Skull Shape Divergence Across Three Species of Louisiana Bats

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Introduction

Niche partitioning is an evolutionary process that defines community structure and regulates the coexistence of species that live in sympatry. One fundamental aspect of niche partitioning is resource use, specifically the partitioning of food resources.

How do morphological changes lead to niche partitioning in sympatric species that have the same diet?

To examine this question, we evaluated intraspecific and interspecific variation in three species of bat that all co-occur in Louisiana and Mississippi.

Intraspecific Predictions

1. *We predict bat skull shapes and sizes differ within species as they relate to sexual dimorphism.* We expect female bats to be significantly larger than male bats following general sexual size dimorphism trends in bats. As a result, we expect males and females to have significant sexual shape dimorphism so that they are both capable of eating foods of the same hardnesses in spite of size differences.

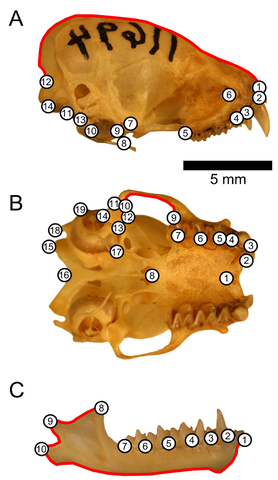
Interspecific Predictions

2. *We predict strong overlap between **Lasiurus borealis (Red bat)** and **Lasiurus seminolus (Seminole bat)** and partial overlap with **Nycticeius humeralis (Evening bat)*** as a result of phylogenetic relatedness. However, since the bats are not occupying different dietary niches, we expect that they will all exhibit the same skull shape statistically.

A. *Lasiurus borealis* B. *L. seminolus* C. *Nycticeius humeralis*

Photos by: Joel Sartore 2021; Michael Durham/Minden Pictures, JM Butler

Methods



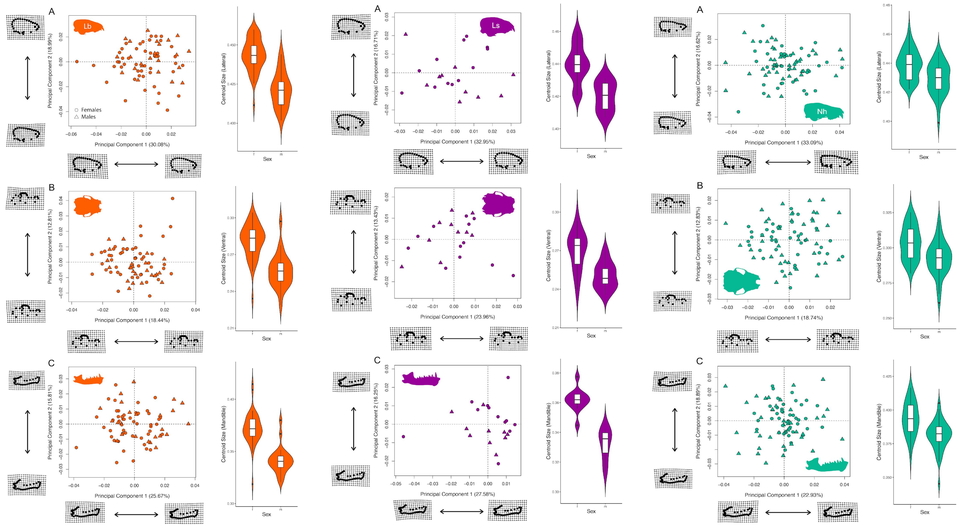
Crania and mandibles from ***Lasiurus borealis*** (n = 72), ***L. seminolus*** (n = 22), and ***Nycticeius humeralis*** (n = 81) were photographed at the Louisiana State University Museum of Natural Sciences (LSUMZ) in uniform views. Skulls were landmarked and semi-landmarked using geometric morphometric methods.

Data were collected in separate (A) **lateral cranial**, (B) **ventral cranial**, and (C) **mandibular** views (Left). Each landmark was chosen with respect to anatomical characters that were reproducible across the three species. To visualize shape change, principal component analyses were used.

Procrustes ANOVAs were then employed to test our predictions:

Sexual shape dimorphism (Shape ~ Size + Sex)
Sexual size dimorphism (Size ~ Sex)
Differences between species (Shape ~ Size + Species)

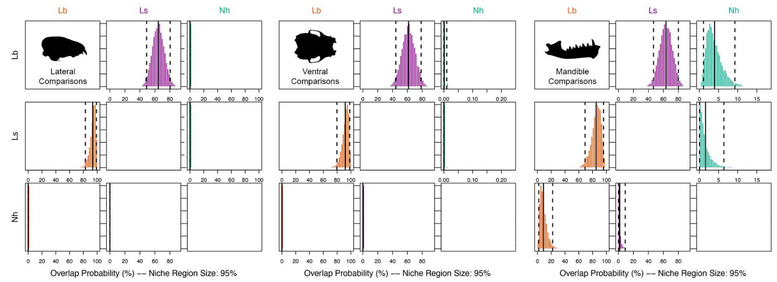
Intraspecific Variation



Prediction 1 Results: Principal component analyses showing differences in male (triangles) and female (circles) shape for (A) lateral cranial, (B) ventral cranial, and (C) mandibular shape. Violin plots showing differences in male and female skull size for each view. ***Lasiurus borealis (Red bat)* on left. *Lasiurus seminolus (Seminole bat)* in middle. *Nycticeius humeralis (Evening bat)* on right.**

Females were found to be larger than males across all species demonstrating sexual size dimorphism (right violin plots). However, we found that the significance of sexual shape dimorphism varied across all species not showing a clear pattern (left principal component plots).

Interspecific Variation



Prediction 2 Results: Principal components and centroid sizes for the (A) lateral cranial, (B) ventral cranial, and (C) mandibular views were input into NicheROVER, which measures overlap between niche variables and generates a confidence interval around a mean amount of overlap. Values range from 0% overlap to 100% overlap.

As predicted. ***L. borealis*** and ***L. seminolus*** showed a great deal of niche overlap, with ***L. seminolus*** niche space being entirely within the bounds of ***L. borealis*** niche space (100% overlap probability).

We observed far less overlap between ***N. humeralis*** and ***L. borealis*** niche spaces than predicted, and even less overlap between ***N. humeralis*** and ***L. seminolus***.

Conclusions

- For our **intraspecific analyses**, we found that sexual size dimorphism was observed in all species as female skulls were larger than males, though sexual shape dimorphism was not a strong component of cranial shape variation.
  - After parturition, juvenile bats typically stay with their mother until they are weaned, and the female must fly while holding the juveniles. Thus, sexual size dimorphism is commonly found across a wide variety of bat species whereby the female is the larger sex.
- In our **interspecific analyses**, we observed considerable overlap in the cranial shape of two species (***L. borealis*** and ***L. seminolus***) in all configurations. In contrast, ***N. humeralis*** cranial configurations were entirely distinct in shape from the other two species, although mandible shape separation was observed to be less distinct among the three species.
  - This may be an example of many-to-one mapping where there are multiple solutions (e.g., different skull shape configurations) that evolve to solve the same problem (e.g., eating the same diet).
- This work is a first step in better understanding the morphological diversity of bats that live in sympatry in the southeastern United States.

Future Directions:

Future work will be done using species distribution modeling to examine to what degree these three bat species overlap in their ranges and whether they likely forage in the same regions in the southeast.

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