A Comparative Study of Morphological Characteristics between Fruit-Eating and Insect-Eating Bats of Dominica

Sarah Davis
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Dr. Lacher

Dr. Heyman

Abstract:

The main goal of this research paper was to explore the morphology of three species of bats, and compare their body structures in relation to their differing diets, using two frugivores (*Artibeus jamaicensis* and *Sturnira lilium)* and one insectivore (*Tadarida brasiliensis*). I evaluated if there was relationship between morphological traits and feeding habits. I tested the hypothesis that the ratio of forearm length to hind foot length is not simply proportional to the size of the bats, but is related more to the diet of each species. The data collected includes; species, sex, weight (gm), forearm length (cm) and hindfoot length (cm), and forearm to foot length ratio. I found no statistically significant relationship between bat morphology and diet. However, there is some type of mechanism that does result in morphological differences between species, in particular *Sturnira lilium* in relation to the other species.

Introduction:

There are many different types of habitats in which bat species can be found. Dominica, a small island in the West Indies, provides a rich diversity of habitats that supports twelve different species of bats (Evans and James, 1997). This "Nature Island of the Caribbean" is located in the Lesser Antilles, between the islands of Guadeloupe and Martinique. The people of this island hold on to the tradition of being an all natural, self-sustaining island, and are against massive development. Therefore, since the island is still largely pristine it allows for the study of many organisms, including bats, in their natural habitats.

Bats belong to the Order Chiroptera, the only flying mammals, and comprise approximately a fourth of all mammal species (Schmidly, 1991). There are bats that navigate by

echolocation, suborder Microchiroptera, and those that generally navigate by sight and possess a claw on their second finger, suborder Megachiroptera. Bats can survive on many different diets and those diets found on Dominica include; fish, insects, nectar and fruit (Evans and James, 1997). Each species of bat has certain characteristics that enable them to be better adapted to their ecological niche including their diets. The differences in the morphology between all the species can be easily recorded, identified, and studied. This study focuses on two frugivore (fruit-eating) bats *Artibeus jamaicensis* and *Sturnira lilium* and an insectivore (insect-eating) bat *Tadarida brasiliensis*. The working hypothesis is that the frugivores would be more similar in morphology than either is to the insectivore.

Materials and Methods:

Bats were netted on the Archbold Tropical Research and Education Center premises next to the small pond by the "Bee House." The net was deployed at approximately 6:40 P.M. each evening of data collection, just as the sun was going down. Bat collection usually occurred between 7:45 and 8:30 PM. Bats were freed from the net and placed in socks that were closed with clothes pins until all bats for the evening were collected. Bat weights were determined using a handheld mechanical Pesola scale that was clipped to the sock holding the bats. Bat forearm length, from the elbow to the wrist, and the foot length, from the ankle to the toes, were measured with a ruler. Analysis of variance (ANOVA) was used to compare mean measurements and Principal Components Analysis was used to assess patterns of variability in morphology.

Results and Discussion:

There was a highly significant difference in the forearm and foot length between all three species, $p < 0.0001$ for both measures (Table 1).

Table 1: ANOVA for forearm and Foot Length Among all Three Species

		Sum of Squares	df	Mean Square	F	Sig.
Forearm (mm)	Between Groups	4053.985	2	2026.993	569.784	.000
	Within Groups	152.971	43	3.557		
	Total	4206.957	45			
Foot (mm)	Between Groups	254.274	2	127.137	55.693	.000
	Within Groups	98.161	43	2.283		
	Total	352.435	45			

I then ran a principal components analysis on all bats for the two morphological variables. There were two principal components analyzed for the two morphological variables, forearm and foot length. The next step was to determine if any factor other than size could explain a significant amount of the variance between species. There were two axes extracted in order to test this. The first axis accounts for 88.4% of the variance, and the second one accounts for 11.6% (Table 2).

Table 2: Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.768	88.383	88.383	1.768	88.383	88.383
2	.232	11.617	100.000	.232	11.617	100.000

Extraction Method: Principal Component Analysis.

Once it was determined that there were two different components explaining variability among individuals in the forearm and foot length of the bats I then determined how each of the components affects each particular length. Since there were all positive scores on the first axis, component 1, then it is obvious that component one can be related to the size variation between

bats. However, the second axis, component 2, shows different signs for forearm and foot length which indicates that there is some type of form difference between the bat species (Table 3).

Table 3: Component Score Coefficient Matrix

	Component	
	1	2
Forearm (mm)	.532	-1.467
Foot (mm)	.532	1.467

Extraction Method: Principal Component Analysis.

The next step was to determine which species component two affected. This was done by graphing the scores of each bat on the two different axes. The bats are graphed according to numbers; #1: *Artibeus jamaicensis,* #2: *Tadarida brasiliensi,* and #3: *Sturnira lilium*. All species sort by size on axis one, however, *Sturnira lilium* is the only species that plots on the positive side of the second axis (Figure 1).

Figure 1: Principal Component Plot

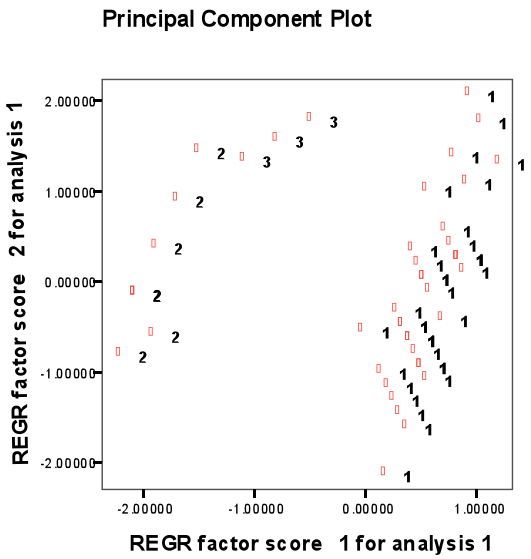

Figure 1 illustrates that there is some other regulating factor, not size, affecting the forearm to foot length ratio. In order to determine what was different between *Sturnira lilium* and

the other two species another table was built that calculated if there was a significant difference in the forearm to foot length ratio (Table 4).

Table 4: ANOVA of ratio of forearm length to hind foot

ANOVA

Ratio

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.438	2	2.719	7.047	.002
Within Groups	16.589	43	.386		
Total	22.026	45			

With a significance value of .002, it became clear that there is a major difference in the forearm to foot length ratio. There was no significant difference between the ratios of *Artibeus jamaicensis* and *Tadarida brasiliensis*. However, *Sturnira lilium* has a significantly smaller ratio than the other two species (Table 5).

Table 5: Forearm to Foot Length Ratios

Tukey HSD

Species	N	Subset for alpha = .05	
	1	2	1
3	3	3.6667	
1	35		4.5257
2	8		5.1750
Sig.		1.000	.170

Although there seems to be no relationship between species morphology and diet, there was a significant, non-size related difference in morphology between the two frugivores. There must be some unknown ecological effect that causes a change in the morphology between bat species.

Conclusion:

While the initial hypothesis is rejected, it was very interesting to learn that there is high variation between species that share the same diet. I was very impressed to find out that there wasn't much of a difference between the frugivores and insectivores besides their general body size. Further studies could be done that attempt to figure out what the particular ecological factors are involved that cause these variations between species.

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