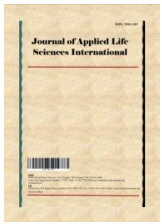

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Comparison of the External Morphology of Straw-coloured Fruit Bats on Different Locations on Obafemi Awolowo University Campus

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Authors' contributions

This work was carried out in collaboration between both authors. Author AOB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author OFI managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Background of the Study: In the past few years, the presence of straw-coloured fruit bats in various parts of the University has been of a great concern to the University community. The movement of straw-coloured fruit bats from one location to another also creates concern of possible destruction of some important ecosystem features on campus.
Objective of the Study: This study compared the external morphology of straw-coloured fruit bats from three different locations on Obafemi Awolowo University campus students' residential area, academic area and staff quarters).
Methodology: Non-lethal trap and mist nets were used in collecting the Straw-coloured fruit bats between June and December 2019. Captured specimen were transported in cages into the laboratory and chloroform was used to anesthetize the specimens before measuring the external morphometric parameters (HB, FA, HF, TIB, EL, TL, Tr, TBL and BW) with the aid of ruler and venier calliper.
Results and Conclusion: A total of 114 fruit bats (66 male and 58 female) were sampled with the use of non-lethal trap and mist nets. The mean Head body length for male specimens from the

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three locations were 204.6±2.1 mm, 214.6±1.2 mm and 216.6±2.6 mm and the mean body weight were 208.5±2.4, 224.6±2.1 and 254.3±2.9 g respectively. The mean Head body length of female specimens were 158.5±1.1 mm, 172.8±1.5 mm, and 186.5±2.6 mm and the mean of body weight from all the locations were 184.6±2.0, 206.5±2.1 and 232.6±2.9g. The specimens from Student hostel had the lowest external morphometric parameters values, while specimens from Staff quarters had the highest morphometric values. The PCA scatter plot showed no relationship in the morphometric parameters of all the specimens from the three locations. The PCA loading showed that HB, TIB and the BW of all the specimen had negative correlation which may be due to different factors. In conclusion, the Straw-coloured fruit Bat on OAU campus showed different external morphometry which may be due to roosting, foraging and predator.

Keywords: Morphometry; bodyweight; tail length; ecology; roosting.

1. INTRODUCTION

The straw-coloured fruit bat, *Eidolon helvum* (Kerr, 1792), is a frugivorous animal in the order Megachiroptera [1,2]. Although historically not viewed as a charismatic species, bats are eco-friendly. Except for the most severe barren region and Polar regions, bats stay in almost every habitat worldwide, simply as they have for more than 50 million years. Nearly 1,240 different species of bats are known today, fully one-quarter of recognized mammal species [3]. Despite their diversity, the world's solely flying mammals remain amongst the least understood of animals [4].

The straw-coloured fruit bat, (*Eidolon helvum*) are found in both woodland and savannah, at an elevation of 2000 ma.s.l in some part of the world [5]. It is gregarious and prefers to roost in tall bushes by using day to rest and feed during the night. However, bat has additionally been found in lofts and in caves in rocks [6]. In Nigeria, they are found on particular trees pecies roosting [1,2] because of fruits of the tree or shade during the day.

Straw-coloured- fruits bats (*E. helvum*) depend on fruit, pollen or nectar [7]. They destroy trees when larger number roosts on smaller branches and twigs. *E. helvum* consumes sweet, juicy fruit, buds, younger leaves of trees, flowers, nectar and pollen [5]. They also chew into tender wood to obtain moisture [8]. According to Dumont and Herrel [7] foraging strategies of *E. helvum* depends on distribution of fruit resources. Bats of the identical sex are suggested to forage together, feed on the same food and pick roosting web sites with comparable characteristic [9].

In Nigeria, *E. helvum* feeds almost completely at night, whereas trees visited in the course of the day are solely for roosting [1,10]. At night, small organizations of bats fly to foraging areas in straight lines. On many occasions, foraging destination is not known, however the effective flight suggests that these bats make use of food sources many kilometres from their roosts [11,12].

Bats set off premature shedding of leaves which may result in the destruction of such timber (by the loss of photosynthetic ability); depending on how long the timber serve as their roost site or camp. This deprives the immediate environment of the complement of their functions, evapotranspiration and provision of carbon sink [13]. The aftermath of their tenting is an aesthetically disagreeable sight or defacement of such landscape characteristic (trees). A contrast of the ecological consequences of the presence of bats in the city surroundings reveals that the fundamental victims are the bushes and a few related features [14].

Bat behaviour or morphology is influenced by spatial and temporal distribution of foraging and roosting sites and are confined by predation and competition [15]. Ajibola et al. [2] reported the morphometric parameters and the feeding factor of Straw-coloured fruit Bats in Obafemi Awolowo University. They reported overcrowding of the bats on trees in different locations of the University which caused destruction of the roosting trees.

Looking into the effects of destruction of roosting sites (trees) on population and external morphology of Straw-coloured fruits Bat on University Campus may additionally grant an insight to ecology behaviour of Straw-coloured fruits Bat in relation to susceptibility to predators and migration. Hence, this study seeks to investigate the external morphology of Straw-coloured fruit Bats from three locations on

Obafemi Awolowo University Campus, to determine the effects of roosting on abundance and other morphological parameters.

2. MATERIALS AND METHODS

2.1 Study Location

This research work was carried out in Obafemi Awolowo University, Ile Ife. The university is located between Latitudes 7°26'N and 7°32'N and between Longitudes 4°31'E and 4°35'E. The landmass is 5605 hectares with an altitude of 300 m above sea level. Rainy and dry seasons characterized the climate with ambient temperature ranges from 20 to 30°C. Study locations were established at the student's hostel; academic area and the university staff quarters.

2.2 Materials Used in the Research Field

The materials used for this study were, non-lethal trap, mist net, measuring ruler, Venire caliper, Thread, Rubber gloves, and Harvard trip balance (OHAUS, US).

2.3 Method of Collection

Non-lethal trap and mist nets were used in collecting the Straw-coloured fruit bats between June and December 2019. The trap consists of a frame with vertical wires which is used to stop flying bat. The bat slide into the bag at the bottom of the trap and the bag with bat inside is transported into the lab. The traps [5] were set in the evening time (4:00 pm) in vertical position between trees and checked in the morning (6:30 am).Captured specimen were transported in cages into the laboratory and chloroform was used to anesthetize (by putting cotton wool that contained chloroform in their cage between 3-5 min) [2] the specimens before measuring the external morphometric parameters (Fig. 1). Ethical approval was obtained from the ethics committee of the University. The specimens were later released after they have gained consciousness.

2.4 Identification of Specimens

The Straw-coloured fruits Bat was identified by the descriptions given by Kruskop [16]. The male specimen was determined with hands and transverse vulva opening of the female specimen. The sub adults specimen was identified by layers of relatively transparent cartilage at the epiphysal ends of the wing.

2.5 Data Analysis

One-way analysis of variance (ANOVA) was used to determine the significant difference between the means, while the significant mean was separated at $p \leq 0.05$ using Least Significant Difference (LSD) test from System Analysis Software (SAS Institute, 1997). Principal Component Analysis (PCA) was carried out with PAST version.

3. RESULTS

The abundance of Straw-coloured fruit Bat (male and female) are shown in Table 1. A total of 114 specimens was used for this study. The abundance of male specimens was higher (66) than female (48). Sixteen (16) males and 14 females' specimen were caught in student hostels. The total of 40 specimen was caught from academic area of the University with twenty-

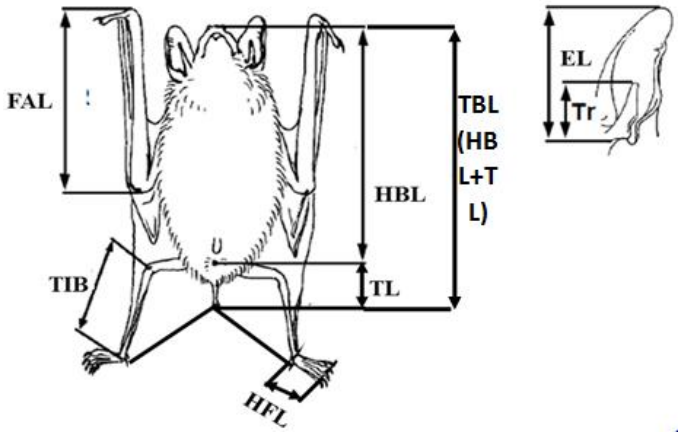

Fig. 1. Schematic representation of the standard measurement of a bat (adapted from 16)

Table 1. The abundance of male and female Bats (*Eidolon helvum*) from three different locations in the University (Student hostel, academic area and staff quarter)

Locations	Male	Female	Total	Percentage (%)
Students Hostel	16	14	30	26.31
Academic area	21	19	40	35.09
Staff quarters	29	15	44	38.60
Total	66	48	114	100

one (21) males and nineteen (19) females. This accounted for 35.09% of the total specimen for the study. The highest percentage (38.60) of Straw-coloured fruit Bat was recorded in the staff quarters with the highest number of male specimen (29) and fifteen (15) females. It can be said from the quantity of the specimen used for this study that male Straw-coloured fruit Bat (*E. helvum*) may be higher on Obafemi Awolowo University campus than female.

The morphometric parameters measured on male Straw-coloured fruit Bat (*E. helvum*) are shown in Table 2. The mean Head body (HB) length of specimen from student hostel was the least (204.6±2.1 mm), followed by specimen from Academic area (214.6±1.2 mm) and the highest mean value was recorded for specimen from Staff quarters (216.6±2.6 mm). The HB range from 196.2 mm in specimen collected from student hostel to 218.2 mm in Staff quarters. The mean Forearm (FA) length of specimen from Staff quarters was the highest (172.6±1.5 mm) while least FA was recorded at the student hostel (150.1±1.1 mm). There was significant difference ($P < 0.05$) in the FA for the male specimen from all the study locations. The FA value ranged from 145.5 mm (student hostel) to 181.5 mm (staff quarters). The mean Hind foot (HF) length of all the specimen were significantly different ($P < 0.05$) from each location.

The mean HF of specimen from student hostel was the least (83.5±0.9 mm), followed by specimen from academic area (86.7±0.9 mm) and that of staff quarters was 91.7±0.9 mm. The mean Tibia length (TIB) followed the same trend as HF with specimen from Student hostel having the least TIB value (69.7±0.8 mm) and specimen from Staff quarters having the highest TIB value (81.6±0.6 mm).

The mean value of Ear length (EL), Tragus length (Tr), and Total body length (TBL) showed a significant difference ($p < 0.05$). The EL, Tr and TBL of specimen from student hostel were the least (29.2±0.5, 5.5±0.1 and 211.2±2.1 mm), followed by specimen from academic area (31.3±0.6, 6.8±0.2 and 221.9±2.8 mm). Specimen from staff quarters had the highest value for EL, Tr and TBL (33.5±0.7, 7.1±0.5 and 223.6±2.4 mm). There was no significant difference in the Tail length (TL) of the specimen from academic area and Staff quarters (7.3±0.3 and 7.6±0.4 mm). The Tail length (TL) of specimen from student hostels were the least with mean value of 6.6±0.2 mm. The Body weight (BW) of the specimen ranged between 165 to 266.8 g. The mean BW of specimen from Student hostel was 208.5±2.4 g, while the specimen from academic area was 224.6±2.1 g. The mean BW for specimen from Staff quarters was 254.3±2.9 g and it was the highest among all the specimen.

The results of the measured morphometric parameters from female Straw-coloured fruit Bat (*E. helvum)* was similar to that of male (Table 2). The Head body (HB) length of all the specimen were significantly difference ($p < 0.05$), with highest mean value obtained from specimen from staff quarters (186.5 mm) and the least from specimen from student hostel (158.5 mm). The mean Forearm (FA) length of the specimen from students' hostel was 113.1±0.5 mm and ranged between 105.5 to 117.2 mm. The mean FA of specimen from academic area ranged between 121.2 to 125.8 mm with mean value of 123.2±1.1 mm, while the mean FA value for specimen from Staff quarters ranged between 138.2 to 145.9 mm and mean value of 140.6±1.5 mm. The mean value of Hind foot (HF) of all the specimen from the three locations was significantly difference ($p < 0.05$), with specimen from Staff quarters having the highest range (60.1-66.2 mm) and mean value of 63.6± 0.9 mm. The specimen from academic area have the mean value of 57.3±0.6 mm while specimen from Student Hostels have the mean value of 51.5±0.7 mm for HF. The mean Tibia length (TIB) of the specimen from the three locations (Students Hostels, academic area and Staff quarters) were 42.5±0.6, 48.6±0.8 and 53.7±0.6 mm. The TIB value ranged between 39.5 mm from specimen from Student hostels to 56.1 mm from specimen from Staff quarters.

Table 2. The morphometric parameters of male bat (*Eidolon helvum*) caught at three different locations in the university (student hostel, academic area and staff quarter)

Locations	Statistic	HB (mm)	FA (mm)	HF (mm)	TIB (mm)	EL (mm)	TL (mm)	Tr (mm)	TBL (mm)	BW (g)
Student	Mean	204.6^{a}±2.1	150.1^{a}±1.1	83.5^{a}±0.9	69.7^{a}±0.8	29.2^{a}±0.5	6.6^{a}±0.2	5.5^{a}±0.1	211.2^{a}±2.1	208.5^{a}±2.4
Hostels	Range	196.2-209.0	145.5-165.2	80.5-86.4	62.2-73.3	26.5-31.2	5.9-7.2	4.8-6.1	202.1-216.2	165-221.5
Academic	Mean	214.6^{b}±1.2	165.5^{b}±1.2	86.7^{b}±0.9	72.5^{b}±0.8	31.3^{b}±0.6	7.3^{b}±0.3	6.8^{b}±0.2	221.9^{b}±2.8	224.6^{b}±2.1
Area	Range	202.7-216.5	152.5-177.6	82.2-87.9	70.6-74.7	29.9-32.5	6.9-8.2	7.0-8.1	209.6-224.7	181.4-246.6
Staff	Mean	216.6^{b}±2.6	172.6^{c}±1.5	91.7^{c}±0.9	81.6^{c}±0.6	33.5^{c}±0.7	7.6^{b}±0.4	7.1^{c}±0.5	223.6^{c}±2.4	254.3^{c}±2.9
Quarters	Range	212.5-218.2	156.7-181.5	89.5-93.5	79.6-83.1	31.2-34.8	7.1-8.1	6.8-8.2	219.6-226.3	221.5-266.8

**Means within column with different Superscript are significantly different (P≤0.05) from each other*

Footnote: HB is the Head Body length, FA is the Fore arm length, HF is the Hind foot length, TIB is the Tibia length, EL is the Ear length, TL is the Tail length, Tr is the Tragus length, TBL is the Total body length and BW is the Body weight

Table 3.The morphometric parameters of female bat (*Eidolon helvum*) caught at three different locations in the university (student hostel, academic area and staff quarter)

Locations	Statistic	HB (mm)	FA (mm)	HF (mm)	TIB (mm)	EL (mm)	TL (mm)	Tr (mm)	TBL (mm)	BW (g)
Student	Mean	158.5^{a}±1.1	113.1^{a}±0.5	51.5^{a}±0.7	42.5^{a}±0.6	18.6^{a}±0.4	3.6^{a}±0.2	4.5^{a}±0.1	162.1^{a}±2.1	184.6^{a}±2.0
Hostels	Range	142.2-162.5	105.5-117.2	49.2-54.4	39.5-45.4	16.7-21.1	2.2-4.8	3.9-6.1	144.4-167.3	172.5-199.8
Academic	Mean	172.8^{b}±1.5	123.2^{b}±1.1	57.3^{b}±0.6	48.6^{b}±0.8	22.6^{b}±0.6	4.9^{b}±0.3	5.6^{b}±0.2	177.7^{b}±2.8	206.5^{b}±2.1
Area	Range	169.2-173.6	121.2-125.8	50.6-59.6	46.2-51.4	20.1-24.9	3.2-5.6	4.9-7.1	172.4-179.2	201.2-218.3
Staff	Mean	186.5^{c}±2.6	140.6^{c}±1.5	63.6^{c}±0.9	53.7^{c}±0.6	24.8^{c}±0.7	5.6^{c}±0.4	6.9^{c}±0.5	192.1^{c}±2.4	232.6^{c}±2.9
Quarters	Range	181.7-189.4	138.2-145.9	60.1-66.2	50.6-56.1	22.5-27.1	4.4-7.1	5.7-8.1	186.1-195.5	229.4-244.6

**Means within column with different Superscript are significantly different (P≤0.05) from each other*

Footnote: HB is the Head Body length, FA is the Fore arm length, HF is the Hind foot length, TIB is the Tibia length, EL is the Ear length, TL is the Tail length, Tr is the Tragus length, TBL is the Total body length and BW is the Body weight.

The mean Ear length (EL), Tail length (TL), Tragus length (Tr) and Total body length (TBL) showed significant difference at $p < 0.05$. The mean EL, TL, Tr and TBL of the specimen from Student hostels was the least (18.6±0.4, 3.6±0.2, 4.5±0.1 and 162.1±2.1 mm) followed by specimen from academic area (22.6±0.6, 4.9±0.3, 5.6±0.2 and 177.7±2.8 mm) and highest value from specimen from Staff quarters (24.8±0.7, 5.6±0.2, 6.9±0.5 and 192.1±2.4 mm). The mean Bodyweight (BW) of the specimen from Student hostels was 184.6±2.0 g and the values ranged between 172.5 to 199.8 g. The mean BW for specimen from Academic area and Staff quarters were 206.5±2.1 and 232.6±2.9 g respectively.

The measured morphometric parameters for both male and female Straw-coloured fruit Bat (*E. helvum*) showed that the male fruit Bat have higher value when compared with female and specimen from Student hostel have the least value when compare with specimen from Academic area and that of Staff quarters.

The Principal Component Analysis (PCA) scatter plot was used to determine relationship among the morphometric parameters measured in both male and female (Fig. 2). The PCA scatter plot showed relationship between morphometric parameters of male bats recorded at academic area and student hostel. No other relationship was observed in morphometric parameters of male among other locations.

There was no relationship in the morphometric parameters of the female Straw-coloured fruit Batamong all locations. The absence of little (male) or no relationship (female) in the measured morphometry parameters encouraged further PCA loading with correlation analysis on the measured morphometry parameters.

From the PCA loading graph (Fig. 3), The Head body (HB) length, Hind foot (HF) length, Tibia (TIB) length, Ear length (EL) and Bodyweight (BW) have negative correlation in the male specimen from all the locations, while Forearm (FA) length, Tragus (Tr) length, Tail length (TL), and Total Body length have positive correlation among all the specimen. Morphometric parameters such as HB, FA, TIB, and BW have negative correlation in the PCA loading for female specimens, while HF, EL, Tr and TBL showed positive correlation.

4. DISCUSSION

The variation in the abundance of Straw-coloured fruit Bat (*E. helvum*) from the three locations may be attributed to some factors. One of the factorsis the distribution of roosting trees which were in large quantity in staff quarters and academic area when compared to student hostel. Predator may also contribute to the abundance of bats in various locations. Since bats are considered as bush meat [17] some hunters or poachers may have access to bats roosting on short trees. Availability of fruit (Food) may also

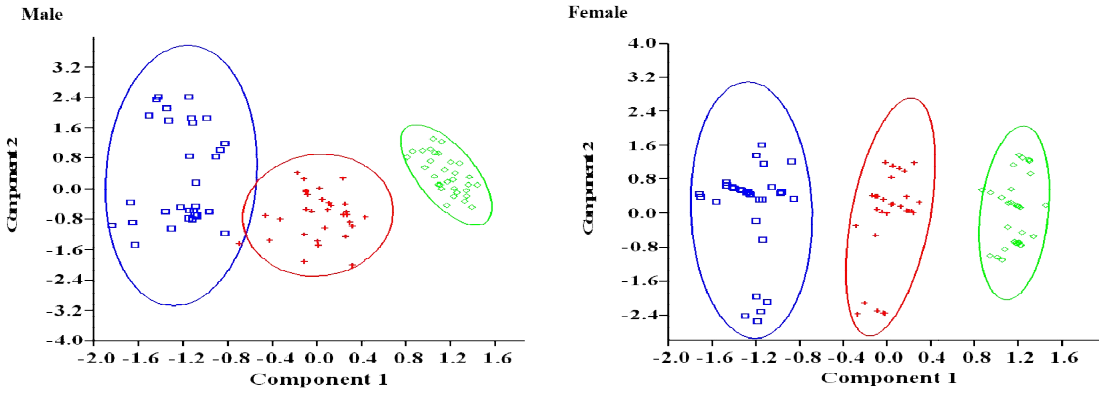

Fig. 2. Principal component analysis (PCA) scatter plot showing morphometric relationship between male and FemaleBat specimen collected in three locations in Obafemi Awolowo University

Keys
Blue colour is specimen from Student Hostels
Red colour is specimen from Academic Area
Green colour is specimen from Staff Quarter

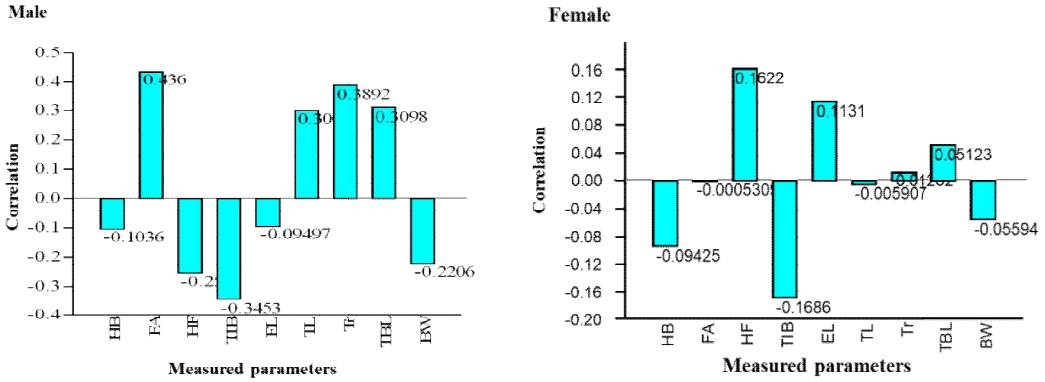

Fig. 3. PCA factor loading plot showing the correlation in morphometric parameters in male and female bats specimen from three different location in Obafemi Awolowo University (cut off of 0.7)

Footnote: HB is the Head Body length, FA is the Fore arm length, HF is the Hind foot length, TIB is the Tibia length, EL is the Ear length, TL is the Tail length, Tr is the Tragus length, TBL is the Total body length and BW is the Body weight

contribute to least abundance of bats recorded from student hostel when compared to other two locations (academic area and staff quarters). Patterson et al. [15] reported fruit bat migration may be influenced by feeding and roosting sites, while their migration is limited by predators and competition.

The ratio of male fruit bat was also higher than female in all the three locations of this study, and this may be attributed to seasonal breading which may reduce the search for food in female fruit bat compared to male [18]. Also, bats of the same sex are reported to forage together, feed on the same food and choose roosting sites with similar characteristic [9]. Levin et al. [9] reported that male bats forage in cooler elevation while female bat forage around rivers which were not available in our collection sites.

The measured morphometric parameters showed that specimen from student hostels have least values when compared to other locations (academic area and staff quarters). The least value of the morphometric parameters observed in the specimens from different locations may be attributed to age which was not taken into consideration in this study. The specimen from student hostel may be juvenile Straw-coloured fruit Bats while specimen from academic area and staff quarters are matured ones. Kruskop [16] reported that juvenile bat has lower morphometry parameters when compared to adults. Weight is a good indicator of overall condition of an individual bat including maturity, reproduction state and amount of body fat [16]. The decrease in morphometric parameter measured values may also be attributed to type of food (hard or soft fruit) in such location when compared to other locations. Aguirre et al. [19] reported that fruit hardness, fruit size and bite forces for species in a community may vary and be responsible for their feeding ability. Dumont [20] reported that fresh fig is fairly hard and require more force to crush than papaya which is soft and abundant in academic area [2] and staff quarters. The fact that larger bat does select larger prey or fruits and that only larger bat will eat large beetles suggest that food hardness has major consequence for diet selection.

The differences seen in the scatter plot of PCA (Fig. 2) may be due to difference in the external morphometric parameters measured which showed that specimen from student hostel was big while the specimen from academic area were bigger and the specimen from Staff quarters were biggest in body weight. The PCA loading (Fig. 3) showed a negative correlation in some external morphometric parameters (HB, HF, TIB, EL and BW) of male Straw-coloured fruit Bat (*E. helvum*), while HB, FA, TIB, TL and BW also showed negative correlation in female Straw-coloured fruit Bat on Obafemi Awolowo University. The negative correlation maybe attributed to different age of the specimen from the study area in which specimen from staff quarter may be older than specimen from student hostels and academic area. Wing, body weight and tail length were used by Schmider et al. [21] to discriminate between closely related Horseshoe Bat (Rhinolophidae and Chiroptera).

They reported that external morphology is commonly used to identify bats as well as to investigate flight and foraging behaviour. While FA, HB and BW may be used to determine the age and maturity of the fruit bats, FA has been reported as the most vital measurement reflecting overall size of bat [16].

The presence of Straw-coloured fruits Bat on Obafemi Awolowo University community calls for concern as batsare carriers of different viruses. Straw-coloured fruit Bat (*E. helvum*) are of great interest to those working in the fields of Public Health and emerging infectious diseases [24]. The report of Heyman et al. [22,23,24] showed that Lagos Bat virus, henipaviruses, and Ebola virus were found in a single colony of Straw-coloured fruit Bat in Accra Ghana, West Africa. Therefore, it is important to control the spread of the fruit bat on Obafemi Awolowo University community.

5. CONCLUSION

The Straw-coloured fruits Bat in the Student hostel has least external morphometry compare to Straw-coloured fruit Bat from other locations on Obafemi Awolowo University. There is negative correlation in some external morphometric measure which may indicate difference in age or maturity of the specimen used for this study despite age and maturity are not considered for this study.

6. RECOMMENDATION

Further study is required to determine if there is another close specie of fruit Bat on Obafemi Awolowo University.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Okon EE. Fruit bats at Ife: Their roosting and food preferences (Ife fruit Bat project no. 2). Nigerian field. 1974;39:33-40.
2. Ajibola E, Ojo O, Omoshehin T. Morphometric parameters and aspects of the feeding habits of the Straw-coloured fruit Bat (Eidolon helvum) on Obafemi Awolowo University Campus, Ile-Ife, Nigeria. International Journal of Biology Research. 2018;3(2):188-191.
3. Prothero DR. The Princeton field guide to prehistoric mammals. Princeton University Press. 2016;112.
4. Vanthomme H, Bellé B, Forget PM. Bushmeat hunting alters recruitment of large-seeded plant species in Central Africa. Biotropica. 2010;42(6):672-679.
5. Agyei-Ohemeng J. Aspects of the ecology of fruit Bat (*Eidolon helvum*) in the University of Energy and Natural Resources*, Sunyani* (Doctoral dissertation); 2015.
6. Hayes MA, Adams RA. Maternity roost selection by fringed myotis in Colorado. Western North American Naturalist. 2015;75(4):460-473.
7. Dumont ER, Herrel A. The effects of gape angle and bite point on bite force in Bats. Journal of Experimental Biology. 2003;206(13):2117-2123.
8. Nowak RM, Paradiso JL. Walker's mammals of the world, Fourth ed The Johns Hopkins Univ. Press, Baltimore, Maryland. 1983;1:1-568
9. Levin E, Roll U, Dolev A, Yom-Tov Y, Kronfeld-Shcor N. Bats of a gender flock together: sexual segregation in a subtropical Bat. PloS one. 20113;8(2).
10. Fahr J, Abedi-Lartey M, Esch T, Machwitz M, Suu-Ire R, Wikelski M, Dechmann DK. Pronounced seasonal changes in the movement ecology of a highly gregarious central-place forager, the African straw-coloured fruit Bat (Eidolon helvum). PloS one. 2015;10(10).
11. Happold DCD. The Mammals of Nigeria. Clarendon; 1987.
12. Rainho A, Palmeirim JM. The importance of distance to resources in the spatial modelling of Bat foraging habitat. PLoS One. 2011;6(4).
13. Wund M, Myers P. Chiroptera ‘(online), Animal Diversity web; 2015. Available:http://animaldiversity.ummz.ummich.edu/site/accounts/information/Chiroptera.html (Accessed March 26, 2020).
14. Kaňuch P, Danko Š, Celuch M, Krištín A, Pjenčák P, Matis Š, Šmídt J. Relating bat species presence to habitat features in natural forests of Slovakia (Central Europe). Mammalian Biology. 2008;73(2): 147-155.

15. Patterson BD, Willig MR, Stevens RD. Trophic strategies, niche partitioning and patterns of ecological organization. Bat ecology. 2003;9:536-557.
16. Kruskop SV. Bats of Vietnam. Checklist and an identification manual. Joint Russian-Vietnamese Sciences and Technological Tropical Centre and Zoological Museum of Moscow MV Lomonosov State University. 2013;299.
17. Kamins AO, Restif O, Ntiamoa-Baidu Y, Suu-Ire R, Hayman DT, Cunningham AA, Rowcliffe JM. Uncovering the fruit Bat bushmeat commodity chain and the true extent of fruit Bat hunting in Ghana, West Africa. Biological Conservation. 2011; 144(12):3000-3008.
18. Hayman DT, McCrea R, Restif O, Suu-Ire R, Fooks AR, Wood JL, Rowcliffe JM. Demography of straw-colored fruit Bats in Ghana. Journal of Mammalogy. 2012; 93(5):1393-1404.
19. Aguirre LF, Herrel A, Van Damme R, Matthysen E. The implications of food hardness for diet in Bats. Functional Ecology. 2003;17(2):201-212.
20. Dumont ER. The effect of food hardness on feeding behaviour in frugivorous Bats (Phyllostomidae): an experimental study. Journal of Zoology. 1999;248(2): 219-229.
21. Schmieder DA, Benítez HA, Borissov IM, Fruciano C. (Bat species comparisons based on external morphology: A test of traditional versus geometric morphometric approaches. PloS one. 2015;10(5).
22. Hayman DT, Fooks AR, Horton D, Suu-Ire R, Breed AC, Cunningham AA, Wood JL. Antibodies against Lagos Bat virus in megachiroptera from West Africa. Emerging Infectious Diseases, 2008;14(6): 926.
23. Hayman DT, Suu-Ire R, Breed AC, McEachern JA, Wang L, Wood JL, Cunningham AA. Evidence of henipavirus infection in West African fruit Bats. PloS one. 2008;*3*(7).
24. Hayman DT, Emmerich P, Yu M, Wang LF, Suu-Ire R, Fooks AR, Wood JL. Long-term survival of an urban fruit Bat seropositive for Ebola jnand Lagos Bat viruses. PloS one. 2010;5(8).

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