMARKING



Stratovan Checkpoint
3D landmarking editing interface used to distinguish between right and left disparities of the anole skull

R Statistical Software
Dataset of points collected from Stratovan Checkpoint were analyzed statistically

Results

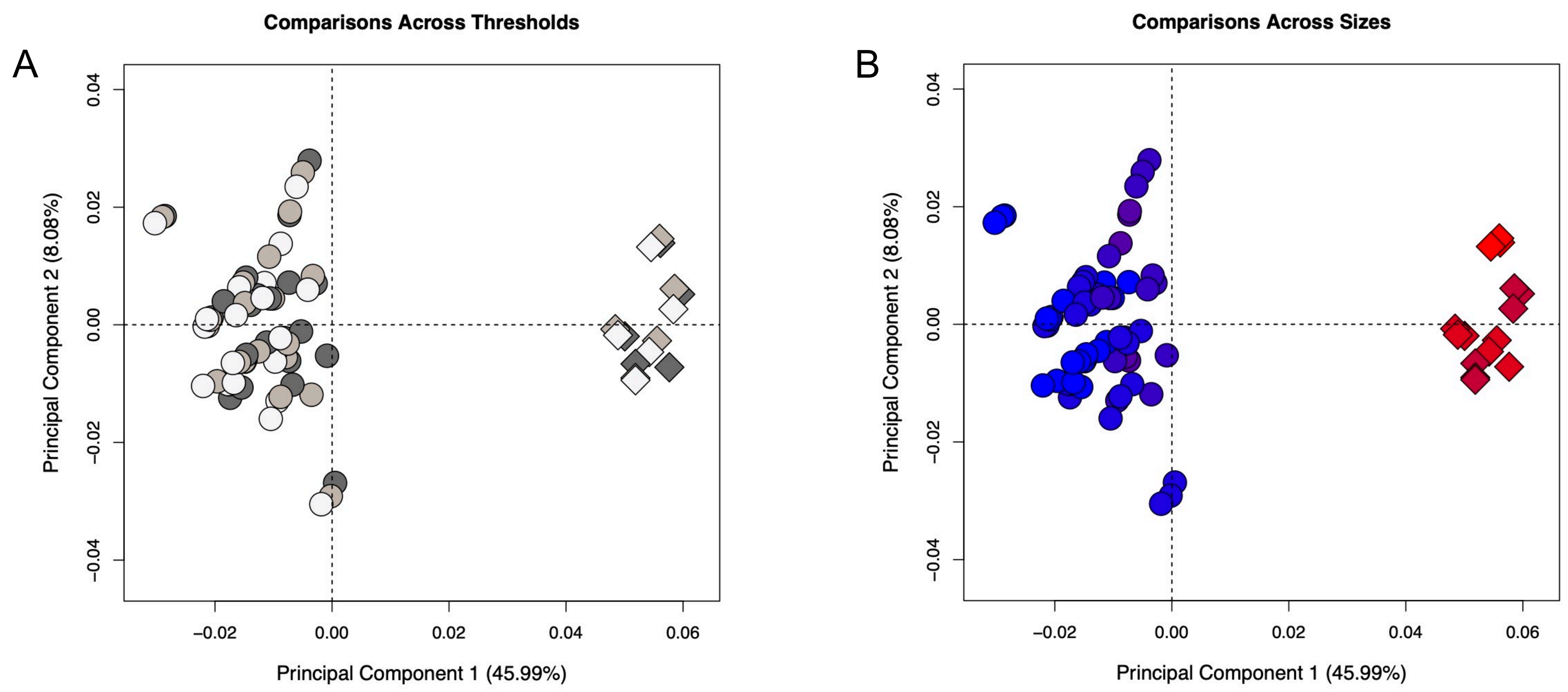


Figure 1: This is a principal component analysis showing the major differences in shape morphospace. (A) The colors represent the three thresholding masks used. This demonstrates that the thresholding differences did not strongly impact skull shape. White = mask 60, light gray = mask 55, dark gray = mask 50. (B) The colors represent skull size. The redder dots are larger lizards and the bluer dots are smaller lizards. Basically, the main difference is that males (diamonds) and females (circles) have different skull shapes and also different sizes.

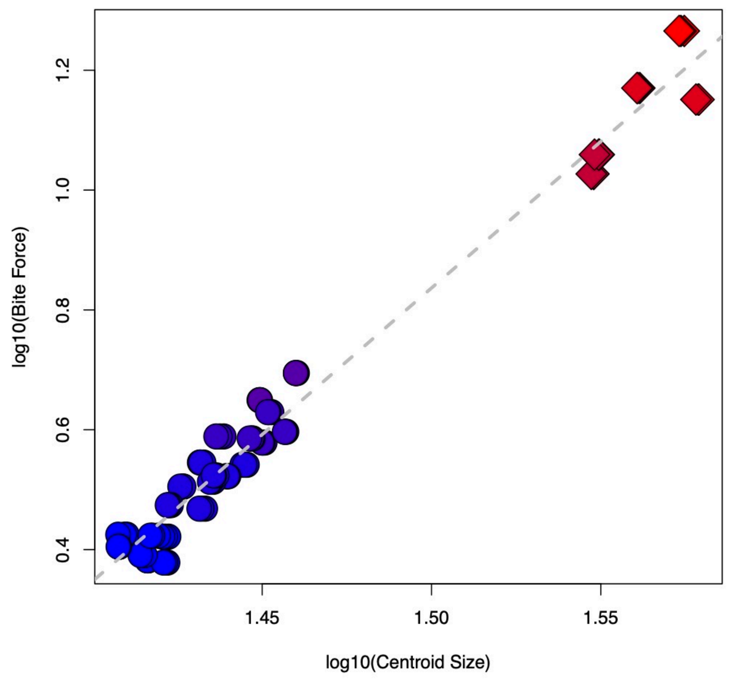


Figure 2: This graph represents the size of the anole's crania compared to their bite force. The redder dots are larger lizards and the bluer dots are smaller lizards. Males are diamonds. Females are circles. As skull size increases, bite force increases linearly where males have the highest bite force and skull size.

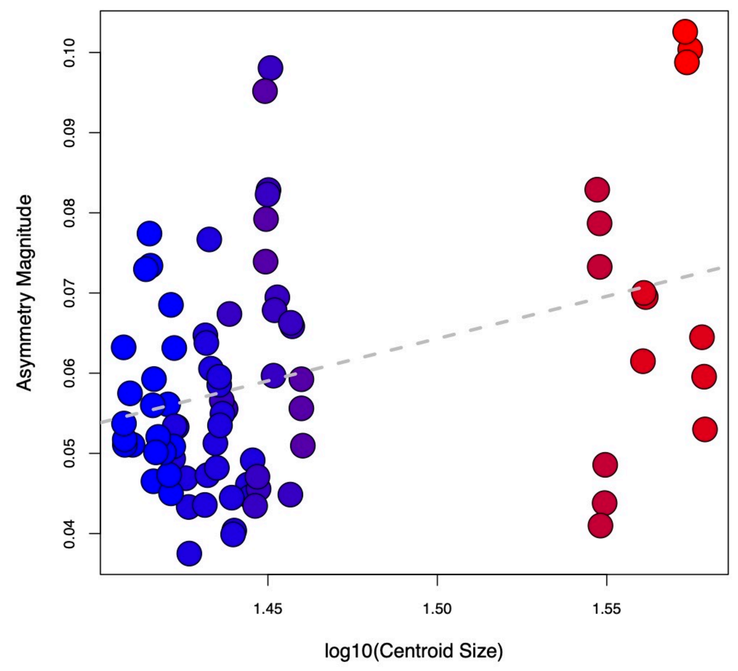


Figure 3: This plot demonstrates that as centroid size of the skull increases, asymmetry magnitude increases. However, there is a lot of scatter such that some of our larger anoles also had low magnitudes of asymmetry. The redder dots are larger lizards and the bluer dots are smaller lizards.

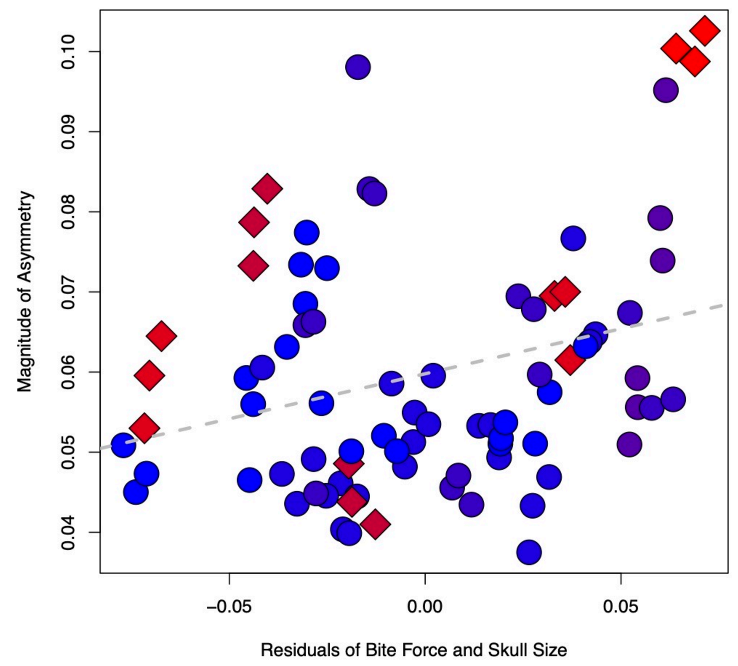


Figure 4: To account for the relationship between bite force and centroid size, we took the residuals of those two variables to remove the size component from bite force. Regardless, as bite force residuals increase, magnitudes of asymmetry increase.

Conclusions

QUESTION 1:
From our results, we found that the more asymmetrical features present in the cranial morphology of the green anole, the stronger bite force was present. We hypothesize that the thin cranial bone in anoles may deform following repeated biting events and thus that high bite forces led to increased asymmetry in our sample. This asymmetry appears to not lead to a substantial decrease in functionality since highly asymmetric anoles functioned best in terms of bite force.

QUESTION 2:
The magnitude of asymmetry seems to increase propotionally to the size of the anole. So, the bigger the anole, the larger magnitude of asymmetry is present.

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