INTERNAL AND EXTERNAL MORPHOMETRY OF THOMAS'S ROPE SQUIRREL (*FUNISCIURUS ANERYTHRUS)* AND GAMBIAN SUN SQUIRREL (*HELIOSCIURUS GAMBIANUS*) IN IBADAN, NIGERIA

[1]COKER, Oluwakayode Michael, [2]JUBRIL, Afusat Jagun, [1]ISONG, Otobong Mfon and [1]OMONONA, Abosede Olayemi

[1]Department of Wildlife and Ecotourism Management, University of Ibadan, Ibadan, Nigeria.
[2]Department of Veterinary Pathology, University of Ibadan, Ibadan, Nigeria.

Corresponding Author: Coker, O. M. Department of Wildlife and Ecotourism Management, University of Ibadan, Ibadan, Nigeria. **Email:** liftingup2003@gmail.com **Phone:** +234 8054150061

Received *May 15, 2020;* ***Revised*** *June 13, 2020;* ***Accepted*** *July 18, 2020*

ABSTRACT

Currently, no information exists regarding internal and external morphometrics and their correlations in Funisciurus anerythrus and Heliosciurus gambianus. Therefore, this study examined the relationships among the internal and external morphometrics of the two species in University of Ibadan, Ibadan, Nigeria. Samples of adult F. anerythrus (n = 20) and H. gambianus (n = 13) were trapped from the wild at various locations within the campus. Live weights (LW), external measurements and weights of internal organs were taken. Comparisons within and between both species were carried out using T-tests and Pearson's correlation coefficient at p<0.05. H. gambianus was significantly bigger than F. anerythrus for all the measured parameters, except in ear and snout lengths. Male F. anerythrus was significantly bigger than female in LW, body length (BL) and shoulder to tail length (STL) while, female H. gambianus was significantly bigger than male in trunk circumference (TC). In male F. anerythrus, BL significantly correlates with STL (r = 0.85). In female F. anerythrus, LW correlates significantly with hind limb length (r = 0.62) and both kidneys. In male H. gambianus, LW correlates significantly with head length (r = 0.79), tail length (r = 0.81), BL (r = 0.97), STL (r = 0.87), and the weights of lungs and kidneys. In female H. gambianus, LW correlates significantly with TC (r = 0.99) and right lung weight (r = 0.92). Both species show some levels of sexual dimorphism and substantial positive correlations among the external and internal measurements.

Keywords: Correlation, *Funisciurus anerythrus*, *Heliosciurus gambianus,* Internal organs, Morphometrics, Sexual dimorphism

INTRODUCTION

Body forms (the direct products of genetic make-up) and their measurements (morphometrics) had contributed to the study of forms, shapes and fitness in organisms (Tanna *et al*., 2011). According to Claude (2008), it is useful in the field of biology, agriculture and forensic science. Morphometrics is used in analyzing variability in size and shape of organs and organisms and how these parameters vary with other variables (Slice, 2007; Claude, 2008; Reyment, 2010; Parés-Casanova, 2017). Claude (2008) stated that morphometrics can be used to monitor the impact of mutations on shape, detect developmental changes in form, study evolutionary relationships, as well as for estimating quantitative-genetic parameters.

Variation among individuals is essential, as its presence in a species is a requirement for adaptive evolutionary change (Allentoft and O'Brien, 2010; Allendorf *et al*., 2013). Morphological variability among different geographical populations could be attributed to different genetic structure of populations and to different environmental conditions prevailing in each geographic area (Mamuris *et al*., 1998). This variation is influenced and constrained by the interaction of complex genetic and environmental factors (Alberch, 1983) shown by developmental responses (Klingenberg, 2010). As such, assessment of variation within and among individuals in populations of a species is important at morphological and molecular levels (Habel *et al*., 2015).

According to Brown *et al*. (2014), the squirrels are diverse group of small mammals which vary in size and belong to a family of rodents known as the Sciuridae. There are approximately 280 species of squirrels belonging to 60 genera broken into five subfamilies (IUCN, 2018), which vary greatly in geographic range and habitat and are found on all the continents excluding Australia and Antarctica. Squirrels are predominantly herbivorous. However, insects, eggs and the occasional small vertebrate may be part of the diverse diet of these animals (Jansa and Myers, 2000; Lurz, 2011; Brown *et al*., 2014; IUCN, 2018). Squirrels are economically important as sources of protein, pollination agents and agents of seed dispersal (Fitzgibbon *et al.,* 1995; Chakravarthy and Thyagaraj, 2012; IUCN, 2018). They are useful in medical and scientific research (Gurnell, 1987; Thorington and Ferrell, 2006) and serve as vectors of human and domestic animal diseases as well as crop and household pests.

Both Thomas's Rope Squirrel (*Funisciurus anerythrus* Thomas, 1890) and Gambian Sun Squirrel (*Heliosciurus gambianus* Ogilby, 1835) are listed as Least Concern (LC) by the International Union for the Conservation of Nature (IUCN), in view of its wide distribution and presumed large population. They are generally considered to be quite common species with a stable population. They are tolerant to a degree of habitat modification and are considered to be declining at rates not fast enough to qualify for listing in a more threatened category. It is also possible that these species occur in numerous protected areas (Cassola, 2016; 2017). Despite this, hunting and trading for food and medicinal purposes are major threats for these species (IUCN, 2018).

According to Kingdon (1997), *F. anerythrus* weighs between 200 and 220g, has a head and body (HB) length ranging between 16 and 23 cm and a tail length of between 13 and 20 cm. *H. gambianus* weighs between 250 and 350g at maturity, has a head and body length of between 17 and 27 cm with a tail length of between 18 and 26 cm (Kingdon, 1997). Currently, no information exists regarding the comparisons between internal and external morphometrics of *F. anerythrus* and *H. gambianus*. Therefore, the relationships within and between the internal and external morphometrics of the two squirrel species (*F. anerythrus* and *H. gambianus*) in University of Ibadan, Ibadan, Nigeria were examined in this study.

MATERIALS AND METHODS

This study was carried out within the University of Ibadan campus located in the city of Ibadan (7°23'47"N and 3°55'0"E), Southwestern Nigeria. Twenty (20) samples of adult Thomas's Rope Squirrel (*F. anerythrus*) and thirteen (13) samples of adult Gambian Sun Squirrel (*H. gambianus*) were trapped from the wild at various locations within the University of Ibadan campus. These were then transported in box cages to the Faculty of Veterinary Medicine, University of Ibadan where morphometric data were collected. Animal capture occurred between October 2018 and January 2019. Captured species were identified and authenticated by an animal taxonomist using the field guides of Happold (1987) and Kingdon (1997).

Live weights (LW) of the animals were taken using a weighing balance (Scout Pro SPU402). The tail thickness (TT) (taken at the part of the tail closest to the body) was measured by means of a digital vernier calliper (ML Tools Digital Caliper 68202) for accurate readings to the nearest millimetre (mm). Eleven other external measurements were taken to the nearest 0.01 cm by means of a tape/meter rule. These measurements include: head length (HL) - taken from the tip of snout to the base of the skull, trunk circumference (TC) - taken just below the forelimbs, tail length (TL) - taken from the base of the body to the tip of the tail, left and right ear lengths (EL) - taken from the tragus of the ear to the tip of the pinna, body length (BL) - taken from the tip of the snout to the base of the body just before the tail begins, snout length (SNL) - taken from the tip of the snout to the inner eye corner, fore limb length (FLL) - taken from the joint of the forelimb to the base of the longest digit, hind limb length (HLL) - taken from the joint of the knee to the joint just before the feet, hind foot length (HFL) - taken from the joint of the hind limb to the base of the longest digit, and shoulder to tail length (STL) (Figure 1).

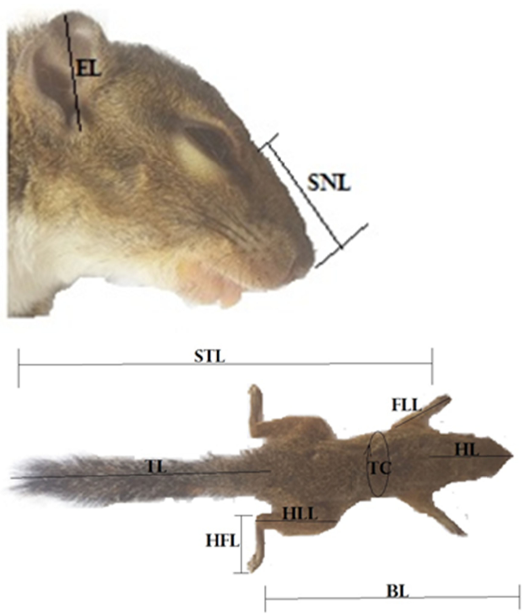

Figure 1: Schematic representation of the external morphometric character measurements for Squirrels (*Heliosciurus gambianus* and *Funisciurus anerythrus*) in Ibadan, Nigeria. ***Legend:*** *HL- Head length, TC- Trunk circumference, TL-Tail length, EL- Ear length, BL- Body length, SNL- Snout length, FLL- Fore limb length, HLL- Hind limb length, HFL-Hind foot length, STL- Shoulder to tail length*

The animals were euthanised in a chloroform chamber and dissected with the aid of dissecting sets. The lungs, heart, liver, testes (for males) and kidneys were carefully exteriorised and weighed in grams.

Data Analysis: Standard descriptive statistics (mean, standard deviation) were derived for the numerical data of both species. Analysis and comparison of data within and between both species were carried out by means of T-tests, and relationships among parameters were carried out using Pearson's correlation coefficient at $p<0.05$. These were done with IBM SPSS 20 Statistical package.

RESULTS

External and Internal Morphometry of Male and Female *F. anerythrus:* The means and standard deviations of the measured parameters for both male and female *F. anerythrus* are presented in Table 1. Most of the mean values of the measured parameters were higher in males except HL, REL, FLL, HFL and TT. Despite the obvious higher values in male *F. anerythrus* only three (LW, BL and STL) of the parameters were significantly higher ($p<0.05$) in female than males. The average LW, BL and STL were 135.91 ± 15.04g, 18.10 ± 0.85 cm and 29.67 ± 2.91 cm, respectively. All values obtained for the weights of the internal organs for *F. anerythrus* were higher in males than in females (Table 1).

External and Internal Morphometry of Male and Female *H. gambianus:* In *H. gambianus*, the average LW, HL, TC, FLL, HLL and TT were 186.74 ± 19.37g, 6.95 ± 0.81 cm, 10.9 ± 1.03 cm, 6.30 ± 0.34 cm, 5.82 ± 0.32 cm and 0.81 ± 0.15 cm, respectively (Table 2). Most of the mean values of the parameters were higher in females than in males except for REL, LEL, BL, SNL and HLL (Table 2). The only significant difference was observed in the trunk circumference and the value is higher in females (11.70 ± 0.67 cm) than in males (10.40 ± 0.91 cm). Except for the weight of the heart, all internal organ measurements for *H. gambianus* were higher in females than in males.

Comparison between the External and Internal Morphometry of *H. gambianus* and *F. anerythrus:* The results of the T-tests of the measured external and internal parameters between *H. gambianus* and *F. anerythrus* showed that *H. gambianus* had significant higher ($p<0.05$) values than *F. anerythrus*, except for LEL, REL and SNL.

Table 1: Mean values and standard deviation of external and internal morphometric parameters of male, female and combined sexes of *Funisciurus anerythrus*

Parameters	Males(n = 8)	Females(n = 12)	Combined (n = 20)
Live weight [LW] (g)	145.03 ± 11.48*	129.83 ± 14.35	135.91 ± 15.04
Head length [HL] (cm)	6.20 ± 0.51	6.51 ± 0.54	6.39 ± 0.53
Trunk circumference [TC] (cm)	9.61 ± 0.77	9.28 ± 0.64	9.41 ± 0.70
Tail length [TL] (cm)	19.61 ± 1.29	16.47 ± 5.39	17.73 ± 4.46
Left ear length [LEL] (cm)	1.64 ± 0.13	1.63 ± 0.18	1.64 ± 0.16
Right ear length [REL] (cm)	1.61 ± 0.14	1.62 ± 0.22	1.62 ± 0.18
Body length [BL] (cm)	18.64 ± 0.67*	17.73 ± 0.79	18.10 ± 0.85
Snout length [SNL] (cm)	2.04 ± 0.15	1.94 ± 0.21	1.98 ± 0.19
Fore limb length [FLL] (cm)	5.13 ± 0.53	5.18 ± 0.32	5.16 ± 0.40
Hind limb length [HLL] (cm)	5.59 ± 0.43	5.43 ± 0.30	5.49 ± 0.36
Shoulder to tail length [STL] (cm)	31.36 ± 1.66*	28.53 ± 3.06	29.67 ± 2.91
Hind foot length [HFL] (cm)	4.06 ± 0.22	4.07 ± 0.14	4.07 ± 0.17
Tail thickness [TT] (cm)	0.60 ± 0.09	0.62 ± 0.09	0.61 ± 0.09
Left lung (g)	0.28 ± 0.06	0.27 ± 0.03	0.27 ± 0.04
Right lung (g)	0.45 ± 0.04	0.43 ± 0.07	0.44 ± 0.06
Heart (g)	0.87 ± 0.12	0.75 ± 0.18	0.80 ± 0.17
Liver (g)	4.92 ± 0.84	4.59 ± 1.06	4.73 ± 0.96
Left kidney (g)	0.53 ± 0.05	0.47 ± 0.08	0.49 ± 0.07
Right kidney (g)	0.47 ± 0.20	0.46 ± 0.08	0.47 ± 0.14
Left testis (g)	1.65 ± 0.57	0.00± 0.00	1.65 ± 0.57
Right testis (g)	1.70 ± 0.65	0.00± 0.00	1.70 ± 0.65

**-Significant at p<0.05*

Table 2: Mean values and standard deviation of external morphometric parameters of male, female and combined sexes of *Heliosciurus gambianus*

Parameters	Males(n = 8)	Females(n = 5)	Combined (n = 13)
Live weight [LW] (g)	184.76 ± 18.44	189.91 ± 22.58	186.74 ± 19.37
Head length [HL] (cm)	6.90 ± 0.87	7.02 ± 0.79	6.95 ± 0.81
Trunk circumference [TC] (cm)	10.40 ± 0.91	11.70 ± 0.67*	10.90 ± 1.03
Tail length [TL] (cm)	26.84 ± 3.27	27.98 ± 1.45	27.28 ± 2.70
Left ear length [LEL] (cm)	1.63 ± 0.16	1.58 ± 0.08	1.61 ± 0.13
Right ear length [REL] (cm)	1.65 ± 0.13	1.62 ± 0.04	1.64 ± 0.10
Body length [BL] (cm)	21.41 ± 1.34	20.78 ± 1.02	21.17 ± 1.23
Snout length [SNL] (cm)	2.16 ± 0.12	2.02 ± 0.30	2.11 ± 0.21
Fore limb length [FLL] (cm)	6.30 ± 0.42	6.30 ± 0.19	6.30 ± 0.34
Hind limb length [HLL] (cm)	5.94 ± 0.15	5.64 ± 0.44	5.82 ± 0.32
Shoulder to tail length [STL] (cm)	41.5 ± 5.09	42.38 ± 3.12	41.84 ± 4.31
Hind foot length [HFL] (cm)	4.55 ± 0.24	4.84 ± 0.32	4.66 ± 0.30
Tail thickness [TT] (cm)	0.77 ± 0.12	0.88 ± 0.18	0.81 ± 0.15
Left lung (g)	0.56 ± 0.13	0.60 ± 0.12	0.57 ± 0.12
Right lung (g)	0.72 ± 0.23	0.81 ± 0.14	0.75 ± 0.20
Heart (g)	1.42 ± 0.46	1.38 ± 0.29	1.40 ± 0.39
Liver (g)	6.31 ± 1.18	6.51 ± 0.96	6.39 ± 1.07
Left kidney (g)	0.72 ± 0.26	0.77 ± 0.14	0.74 ± 0.21
Right kidney (g)	0.72 ± 0.21	0.75 ± 0.11	0.73 ± 0.18
Left testis (g)	0.55 ± 0.27	0.00± 0.00	0.55 ± 0.27
Right testis (g)	0.57 ± 0.29	0.00± 0.00	0.57 ± 0.29

**-Significant at p<0.05*

REL and SNL were higher in *H. gambianus* [1.64 ± 0.10 cm, 2.11 ± 0.21 cm, respectively] than in *F. anerythrus,* [1.62 ± 0.18 cm, 1.98 ± 0.19 cm, respectively] while, LEL was higher in *F. anerythrus* [1.64 ± 0.16 cm] than in *H. gambianus* [1.61 ± 0.13 cm] (Table 3).

Comparisons between Paired Parameters in *H. gambianus* and *F. anerythrus:* Comparing the values of the right and left ears, lungs, kidneys and testes in *H. gambianus* and *F. anerythrus,* it was observed that the right lungs were significantly heavier than the left lungs in both species (Table 4).

Table 3: Comparison between the external and internal morphometry of *Heliosciurus gambianus* and *Funisciurus anerythrus*

Parameters	*Heliosciurus gambianus* (n = 13)	*Funisciurus anerythrus* (n = 20)
Live weight [LW] (g)	186.74 ± 19.37*	135.91 ± 15.04
Head length [HL] (cm)	6.95 ± 0.81*	6.39 ± 0.53
Trunk circumference [TC] (cm)	10.9 ± 1.03*	9.41 ± 0.7
Tail length [TL] (cm)	27.28 ± 2.70*	17.73 ± 4.46
Left ear length [LEL] (cm)	1.61 ± 0.13	1.64 ± 0.16
Right ear length [REL] (cm)	1.64 ± 0.10	1.62 ± 0.18
Body length [BL] (cm)	21.17 ± 1.23*	18.10 ± 0.85
Snout length [SNL] (cm)	2.11 ± 0.21	1.98 ± 0.19
Fore limb length [FLL] (cm)	6.30 ± 0.34*	5.16 ± 0.40
Hind limb length [HLL] (cm)	5.82 ± 0.32*	5.49 ± 0.36
Shoulder to tail length [STL] (cm)	41.84 ± 4.31*	29.67 ± 2.91
Hind foot length [HFL] (cm)	4.66 ± 0.30*	4.07 ± 0.17
Tail thickness [TT] (cm)	0.81 ± 0.15*	0.61 ± 0.09
Left lung (g)	0.57 ± 0.12*	0.27 ± 0.04
Right lung (g)	0.75 ± 0.20*	0.44 ± 0.06
Heart (g)	1.40 ± 0.39*	0.80 ± 0.17
Liver (g)	6.39 ± 1.07*	4.73 ± 0.96
Left kidney (g)	0.74 ± 0.21*	0.49 ± 0.07
Right kidney (g)	0.73 ± 0.18*	0.47 ± 0.14
Left testis (g)	0.55 ± 0.27	1.65 ± 0.57*
Right testis (g)	0.57 ± 0.29	1.70 ± 0.65*

**-Significant at p<0.05*

Table 4: Comparisons between paired parameters in *Heliosciurus gambianus* and *Funisciurus anerythrus*

Parameters	*Heliosciurus gambianus* (n = 13)		*Funisciurus anerythrus* (n = 20)	
	Left	Right	Left	Right
Ear length (cm)	1.61 ± 0.13	1.64 ± 0.10	1.64 ± 0.16	1.62 ± 0.18
Lung (g)	0.57 ± 0.12	0.75 ± 0.20*	0.27 ± 0.04	0.44 ± 0.06*
Kidney (g)	0.74 ± 0.21	0.73 ± 0.18	0.49 ± 0.07	0.47 ± 0.14
Testis (g)	0.55 ± 0.27	0.57 ± 0.29	1.65 ± 0.57	1.70 ± 0.65

*Note: n = 8 for Testis in both species, *-Significant at p<0.05*

In *H. heliosciurus*, right ear length (1.64 ± 0.1 cm) and right testis weight (0.57 ± 0.29 g) were higher than the left ear length (1.61 ± 0.13 cm) and left testis weight (0.55 ± 0.27 g), while the weight of left kidney (0.74 ± 0.21 g) was slightly higher than that of the right kidney (0.73 ± 0.18 g). In *F. anerythrus*, left ear length (1.64 ± 0.16 cm) and kidney weight (0.49 ± 0.07g) were higher than the right ear length (1.62 ± 0.18 cm) and kidney weight (0.47 ± 0.14 g), while the value of right testis (1.70 ± 0.65 g) was higher than left testis (1.65 ± 0.57 g). In both species, the left kidney had higher value than the right kidney and the right testis had higher value than the left kidney.

Relationships among Measured Parameters of *F. anerythrus* and *H. gambianus:* Tables 5, 6, 7 and 8 showed the Pearson's correlation coefficient (r) correlation matrices of the relationships between each pair of the parameters for both species.

In male *F. anerythrus*, the LW was positively correlated with HL, TL, LEL, BL, FLL, HLL, STL, HFL and TT, while it was negatively correlated with TC, REL and SNL, none of which was statistically significant. HL was positively correlated with TC, LEL, REL, BL, and SNL (r = 0.73; p<0.05), while it was negatively correlated with TL, FLL, HLL, STL, HFL and TT. TC was positively correlated with TL and BL, while it was negatively correlated with LEL, REL, SNL, FLL, HLL (r =-0.86; p<0.00), STL, HFL and TT (Table 5).

Table 5: Pearson's correlation coefficient (r) of the external body morphometry of the male (lower matrix) and female (upper matrix) *Funisciurus anerythrus* from Ibadan, Nigeria

	LW (g)	HL (cm)	TC (cm)	TL (cm)	LEL (cm)	REL (cm)	BL (cm)	SNL (cm)	FLL (cm)	HLL (cm)	STL (cm)	HFL (cm)	TT (cm)
LW (g)	1	0.32	0.24	0.55	0.22	0.41	0.55	0.24	0.26	0.62*	0.37	-0.35	0.02
		(0.32)	(0.47)	(0.06)	(0.50)	(0.19)	(0.07)	(0.46)	(0.41)	(0.03)	(0.24)	(0.26)	(0.95)
HL (cm)	0.11	1	-0.578*	0.26	0.48	0.53	-0.27	0.60*	-0.18	0.50	0.61*	-0.35	-0.44
	(0.80)		(0.05)	(0.41)	(0.11)	(0.08)	(0.39)	(0.04)	(0.57)	(0.10)	(0.04)	(0.27)	(0.15)
TC (cm)	-0.12	0.11	1	0.02	-0.14	-0.27	0.58	-0.42	0.32	0.07	-0.08	0.43	0.51
	(0.77)	(0.80)		(0.96)	(0.66)	(0.41)	(0.05)	(0.18)	(0.31)	(0.83)	(0.80)	(0.17)	(0.09)
TL (cm)	0.52	-0.30	0.18	1	-0.32	-0.15	0.36	0.02	-0.14	0.71*	0.21	-0.44	0.45
	(0.19)	(0.48)	(0.67)		(0.32)	(0.65)	(0.25)	(0.94)	(0.67)	(0.01)	(0.52)	(0.16)	(0.14)
LEL (cm)	0.19	0.22	-0.28	-0.27	1	0.91**	-0.21	0.55	0.27	0.03	0.21	-0.02	-0.47
	(0.65)	(0.61)	(0.51)	(0.52)		(0.00)	(0.51)	(0.06)	(0.40)	(0.92)	(0.52)	(0.94)	(0.12)
REL (cm)	-0.14	0.04	-0.54	-0.21	0.78*	1	-0.21	0.57	0.29	0.10	0.21	-0.10	-0.49
	(0.76)	(0.92)	(0.17)	(0.61)	(0.02)		(0.51)	(0.05)	(0.36)	(0.75)	(0.51)	(0.76)	(0.11)
BL (cm)	0.39	0.37	0.03	0.65	0.10	0.11	1	0.10	0.08	0.56	0.35	0.08	0.62*
	(0.34)	(0.37)	(0.95)	(0.08)	(0.82)	(0.81)		(0.76)	(0.82)	(0.06)	(0.27)	(0.82)	(0.03)
SNL (cm)	-0.09	0.73*	-0.01	-0.20	0.14	0.04	0.57	1	-0.11	0.55	0.65*	-0.13	-0.23
	(0.84)	(0.04)	(0.99)	(0.63)	(0.75)	(0.92)	(0.14)		(0.74)	(0.07)	(0.02)	(0.68)	(0.48)
FLL (cm)	0.08	-0.55	-0.14	0.25	-0.68	-0.38	-0.38	-0.64	1	-0.24	-0.17	0.10	0.06
	(0.85)	(0.15)	(0.74)	(0.56)	(0.06)	(0.35)	(0.35)	(0.09)		(0.45)	(0.59)	(0.76)	(0.86)
HLL (cm)	0.52	-0.16	-0.86**	0.25	0.09	0.22	0.21	-0.08	0.28	1	0.74**	-0.19	0.30
	(0.19)	(0.70)	(0.01)	(0.56)	(0.84)	(0.60)	(0.62)	(0.85)	(0.50)		(0.01)	(0.56)	(0.35)
STL (cm)	0.32	-0.05	-0.21	0.80*	-0.01	0.23	0.85**	0.16	-0.05	0.45	1	0.20	0.05
	(-0.44)	(-0.90)	(-0.61)	(-0.02)	(-0.99)	(-0.58)	(-0.01)	(-0.71)	(-0.91)	(-0.26)		(-0.54)	(0.88)
HFL (cm)	0.25	-0.01	-0.14	-0.31	-0.14	-0.22	-0.67	-0.56	0.55	0.16	-0.57	1	0.39
	(0.55)	(0.98)	(0.74)	(0.45)	(0.74)	(0.60)	(0.07)	(0.15)	(0.16)	(0.71)	(0.14)		(0.21)
TT (cm)	0.45	-0.74*	-0.36	0.52	-0.30	-0.19	-0.06	-0.55	0.73*	0.63	0.28	0.21	1
	(0.27)	(0.04)	(0.38)	(0.19)	(0.47)	(0.65)	(0.89)	(0.16)	(0.04)	(0.10)	(0.51)	(0.62)	

***Note**: LW- Live weights, TT- Tail thickness, HL- Head length, TC- Trunk circumference, TL- Tail length, LEL- Left Ear lengths, REL- Right Ear lengths, BL- Body length, SNL- Snout length, FLL- Fore limb length, HLL- Hind limb length, HFL- Hind foot length, STL- Shoulder to tail length; p value in bracket; *-Significant at p<0.05; **-Significant at p<0.01*

TL was positively correlated with BL, FLL, HLL, STL (r = 0.80; p<0.05) and TT, while negatively correlated with LEL, REL, SNL and HFL. LEL was positively correlated with REL (r = 0.78; p<0.05), BL, SNL and HLL, while negatively correlated with FLL, STL, HFL, and TT. REL was positively correlated with BL, SNL, HLL and STL, while negatively correlated with FLL, HFL and TT. BL was positively correlated with SNL, HLL, STL (r = 0.85; p<0.01), while negatively correlated with FLL, HFL and TT. SNL was positively correlated with STL, and negatively correlated with FLL, HLL, HFL and TT. FLL was positively correlated HLL, HFL and TT (r = 0.73; p<0.05), while negatively correlated with STL. HLL was positively correlated with STL, HFL and TT. STL was positively correlated with TT and negatively correlated with HFL.HFL and TT were positively correlated (Table 5).

Live weight (LW) in male *F. anerythrus* was positively correlated with the weights of left and right lungs, liver, left and right kidneys, and left and right testes, while negatively correlated with the weight of the heart (Table 6). The weight of the left lung was positively correlated with the weights of heart (r = 0.77; p<0.05) liver, left kidney, left testis and right testis, while it was negatively correlated with the right kidney (r = -0.82; p<0.05). The weight of the right lung was positively correlated with that of the liver, right kidney, left testis and right testis, while it was negatively correlated with that of the heart and left kidney. The weight of the heart was positively correlated with that of the liver, left kidney, left and right testes, while it was negatively correlated with that of the right kidney. The liver weight was positively correlated with that of the left kidney, left testis and right testis, while it was negatively correlated with that of right kidney. The weight of the left kidney was positively correlated to that of the right and left testes, while it was negatively with that of the right kidney. The weight of the right kidney was positively correlated with that of the right and left testes. The right testis was significantly correlated with that of the left testis (r = 0.968; p<0.01) (Table 6).

In female *F. anerythrus,* there was a positive correlation between the live weight (LW) and HL, TC, TL, LEL , REL, BL, SNL, FLL, HLL (r = 0.62; p<0.05), STL and TT but there was negative correlation between LW and HFL (Table 5). HL was positively correlated with TL, LEL, REL, SNL (r = 0.60; p<0.05), HLL (r = 0.61; p<0.05) and STL, while it was negatively correlated with TC (r = -0.58; p<0.05), BL, FLL, HFL, TT (Table 5). TC was positively correlated with TL, BL, FLL, HLL, HFL, TT, and negatively correlated with LEL, REL, SNL, STL. TL was positively correlated with BL, SNL, HLL (r = 0.705; p<0.05), STL, and TT, while it was negatively correlated with LEL, REL, FLL and HFL. LEL was positively correlated with REL (r = 0.91; p<0.01), SNL, FLL, HLL and STL, while negatively correlated with BL, HFL and TT (Table 5). REL was positively correlated with SNL, FLL, HLL and STL, but negatively correlated with BL, HFL and TT. BL was positively correlated with SNL, FLL, HLL, STL, HFL and TT (r = 0.62; p<0.05). SNL was positively correlated with HLL and STL (r = 0.65; p<0.05) but negatively correlated with FLL, HFL and TT. FLL was positively correlated with HFL and TT but negatively correlated with HLL and STL. HLL was positively correlated with STL (r = 0.744; p<0.01) and TT but negatively correlated with HFL. STL was positively correlated with HFL and TT. HFL was positively correlated with TT.

The correlation coefficients among the internal organ weights together with the live weight in female *F. anerythrus* are as follows: LW was positively correlated with the weights of left lung, right lung, heart, liver, left kidney (r = 0.620; p<0.05) and right kidney (r = 0.59; p<0.05) (Table 6). The weight of the left lung was positively correlated with that of the right lung (r =0.59; p<0.05), heart, liver, left kidney and right kidney. The weight of the right lung was positively correlated with heart, liver, left kidney (r = 0.66; p<0.05) and right kidney. The heart weight was positively correlated with that of the liver, left kidney and right kidney. The liver weight was significantly positively correlated with that of left kidney (r = 0.67; p<0.05) and right kidney(r = 0.75; p<0.01). The right kidney was also significantly positively correlated with the left kidney (r = 0.94; p<0.01) (Table 6).

Table 6: Pearson's correlation coefficient (r) of the internal organ morphometry of the male (lower matrix) and female (upper matrix) *Funisciurus anerythrus* from Ibadan, Nigeria

	Live Weight (g)	Left Lung (g)	Right Lung (g)	Heart (g)	Liver (g)	Left Kidney (g)	Right Kidney (g)	Left Testis (g)	Right Testis (g)
Live Weight (g)	1	0.30	0.21	0.19	0.29	0.62*	0.59*	0.00	0.00
		(0.35)	(0.51)	(0.56)	(0.35)	(0.03)	(0.04)		
Left Lung (g)	0.15	1	0.59*	0.30	0.08	0.42	0.53	0.00	0.00
	(0.73)		(0.04)	(0.35)	(0.81)	(0.18)	(0.08)		
Right Lung (g)	0.59	-0.05	1	0.36	0.21	0.66*	0.55	0.00	0.00
	(0.13)	(0.91)		(0.25)	(0.51)	(0.02)	(0.06)		
Heart (g)	-0.13	0.77*	-0.03	1	0.21	0.20	0.25	0.00	0.00
	(0.76)	(0.02)	(0.94)		(0.51)	(0.54)	(0.43)		
Liver (g)	0.59	0.26	0.34	0.18	1	0.67*	0.75**	0.00	0.00
	(0.12)	(0.53)	(0.41)	(0.67)		(0.02)	(0.01)		
Left Kidney (g)	0.41	0.46	-0.10	0.24	0.69	1	0.94**	0.00	0.00
	(0.32)	(0.25)	(0.81)	(0.57)	(0.06)		(0.00)		
Right Kidney (g)	0.11	-0.82*	0.40	-0.70	-0.16	-0.23	1	0.00	0.00
	(0.80)	(0.01)	(0.33)	(0.06)	(0.70)	(0.59)			
Left Testis (g)	0.54	0.10	0.57	0.32	0.22	0.20	0.20	1	0.00
	(0.17)	(0.82)	(0.14)	(0.44)	(0.61)	(0.63)	(0.64)		
Right Testis (g)	0.59	0.27	0.56	0.35	0.21	0.29	0.09	0.97**	1
	(0.12)	(0.52)	(0.15)	(0.40)	(0.61)	(0.48)	(0.83)	(0.00)	

*p value in bracket; *-Significant at p<0.05; **-Significant at p<0.01*

In male *H. gambianus*, the live weight (LW) was positively correlated with HL (r = 0.79; p<0.05), TC, TL (r = 0.81; p<0.05), LEL, REL, BL (r = 0.97; p<0.01), SNL, FLL, HLL, STL (r = 0.87; p<0.01) and HFL but negatively correlated with TT. HL was positively correlated with TC, TL (r = 0.78; p<0.05), REL, BL, SNL, FLL, HLL, STL (r = 0.78; p<0.05) and HFL but negatively correlated with LEL and TT. TC was positively correlated with TL, LEL , REL, BL, HLL and STL, but negatively correlated with SNL, FLL, HFL and TT. TL was positively correlated with LEL, REL, BL (r = 0.84; p<0.01), SNL, FLL, HLL, STL (r = 0.98; p<0.01), HFL but negatively correlated with TT. LEL was positively correlated with REL (0.83; p<0.05), BL, FLL, HLL, STL, HFL, TT but negatively correlated with SNL. REL was positively correlated with BL, HLL, STL, HFL and TT but negatively correlated with SNL and FLL (Table 7).

BL was positively correlated with SNL, FLL, HLL, STL (r = 0.90; p<0.01) and HFL but negatively correlated with TT. SNL was positively correlated with FLL, HLL, STL, HFL (0.71; p<0.05) and TT. FLL was positively correlated with HLL, STL, HFL and TT. HLL was positively correlated with STL, HFL and TT. STL was positively correlated with HFL and negatively correlated with TT. HFL was negatively correlated with TT (Table 7).

Among the internal organs in male *H. gambianus,* LW was positively correlated with the weights of left lung (r = 0.73; p<0.05), right lung (r = 0.82; p<0.05), heart, liver, left kidney (r = 0.79; p<0.05), right kidney (r = 0.82; p<0.05), left testis and right testis. The left lung was positively correlated with right lung, heart (r = 0.72; p<0.05), liver, left kidney, right kidney, left testis and right testis. The right lung was positively correlated with heart, liver, left kidney (r = 0.87; p<0.01), right kidney (r = 0.88; p<0.01), left testis and right testis (r = 0.71; p<0.05).

Table 7: Pearson's correlation coefficient (r) of the external body morphometry of the male (lower matrix) and female (upper matrix) *Heliosciurus gambianus* from Ibadan, Nigeria

	LW (g)	HL cm)	TC (cm)	TL (cm)	LEL (cm)	REL (cm)	BL (cm)	SNL (cm)	FLL (cm)	HLL (cm)	STL (cm)	HFL (cm)	TT (cm)
LW (g)	1	0.80	0.99**	0.59	-0.57	-0.75	0.32	0.65	-0.29	0.83	0.69	0.48	0.23
		(0.10)	(0.00)	(0.30)	(0.32)	(0.14)	(0.60)	(0.23)	(0.64)	(0.08)	(0.20)	(0.41)	(0.72)
HL (cm)	0.79*	1	0.85	0.90*	-0.94*	-0.44	0.03	0.94*	-0.24	0.77	0.87	0.57	-0.36
	(0.02)		(0.07)	(0.04)	(0.02)	(0.46)	(0.97)	(0.02)	(0.70)	(0.13)	(0.06)	(0.32)	(0.56)
TC (cm)	0.55	0.10	1	0.66	-0.62	-0.75	0.28	0.68	-0.36	0.82	0.71	0.56	0.15
	(0.15)	(0.82)		(0.23)	(0.26)	(0.14)	(0.65)	(0.21)	(0.55)	(0.09)	(0.18)	(0.33)	(0.82)
TL (cm)	0.81*	0.78*	0.46	1	-0.89*	-0.45	0.23	0.87	0.06	0.80	0.95*	0.78	-0.38
	(0.02)	(0.02)	(0.26)		(0.05)	(0.44)	(0.71)	(0.05)	(0.92)	(0.11)	(0.01)	(0.12)	(0.53)
LEL (cm)	0.19	0-.14	0.23	0.35	1	0.13	0.20	-0.97**	0.16	-0.59	-0.81	-0.43	0.64
	(0.66)	(0.75)	(0.59)	(0.39)		(0.83)	(0.75)	(0.01)	(0.80)	(0.30)	(0.10)	(0.47)	(0.24)
REL (cm)	0.37	0.01	0.35	0.37	0.83*	1	-0.81	-0.22	0.00	-0.81	-0.57	-0.77	-0.62
	(0.37)	(0.98)	(0.40)	(0.37)	(0.01)		(0.10)	(0.72)	(1.00)	(0.09)	(0.32)	(0.13)	(0.26)
BL (cm)	0.93**	0.66	0.59	0.84**	0.44	0.62	1	-0.06	0.54	0.64	0.41	0.64	0.73
	(0.00)	(0.08)	(0.12)	(0.01)	(0.28)	(0.10)		(0.93)	(0.35)	(0.24)	(0.49)	(0.20)	(0.16)
SNL (cm)	0.39	0.58	-0.13	0.57	-0.02	-0.23	0.31	1	0.00	0.71	0.87	0.40	-0.49
	(0.34)	(0.13)	(0.76)	(0.14)	(0.96)	(0.58)	(0.46)		(1.00)	(0.18)	(0.05)	(0.50)	(0.40)
FLL (cm)	0.14	0.64	-0.56	0.44	0.02	-0.05	0.11	0.49	1	0.21	0.24	0.08	0.17
	(0.74)	(0.09)	(0.15)	(0.28)	(0.96)	(0.90)	(0.80)	(0.22)		(0.73)	(0.70)	(0.89)	(0.79)
HLL (cm)	0.30	0.29	0.02	0.41	0.26	0.47	0.400	0.41	0.23	1	0.92*	0.75	0.21
	(0.47)	(0.48)	(0.96)	(0.32)	(0.54)	(0.24)	(0.33)	(0.31)	(0.59)		(0.03)	(0.15)	(0.74)
STL (cm)	0.87**	0.80*	0.50	0.98**	0.31	0.37	0.90**	0.57	0.35	0.40	1	0.74	-0.17
	(0.01)	(0.02)	(0.21)	(0.00)	(0.45)	(0.34)	(0.00)	(0.14)	(0.39)	(0.33)		(0.15)	(0.78)
HFL (cm)	0.70	0.80*	-0.08	0.78*	0.33	0.31	0.71	0.712*	0.69	0.45	0.79*	1	0.10
	(0.05)	(0.02)	(0.85)	(0.02)	(0.42)	(0.45)	(0.05)	(0.05)	(0.06)	(0.27)	(0.02)		(0.87)
TT (cm)	-0.63	-0.41	-0.57	-0.23	0.30	0.16	-0.38	0.06	0.28	0.34	-0.30	-0.03	1
	(0.094)	(0.309)	(0.14)	(0.59)	(0.48)	(0.70)	(0.36)	(0.89)	(0.50)	(0.41)	(0.47)	(0.95)	

***Note**: LW- Live weights, TT- Tail thickness, HL- Head length, TC- Trunk circumference, TL- Tail length, LEL- Left Ear lengths, REL- Right Ear lengths, BL- Body length, SNL- Snout length, FLL- Fore limb length, HLL- Hind limb length, HFL- Hind foot length, STL- Shoulder to tail length; p value in bracket; *-Significant at p<0.05; **-Significant at p<0.01*

Table 8: Pearson's correlation coefficient (r) of the internal organ morphometry of the male (lower matrix) and female (upper matrix) *Heliosciurus gambianus* from Ibadan, Nigeria

	Live Weight (g)	Left Lung (g)	Right Lung (g)	Heart (g)	Liver (g)	Left Kidney (g)	Right Kidney (g)	Left Testis (g)	Right Testis (g)
Live Weight (g)	1 (0.00)	0.53 (0.36)	0.92* (0.03)	0.52 (0.37)	0.60 (0.29)	0.85 (0.07)	0.79 (0.11)	0.00	0.00
Left Lung (g)	0.73* (0.04)	1	0.65 (0.23)	0.93* (0.02)	0.23 (0.71)	0.623 (0.26)	0.60 (0.28)	0.00	0.00
Right Lung (g)	0.82* (0.01)	0.63 (0.09)	1	0.75 (0.14)	0.31 (0.62)	0.70 (0.19)	0.63 (0.25)	0.00	0.00
Heart (g)	0.67 (0.07)	0.72* (0.04)	0.66 (0.07)	1	-0.04 (0.96)	0.45 (0.45)	0.41 (0.45)	0.00	0.00
Liver (g)	0.22 (0.59)	0.09 (0.84)	0.47 (0.24)	0.28 (0.50)	1	0.87 (0.06)	0.90* (0.04)	0.00	0.00
Left Kidney (g)	0.79* (0.02)	0.64 (0.09)	0.87** (0.00)	0.63 (0.10)	0.39 (0.35)	1	0.99** (0.00)	0.00	0.00
Right Kidney (g)	0.82* (0.01)	0.62 (0.10)	0.88** (0.00)	0.61 (0.11)	0.37 (0.36)	0.99** (0.00)	1	0.00	0.00
Left Testis (g)	0.44 (0.28)	0.46 (0.25)	0.44 (0.27)	0.86** (0.01)	0.44 (0.28)	0.30 (0.48)	0.27 (0.51)	1	0.00
Right Testis (g)	0.61 (0.11)	0.59 (0.13)	0.71* (0.05)	0.90** (0.00)	0.51 (0.20)	0.59 (0.12)	0.57 (0.14)	0.92** (0.00)	1

*p value in bracket; *-Significant at p<0.05; **-Significant at p<0.01*

There were positive correlations between the weight of the heart and the weights of liver, left kidney, right kidney, left testis ($r = 0.86$; $p<0.01$) and right testis ($r = 0.90$; $p<0.01$). The liver weight was positively correlated with the weights of left kidney, right kidney, left testis and right testis. The weight of the left kidney was positively correlated with that of right kidney ($r = 0.99$; $p<0.01$), left testis and right testis. The weight of the right kidney was positively correlated with that of left testis and right testis, while the weights of the right and left testes were significantly positively correlated ($r = 0.92$; $p<0.01$) (Table 8).

In female *H. gambianus*, LW was positively correlated with HL, TC ($r = 0.99$; $p<0.01$), TL, BL, SNL, HLL, STL, HFL and TT but negatively correlated with LEL, REL and FLL. HL was positively correlated with TC, TL ($r = -0.90$; $p<0.05$), BL, SNL ($r = -0.94$; $p<0.05$), FLL, HLL, STL, HFL, TT but negatively correlated with LEL ($r = -0.94$; $p<0.05$), REL, FLL and TT. TC was positively correlated with TL, BL, SNL, HLL, STL, HFL and TT but negatively correlated with LEL, REL and FLL. TL was positively correlated with BL, SNL, FLL, HLL, STL and HFL but negatively correlated with LEL ($r = -0.89$; $p<0.05$), REL and TT. LEL was positively correlated with REL, BL and FLL, TT but negatively correlated with SNL ($r = -0.97$; $p<0.01$), HLL, STL and HFL. REL was positively correlated with FLL but negatively correlated with BL, SNL, HLL, STL, HFL and TT. BL was positively correlated with FLL, HLL, STL, HFL, TT but negatively correlated with SNL. SNL was positively correlated with FLL, HLL, STL and HFL, but negatively correlated with TT. FLL was positively correlated with HLL, STL, HFL and TT. HLL was positively correlated with STL ($r = 0.92$; $p<0.05$), HFL and TT. STL was positively correlated with HFL and negatively correlated with TT. HFL was positively correlated with TT (Table 7).

The LW in female *H. gambianus*, was positively correlated with the weights of left lung, right lung ($r = 0.92$; $p<0.05$), heart, liver, left kidney and right kidney. The weight of the left lung was positively correlated with that of right lung, heart ($r = 0.93$; $p<0.05$), liver, left kidney and right kidney. The weight of the right lung was positively correlated with heart, liver, left kidney and right kidney. The heart weight was positively correlated with that of both right and left kidneys and negatively correlated with the liver weight. The liver weight was positively correlated with that of the left kidney and right kidney ($r = 0.90$; $p<0.05$). The weight of both left and right kidney were positively correlated ($r = 0.99$; $p<0.05$) (Table 8).

DISCUSSION

Morphometrics can be used to monitor the impact of mutations on shape, detect developmental changes in form, study evolutionary relationships, as well as for estimating quantitative-genetic parameters (Claude, 2008). The comparisons between the current morphometric data and that of the previous data can give an insight into the effect of the changing world on biodiversity. *H. gambianus* had significantly higher value for all the parameters than *F. anerythrus,* except for the ear lengths and snout length. Kingdon (1997) recorded LW ranges of 200 – 220 g and 250 – 350 g for *F. anerythrus* and *H. gambianus*, respectively. The present study revealed lower means LW in *F. anerythrus* than *H. gambianus*, respectively. Although some other measurements were still comparable, the BW values showed a decrease that were not in the range of the previous reported measurements. What could have happened in the space of about forty years? Coker *et al*. (2018) opined that the effect of climate change, ecological biodiversity, hunting pressure and habitat destruction, could have resulted in changes in aestivation/hibernation and food availability, may have been responsible.

Sexual dimorphism has been established in many rodents including squirrels (Dewsbury *et al*., 1980; Cerghet *et al*., 2009). In the present study, the live weight, body length and shoulder to tail length can be used in distinguishing between the male and female *F. anerythrus*, since their values were significantly higher in male than in female. The males were generally larger in this species since most of the parameters were higher in males. The opposite seems to occur in *H. gambianus* as the females were generally bigger than males, though this was only significant in the trunk circumference. Iwaniuk (2001) reported sexual brain-size dimorphism in three species of squirrel- *Spermophilus lateralis*, *S. richardsonii* and *S. tridecemlineatus.* However, Bamidele and Akinpelu (2019) found no significant difference in the external morphometrics between male and female orange-headed tree squirrel (*F. leucogenys*) in the savannah forest in Nigeria. Both natural and sexual selections drive body size in organisms and sexual size dimorphism in rodents is driven by selective pressure (Schulte-Hostedde, 2007). Large size in some body parts in female is linked with fecundity and parental care, while small size in some body parts has been linked with early maturation and lower energy demand (Schulte-Hostedde, 2007). In males, large size gives a territorial advantage while small size has early maturation and rapid reproduction advantage (Schulte-Hostedde, 2007).

In animals whose hearts is left-positioned, the left lung tends to be lesser than the right lung presumably due to the enlarged heart which tends to impede the growth of the left lung (Barr, 2001). The right lungs of both *F. anerythrus* and *H. gambianus* were significantly heavier than the left lung. Heavier right lung been recorded in humans (Tanna *et al*., 2011) and cane rat (*Thryonomys swinderianus*) (Ajayi *et al*., 2012). The left kidneys were slightly heavier than right kidneys in both species (*F. anerythrus* and *H. gambianus*). This was in variance with what was discovered in *T. swinderianus* and Hedgehog (*Atelerix albiventris*) in which the right kidneys were slightly heavier that the left kidneys (Ajayi *et al*., 2012; Coker *et al*., 2018). Studies on other species of squirrels are necessary to ascertain if this trend is peculiar to squirrels. The right testes in both species (*F. anerythrus* and *H. gambianus)* were heavier than the left testes and this was in agreement with the findings in *T. swinderianus* (Ajayi *et al*., 2012). The right and left ear lengths in both species in this study had no common trend and were not significantly different from each other.

The HFL has been labelled as an excellent measure for population monitoring for management and conservation, since it stops growing early in life and does not shrink with age (Martin *et al*., 2013). In the present study, there were no significant correlations between the HFL and other external parameters in the male and female *F. anerythrus*, and female *H. gambianus.* In the male *H. gambianus,* HFL was significantly correlated with HL, TL, SNL and STL. Similar finding was recorded in Hedgehog (*A. albiventris*), where the HFL had no significant correlations with other body parameters (Coker *et al*., 2018). The claim on the HFL and its importance in morphometrics need to be substantiated in rodents, since the earlier reports were based on the studies on ungulates. There may be a different trend in other groups of animals.

Expectedly, the lengths of left and right ears were significantly correlated in this study. Either of them can be used to predict the other. And since there was no significant difference between the two, measuring either of them would be sufficient for related future studies. Life weight was correlated with HLL in female *F. anerythrus,* with TC in female *H. gambianus* and with HL, TL, BL and STL in male *H. gambianus.* Therefore, one or combination of these parameters can be used in predicting the live weight.

The relationships between the body weight and that of internal organs have been found to be different in male and female in humans (Mathuramon *et al*., 2009). In the present study, LW and liver weight in female *F. anerythrus* were significantly correlated with the weights of both right and left kidneys, but there were no significant correlations between LW and that of other internal organs in the male. In female, the right and left kidneys were significantly correlated, which is not so in male. The significant positive correlation that exists between the right and left testes in this species was in agreement with the findings of Ajayi *et al*. (2012).

In *H. gambianus,* the weight of the right lung can be used in predicting the LW in female, while the weights of the left and right lungs and kidneys can be used either singly or in combinations to predict the LW in the male. The heart weights are significantly correlated with that of the left lung in both sexes. Also, the weights of the right and the left kidneys in both sexes are significantly correlated and therefore can be used in predicting one another (Coker *et al*., 2018). In males of *H. gambianus*, just like in *F. anerythrus* and male *T. swinderianus* (Ajayi *et al*., 2012) the weights of the left and right testes were strongly correlated.

Conclusion: Not many research works have focused on the comparisons of the external and internal morphometry in squirrels. This work is an effort towards this purpose. Both *F. anerythrus* and *H. gambianus* showed some levels of sexual dimorphism and a substantial positive correlation among the external and internal measurements. The live weights of *F. anerythrus* and *H. gambianus* showed a decrease in value when compared to the value measured about forty years ago. Climatic change, deforestation and hunting pressure might have been responsible, since they are capable of altering the ecological dynamics of the species. This study provides a base for further investigation on external and internal morphometry in squirrels for conservation and genetic data base.

ACKNOWLEDGEMENTS

The authors thank Dr O. O. Ola, Dr T. A. Jarikre both of the Department of Veterinary Pathology, University of Ibadan and Dr A. T. Adetuga of the Department of Wildlife and Ecotourism Management of the same university for their help in data collection.

REFERENCES

AJAYI, I. E., SHAWULU, J. C. and NAFARNDA, W. D. (2012). Organ body weight relationship of some organ in the male African grasscutter (*Thryonomys swinderianus*). *Journal of Advanced Veterinary Research*, 2(2): 86 – 90.

ALBERCH, P. (1983). Morphological variation in the neotropical salamander genus *Bolitoglossa*. *Evolution,* 37(5): 906 – 919.

ALLENDORF, F. W., LUIKART, G. and AITKEN, S. N. (2013). *Conservation and the Genetics of Populations*. Wiley-Blackwell, Chichester, United Kingdom.

ALLENTOFT, M. E. and O'BRIEN, J. (2010). Global amphibian declines, loss of genetic diversity and fitness: a review. *Diversity*, 2(1): 47 – 71.

BAMIDELE, A. O. and AKINPELU, A. I. (2019). Cranial and external morphology of male and female orange headed tree squirrels (*Funisciurus leucogenys*) in selected locations of savannah forest in Nigeria. *Journal of Applied Life Sciences International,* 21(2): 1 – 12.

BARR, M. (2001). Organ asymmetries as correlates of other anomalies. *American Journal of Medical Genetics*, 101(4): 328 – 333.

BROWN, E., PERI, A. and SANTAROSA, N. (2014). *Sciuridae*. Animal Diversity Web. https://animaldiversity.org/accounts/Sciuridae/ Accessed November 09, 2018.

CASSOLA, F. (2016). *Funisciurus anerythrus*. *In: The IUCN Red List of Threatened Species 2016: e.T8756A115088410.* http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T8756A22269868.en Accessed June 08, 2020.

CASSOLA, F. (2017). *Heliosciurus gambianus* (errata version published in 2017). *In: The IUCN Red List of Threatened Species 2016: e.T9830A115094544*. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T9830A22260303.en Accessed February 17, 2020.

CERGHET, M., SKOFF, R. P., SWAMYDAS, M. and BESSERT, D. (2009). Sexual dimorphism in the white matter of rodents. *Journal of the Neurological Sciences*, 286(1-2): 76 – 80.

CHAKRAVARTHY, A. K. and THYAGARAJ, N. E. (2012). The palm squirrel in coconut plantations: ecosystem services by therophily. *Mammalia,* 76(2): 193 – 199.

CLAUDE, J. (2008). *Morphometrics with R.* Springer, New York.

COKER, O. M., OLUKOLE, S. G. and UDJE, O. A. (2018). External and internal morphometry of the four-toed hedgehog (*Atelerix albiventris* Wagner, 1841) in Ibadan, Nigeria. *Animal Research International*, 15(2): 3002 – 3012.

DEWSBURY, D. A., BAUMGARDNER, D. J., EVANS, R. L. and WEBSTER, D. G. (1980). Sexual dimorphism for body mass in 13 taxa of muroid rodents under laboratory conditions. *Journal of Mammalogy*, 61(1): 146 – 149.

FITZGIBBON, C. D., MOGAKA, H. and FANSHAWE, J. H. (1995). Subsistence hunting in Arabuko-Sokoke Forest, Kenya, and its effects on mammal populations. *Conservation Biology*, 9(5): 1116 – 1126.

GURNELL, J. (1987). *The Natural History of Squirrels*. Facts on File Incorporated, New York, USA.

HABEL, J. C., ZACHOS, F. E., DAPPORTO, L., ROEDDER, D., RADESPIEL, U., TELLIER, A. and SCHMITT, T. (2015). Population genetics revisited – towards a multidisciplinary research field. *Biological Journal of the Linnean Society*, 115(1): 1 – 12.

HAPPOLD, D. C. D. (1987). *The Mammals of Nigeria.* Clarendon Press, Oxford, United Kingdom.

IUCN (2018). *Red List of Threatened Species, Version 2018-1*. www.iucnredlist.org Accessed November 09, 2018.

IWANIUK, A. N. (2001). Interspecific variation in sexual dimorphism in brain size in Nearctic ground squirrels (*Spermophilus* spp.). *Canadian Journal of Zoology*, 79(5): 759 – 765.

JANSA, S. and MYERS, P. (2000). *Family Sciuridae*. Animal Diversity Web. http://animaldiversity.ummz.umich. edu /site/accounts/information/Sciuridae.html Accessed November 09, 2018.

KINGDON, J. (1997). *The Kingdon Field Guide to African Mammals*. Academic Press, San Diego, California.

KLINGENBERG, C. P. (2010). Evolution and development of shape: integrating quantitative approaches. *Nature Reviews Genetics*, 11(9): 623 – 635.

LURZ, P. (2011). *Squirrels and Relatives III: Tree Squirrels*. Grzimek's Animal Life. http://animals.galegroup.com.proxy.lib. umich.edu Accessed April 16, 2011.

MAMURIS, Z., APOSTOLIDIS, A. P., PANAGIOTAKI, P., THEODOROU, A. J. and TRIANTAPHYLLIDIS, C. (1998). Morphological variation between red mullet populations in Greece. *Journal of Fish Biology*, 52(1): 107 – 117.

MARTIN, J. G. A., FESTA-BIANCHET, M., CÔTÉ, S. D. and BLUMSTEIN, D. T. (2013). Detecting between individual differences in hind foot length in populations of wild mammals. *Canadian Journal of Zoology*, 91(3): 118 – 123.

MATHURAMON, P., CHIRACHARIYAVEJ, T., PEONIM, A. V. and ROCHANAWUTANON,M. (2009). Correlation of internal organ weight with body weight and length in normal Thai adults. *Medical journal of the Medical Association of Thailand*,92(2): 250 – 258..

PARÉS-CASANOVA, P. (2017). Introductory chapter - morphometric studies: beyond pure anatomical form analysis. Pages 1 – 6. *In: New Insights into Morphometry Studies*. IntechOpen. https://doi.org/10. 5772/intechopen.69682

REYMENT, R. A. (2010). Morphometrics: an historical essay. Pages 9 – 24. *In*: ELEWA, A. M. and ELEWA, A. M.(Eds.). *Morphometrics for Nonmorphometricians*. Springer, Berlin, Heidelberg.

SCHULTE-HOSTEDDE, A. I. (2007). Sexual size dimorphism in rodents. Pages 115 – 128. *In*; WOLFF, J. O. and SHERMAN, P. W. (Eds.). *Rodent Societies: An Ecological and Evolutionary Perspective*. University of Chicago Press, Chicago, USA.

SLICE, D. E. (2007). Geometric morphometrics. *Annual Review of Anthropology,* 36: 261 – 281.

TANNA, J. A., PATEL, P. N. and KALELE, S. D. (2011). Relation between organ weights and body weight in adult population of Bhavnagar region - a post-mortem study. *Journal of Indian Academy of Forensic Medicine*, 33(1): 57 – 59.

THORINGTON, R. and FERRELL, K. (2006). *Squirrels - The Animal Answer Guide*. Johns Hopkins University Press, Baltimore, Maryland.