EXTERNAL AND INTERNAL MORPHOMETRY OF THE FOUR-TOED HEDGEHOG (*ATELERIX ALBIVENTRIS* WAGNER, 1841) IN IBADAN, NIGERIA

[1]COKER, Oluwakayode Michael, [2]OLUKOLE, Samuel Gbadebo and [1]UDJE, Oghenetejiri Aquila

[1]Department of Wildlife and Ecotourism Management, Faculty of Renewable Natural Resources, University of Ibadan, Ibadan, Oyo State, Nigeria.

[2]Department of Veterinary Anatomy, Faculty of Veterinary Medicine, University of Ibadan, Ibadan, Oyo State, Nigeria.

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

Received: April 16, 2018 **Revised:** June 30, 2018 **Accepted:** July 13, 2018

ABSTRACT

Body size and measurements are important determinant of fitness in many species. The four-toed hedgehog (Atelerix albiventris) is the most preferred pet species of the hedgehogs and has been found in Africa to be eaten as bush meat and hunted for fertility charms. This puts the animal at risk. The morphometrics of the hedgehog genera has been carried out with little attention to the comparison between its external and internal body parts. This study is therefore aimed at determining the relationships among the external and internal morphometries of A. albiventris in Ibadan, Oyo State, Nigeria. Twelve (12) adult individuals comprising of 5 males and 7 females were used in this study and were all gotten from the wild in Ibadan, Nigeria. Live weights, external body measurements and weights of some internal organs were measured. Means and standard deviations were calculated. The T-tests and Pearson's correlation coefficients were conducted at $\alpha_{0.05}$. The snout length and the tail thickness in males were significantly greater than that of females. Live weights in male correlates significantly with the trunk circumference, while in females it correlates with trunk circumference, body length, lung weight and heart weight. Several significant correlations were established among both external and internal parameters measured. This study revealed a reduction in the size of Atelerix albiventris when compared with the previous similar studies. Factors such as increased hunting and habitat destruction might have been responsible for this.

Keywords: Body size, Correlation, Internal organs, Morphometry, *Atelerix albiventris*

INTRODUCTION

Body size and measurements are important determinant of fitness in many species (Gaillard *et al*., 2000; Roff, 2002). Morphometry refers to the quantitative analysis of form including size and shape. Morphometric analysis are commonly performed on organisms and are useful in analyzing fossil records, impact of mutation on shape, developmental changes in form, correlations between ecological factors and shape and estimating quantitative-genetic parameters of shape. It can be used to quantify a trait of evolutionary significance, detect changes in shape and deduce development, function or evolutionary relationships (Marcus, 1990).

Atelerix albiventris is widely used in biomedical research and sold in the exotic pet trade (Santana *et al.,* 2010). This species is also the most preferred pet species among the hedgehogs (Chaprazov *et al.*, 2014) and in Africa it is eaten as bush meat (Okaeme and Osakwe, 1988) and hunted for fertility charms (Kingdon, 1974). This is not healthy for the conservation of the animal, even though, they are presently classified as least concerned by IUCN because it is widely distributed, has a large population, has a high habitat adaptation level, found in different protected areas and is not declining fast enough to be listed in a more threatened category (IUCN, 2016).

A. albiventris is an insectivore in the Family: Erinaceidae (Subfamily: Erinaceinae) with variable common names but is most widely known as the four-toed hedgehog. *A. albiventris* is the smallest of the African hedgehogs in the genus *Atelerix* (Santana *et al.*, 2010). The *A. albiventris* is widespread in West and Central Africa. It is native to Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Cote d'Ivoire, Djibouti, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Kenya, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra-Leone, South Sudan (IUCN, 2016). *A. albiventris* occupies a variety of terrestrial habitats including grasslands, scrubs, savannah, suburban gardens, woodlands, bush, thickets, agricultural land such as plantations, fields, gardens, hills and mountains less than 2000 m in elevation (Haltenorth and Diller, 1988). In Nigeria, *A. albiventris* is found in the rainforest, derived savanna, guinea savanna, Sudan savanna and Sahel savanna (Happold, 1987). The animal stays in shelter throughout the day to rest but only comes out at night to forage and rear its young (Kingdon, 1997). In Kenya, the species is rarely found during the dry season due to aestivation. It is usually found between April and June and then October to November (Kingdon, 1974). Their home ranges between 200 and 300 meters from their burrow (Haltenorth and Diller, 1988).

A. albiventris could be opportunistic omnivores, feeding on plant materials, but the animal primarily feeds on invertebrates such as termites, beetles, earthworms, millipedes, ants, grasshoppers and slugs (Santana *et al.*, 2010). This animal will readily eat carrion and road kill at night (Kingdon, 1974), rendering ecosystem services in the process by cleaning up decaying matter in the environment. They also sometimes eat small vertebrates such as lizards, frogs and young or egg of ground nesting birds (Haltenorth and Diller, 1988). Fungi, fallen fruits in gardens, snails, crabs, groundnut, and roots are also consumed by the species (Santana *et al.*, 2010).

Happold (1987) recorded measurements of 210 mm for length of head and body, 25 mm for length of tail, 30 mm for length of hind foot, and 25 mm for length of ear. *A. albiventris* weigh between 250 and 600 grams and the spine length ranged between 0.5 and 1.0 cm (Smith, 1992). Girgiri *et al*. (2015) studied the morphometrics of some visceral organs of the animal and recorded an average weight of 239.5 ± 28.3 grams. Little attention has been given to its external and internal body parts (Robbins and Setzer, 1985). This research therefore determines the correlation of the weight of the internal organs and the general body weight of the *A. albiventris* in Ibadan, Oyo State, Nigeria, as well as correlates the body weight with the measurement of the external body parts.

MATERIALS AND METHODS

The study was carried out in the city of Ibadan (7°23'47"N and 3°55'0"E), Southwestern Nigeria. The animals were captured from the wild and were transported in cages to the laboratory of the Department of Veterinary Anatomy, University of Ibadan for further procedures. Twelve (12) adult individuals comprising of 5 males and 7 females were used. Live weight of the animals were measured using an electronic weighing balance (Kern: Model EW820-2NM) with sensitivity of 0.1 g. The animals were then placed on white platforms and the body parts such as head length (HL) [distance between the nose tip to the base of the skull], trunk circumference (TC) [circumference of the thoracic region at the point closest to the scapula], tail length (TL) [distance between the base of the tail and its tip], spine length (SPL) [distance between the tip and base of plucked spine], ear length (EL) [widest distance between the base of the ear and its tip], body length (BL) [distance from the tip of the nose to the base of the tail], snout length (SNL) [distance between the tip of the nose and the base of the eye socket], fore limb length (FLL) [distance from the tip of the fore limb to the elbow], hind limb length (HLL) [distance between the heel and the head of the tibia], hind foot length (HFL) [distance between the tip of the longest toe and the heel], shoulder to tail length (STL) [distance between the base of the neck and the tip of the tail], tail thickness (TT) [diameter of the tail at the point closest to its base] were measured in centimeters using tape rule, meter rule and vernier calipers (Figure 1). Three spines each were removed from the crown of the animal and measured by a metre rule to get their lengths. The average of the three lengths was gotten to give the length of the animal's spine length (SPL). The animals were then euthanized with chloroform in an enclosed glass jar, placed on dissecting tray and carefully dissected with the aid of scalpel blade and scissors. Lungs, heart, liver, kidney and testis (for males) were carefully exteriorized and weighed. The values were recorded in grams.

Data Analysis: Means and standard deviations were calculated. The T-tests and Pearson's correlation coefficients were conducted at $p<0.05$. The Pearson correlation coefficient (r) with two tailed tests of statistical significance at 0.05 levels was carried out to find out the strength of association and the consistency of the relationships between the life weight(g) of the animals and measurements of other external and internal morphometric parameters.

RESULTS

External and Internal Morphometry of Male and Female *Atelerix albiventris:* The mean and standard deviation of the external and internal body morphometric parameters are presented in Table 1. The mean HL for the male [5.18 ± 0.59 cm] animals was higher than HL of the female [4.91 ± 0.57 cm] animals. Similarly, the EL recorded in the male [2.24 ± 0.10 cm] animals was greater than the EL of the female [2.12 ± 0.28 cm] animals. The mean values of HFL [2.94 ± 0.25 cm], HLL [4.16 ± 0.47 cm], SNL [2.21 ± 0.74 cm], SPL [5.55 ± 0.56 cm], TL [1.95 ± 0.34 cm] and TT [0.50 ± 0.09 cm] in male animals were higher than HFL [2.75 ± 0.19], HLL [4.03 ± 0.32 cm], SNL [1.97 ± 0.18 cm], SPL [5.23 ± 0.32 cm], TL [1.61 ± 0.28 cm] and TT [0.34 ± 0.09 cm] in female animals. On the other hand, the mean values for live weight [178.94 ± 39.09 g], STL [13.42 ± 1.3 cm], TC [16.13 ± 1.13 cm] and BL [21.61 ± 2.81 cm] in female animals were higher than live weight [170.04 ± 33.44 g], STL [12.34 ± 2.73 cm], TC [15.70 ± 1.53 cm] and BL [20.6 ± 2.67 cm] of the male animals. The SNL and TT were significantly different ($p<0.05$) between the females and males (Table 1).

The mean weight of the lung was higher in the females [1.55 ± 0.49 g] than in the males [1.39 ± 0.54 g]. The average heart weight was higher in the males [0.87 ± 013 g] than in the females [0.78 ± 0.12 g]. The mean weight of the liver was higher in the females [9.78 ± 2.70 g] than in the males [8.43 ± 1.50 g] animals. Similarly, the average weight of the left kidney was higher in the females [1.34 ± 0.43 g] than in the males [1.20 ± 0.49 g], while the right kidney of the males [1.34 ± 0.55 g] had similar mean value with that of females [1.34 ± 0.43 g] (Table 2).

Relationships among measured parameters of male and female *Atelerix albiventris:* The correlation matrixes showing the relationship between each pair of the measured parameters were presented in the Tables 3 and 4. In the males hedgehog**,** positive correlations occurred between the Live weight and the HL [r = 0.538], STL [r = 0.675], BL [r = 0.586], HFL [r = 0.772], HLL [r = 0.502], FLL [r = 0.217], TL [r = 0.729], TT [r = 0.842] and TC [r = 0.969] (Table 2). On the other hand, negative correlations occurred between the live weight of the males and EL [r = -0.611], SNL [r = -0.758] and SPL [r = -0.444]. There are positive correlations between the weight of the male animals and the weight of testis [r = 0.561], heart weight [r = 0.177], weight of Liver

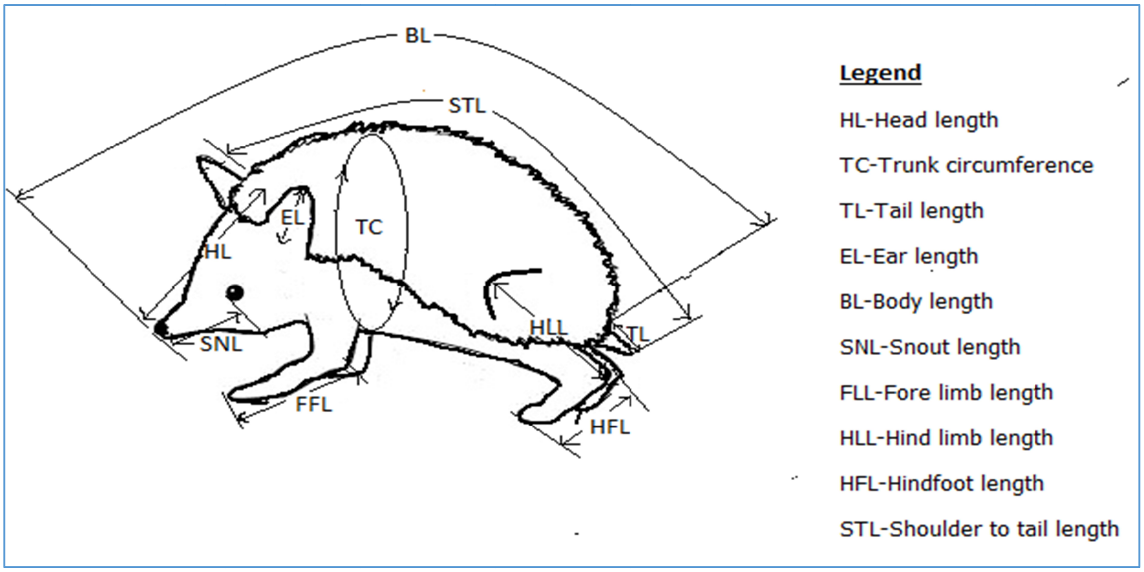

Figure 1: Schematic representation of morphometric character measurements for *Atelerix albiventris* in Ibadan, Nigeria

Table 1: Sexual dimorphism in external and internal body morphometric of male and female four-toed hedgehog from Ibadan, Nigeria

Parameters	Male	Female	Combined Sex
Live weight [LW](g)	170.04 ± 33.44	178.94 ± 39.09	175.23 ± 35.51
Head length [HL](cm)	5.18 ± 0.59	4.91 ± 0.57	5.03 ± 0.57
Ear length [EL] (cm)	2.24 ± 0.09	2.13 ± 0.28	2.18 ± 0.22
Shoulder tail length [STL](cm)	12.34 ± 2.73	13.43 ± 1.40	12.98 ± 2.02
Body Length [BL](cm)	20.60 ± 2.67	21.61 ± 2.81	21.19 ± 2.68
Hind foot length [HFL] (cm)	2.94 ± 0.25	2.76 ± 0.19	2.83 ± 0.23
Hind limb length [HLL](cm)	4.16 ± 0.47	4.03 ± 0.32	4.08 ± 0.37
Forelimb length [FLL] (cm)	4.86 ± 0.26	4.56 ± 0.45	4.68 ± 0.40
Snout length [SNL] (cm)	2.21 ± 0.07*	1.97 ± 0.18*	2.07 ± 0.19
Spine length [SPL](cm)	1.79 ± 0.08	1.73 ± 0.11	1.76 ± 0.10
Tail length [TL] (cm)	1.95 ± 0.35	1.61 ± 0.28	1.75 ± 0.34
Tail thickness [TT] (cm)	0.50 ± 0.09*	0.34 ± 0.09*	0.40 ± 0.12
Trunk circumference [TC] (cm)	15.70 ± 1.54	16.13 ± 1.13	15.93 ± 1.28
Lungs weight (g)	1.39 ± 0.54	1.55 ± 0.49	1.48 ± 0.49
Testis weight (g)	0.97 ± 0.25	-	-
Heart weight (g)	0.87 ± 0.13	0.78 ± 0.12	0.83 ± 0.13
Liver weight (g)	8.43 ± 1.50	9.78 ± 2.70	9.22 ± 2.35
Right kidney weight (g)	1.34 ± 0.55	1.34 ± 0.43	1.34 ± 0.46
Left kidney weight (g)	1.20 ± 0.49	1.35 ± 0.44	1.29 ± 0.44

**-Significant at $p<0.05$*

Table 2: Relationships between live body weight and all morphometrical parameters of the four-toed hedgehog from Ibadan, Nigeria

Parameters	Male			Female		
	R	p-value	Significance	R	p-value	Significance
Live weight [LW]	1.00	-	-	1.00	-	-
Head Length [HL]	0.54	0.35	NS	0.49	0.26	NS
Ear length [EL]	-0.61	0.27	NS	0.44	0.32	NS
Shoulder tail length [STL]	0.68	0.21	NS	0.17	0.72	NS
Body length [BL]	0.59	0.30	NS	0.84	0.02	S
Hind foot length [HFL]	0.77	0.13	NS	-0.57	0.18	NS
Hind limb length [HLL]	0.50	0.39	NS	0.51	0.24	NS
Forelimb length [FLL]	0.22	0.73	NS	0.13	0.79	NS
Snout length [SNL]	-0.76	0.14	NS	-0.06	0.89	NS
Spine length [SPL]	-0.85	0.71	NS	0.26	0.57	NS
Tail length [TL]	0.73	0.16	NS	0.10	0.83	NS
Tail thickness [TT]	0.84	0.07	NS	0.66	0.11	NS
Trunk circumference [TC]	0.97	0.01	S	0.92	0.01	S
Lungs weight	-0.42	0.49	NS	0.91	0.01	S
Testis weight	0.56	0.33	NS	-	-	-
Heart Weight	0.18	0.78	NS	0.86	0.01	S
Liver weight	0.85	0.07	NS	0.66	0.11	NS
Right kidney weight	0.01	0.99	NS	0.57	0.18	NS
Left kidney weight	0.25	0.75	NS	0.59	0.16	NS

Key: *NS = Not significant, S = Significant*

[r = 0.845), weight of right kidney [r = 0.007] and weight of left kidney [r = 0.254]. On the other hand, negative correlation was recorded between the weight of the male hedgehog and the weight of lungs [r = -0.573] (Table 2).

Among the females hedgehog, there were positive correlations between the weight of the animals and HL [r = 0.493], EL [r = 0.443], STL [r = 0.165], BL [r = 0.840], HLL [r = 0.509], FLL [r = 0.126], SPL [r = 0.220], TL [r = 0.098], TT [r = 0.658] and TC [r = 0.658]. The positive correlations of the live weight with BL and TC were found to be statistically significant ($p<0.05$). On the other hand, negative correlations were found between the live weight of the female and the HFL [r = -0.573] and SNL [r = -0.444]. There are positive correlations between the weight of the females and the weight of lungs [r = 0.561], weight of heart [r = 0.867], weight of Liver [r = 0.657], weight of right kidney [r = 0.569] and weight of left kidney [r = 0.593]. The correlations were significant for both weights of lungs and heart.

Pearson's correlation coefficients (r) between the lengths of each pair of external parts were as follows: In males, the HL is positively correlated with EL, STL, BL, HFL, FLL, SNL, TL, TT and TC, but negatively correlated with HLL and SPL (Table 3). EL is negatively correlated with all other parameters except HL, BL, SNL and SPL. STL is positively correlated with all the other parameters except EL and SNL. BL is positively correlated with all other parameters except HLL and SNL. HFL is positively correlated with all other parameters except EL, HLL, FLL, SNL and SPL. HLL negative correlated with all other parameters except STL, FLL, TL, TT and TC.

Table 3: Pearson's correlation coefficient (r) of the external body morphometry of the male (lower matrix) and female (upper matric) African four-toed hedgehog from Ibadan, Nigeria

	HL	EL	STL	BL	HFL	HLL	FLL	SNL	SPL	TL	TT	TC
HL	1	-0.086 (0.855)	0.322 (0.482)	0.53 (0.221)	0.052 (0.911)	0.798* (0.032)	0.61 (0.146)	-0.367 (0.418)	0.835* (0.019)	0.446 (0.316)	0.039 (0.934)	0.626 (0.183)
EL	0.304 (0.619)	1	-0.329 (0.472)	0.166 (0.722)	-0.004 (0.992)	0.249 (0.591)	0.117 (0.803)	0.381 (0.399)	-0.389 (0.389)	0.461 (0.298)	0.124 (0.791)	0.117 (0.826)
STL	0.775 (0.123)	-0.029 (0.964)	1	0.62 (0.137)	0.306 (0.505)	0.415 (0.355)	0.528 (0.223)	0.163 (0.728)	0.693 (0.084)	-0.116 (0.804)	0.486 (0.269)	0.543 (0.266)
BL	0.910* (0.032)	0.272 (0.658)	0.796 (0.107)	1	-0.326 (0.475)	0.682 (0.091)	0.342 (0.453)	-0.141 (0.763)	0.546 (0.205)	-0.104 (0.824)	0.666 (0.102)	0.949** (0.004)
HFL	0.768 (0.13)	-0.089 (0.887)	0.529 (0.359)	0.835 (0.079)	1	0.188 (0.687)	0.617 (0.14)	0.396 (0.379)	0.269 (0.56)	0.515 (0.237)	-0.404 (0.369)	-0.304 (0.558)
HLL	-0.167 (0.788)	-0.73 (0.161)	0.448 (0.449)	-0.09 (0.885)	-0.132 (0.832)	1	0.704 (0.078)	-0.331 (0.469)	0.753 (0.051)	0.349 (0.443)	0.017 (0.97)	0.633 (0.177)
FLL	0.352 (0.562)	-0.129 (0.837)	0.487 (0.406)	0.029 (0.963)	-0.122 (0.845)	0.394 (0.511)	1	0.106 (0.821)	0.609 (0.147)	0.443 (0.32)	-0.149 (0.75)	0.533 (0.277)
SNL	0.092 (0.884)	0.867 (0.057)	-0.354 (0.559)	-0.101 (0.872)	-0.295 (0.629)	-0.816 (0.092)	0.026 (0.967)	1	-0.344 (0.45)	0.407 (0.365)	0.404 (0.369)	-0.038 (0.943)
SPL	-0.14 (0.822)	0.549 (0.338)	0.069 (0.912)	0.144 (0.817)	-0.276 (0.654)	-0.062 (0.921)	-0.445 (0.453)	0.181 (0.771)	1	0.199 (0.669)	0.093 (0.842)	0.487 (0.327)
TL	0.435 (0.464)	-0.282 (0.645)	0.81 (0.096)	0.682 (0.205)	0.532 (0.356)	0.595 (0.29)	0.200 (0.11)	-0.706 (0.183)	0.277 (0.652)	1	-0.095 (0.839)	0.004 (0.994)
TT	0.794 (0.109)	-0.299 (0.625)	0.787 (0.114)	0.645 (0.24)	0.692 (0.195)	0.315 (0.606)	0.615 (0.27)	-0.36 (0.551)	-0.549 (0.338)	0.501 (0.389)	1	0.565 (0.243)
TC	0.411 (0.492)	-0.727 (0.164)	0.662 (0.223)	0.426 (0.475)	0.596 (0.289)	0.675 (0.211)	0.362 (0.55)	-0.822 (0.088)	-0.483 (0.41)	0.699 (0.189)	0.825 (0.085)	1

Note: *HL-Head length, TC-Trunk circumference, TL-Tail length, SPL-Spine length, EL-Ear length, BL-Body length, SNL-Snout length, FLL-Fore limb length, HLL-Hind limb length, HFL-Hindfoot length, STL-Shoulder to tail length, TT-Tail thickness, p-value in bracket, *-Significant at p<0.05, **-Significant at p<0.01*

Table 4: Pearson's correlation coefficient (r) of the internal organ morphometrics of the male (lower matrix) and female (upper matric) African four-toed hedgehog from Ibadan, Nigeria

	Lungs weight	Testis weight	Heart weight	Liver weight	Right kidney weight	Left kidney weight
Lungs weight	1	_	0.944** (0.005)	0.742 (0.091)	0.415 (0.414)	0.488 (0.326)
Testis weight	0.509 (0.381)	1	_	_	_	_
Heart weight	0.274 (0.655)	0.291 (0.634)	1	0.56 (0.191)	0.483 (0.272)	0.496 (0.257)
Liver weight	0.069 (0.912)	0.84 (0.075)	0.255 (0.679)	1	0.873* (0.01)	0.889** (0.008)
Right kidney weight	0.421 (0.48)	0.303 (0.621)	0.916* (0.029)	0.066 (0.916)	1	0.991** (0.000)
Left kidney weight	0.718 (0.282)	0.907 (0.093)	0.852 (0.148)	0.677 (0.323)	0.995** (0.005)	1

Note: *p-value in bracket, *-Significant at p<0.05, **-Significant at p<0.01*

FLL is positively correlated with all other parameters except EL, HFL, and SPL. SNL is negatively correlated with all other parameters except HL, EL, FLL, and SPL. SPL is positively correlated with all other parameters except HL, HFL, HLL, FLL, TT and TC. TL is positively correlated with all other parameters except EL and SNL. TT is positively correlated with all other parameters except El, SNL and SPL. TC is positively correlated with all other parameters except el, SNL and SPL. Only the correlation between BL and HL is significant in male (Table 3).

In females, HL is positively correlated with all other parameters except EL and SNL (Table 3). EL is positively correlated with all other parameters except HL, STL, HFL and SPL. STL is positively correlated with all other parameters EL, and TL. BL is positively correlated with all other parameters except HFL, SNL and TL. HFL is positively correlated with all other parameters except EL, BL, TT and TC. HLL is positively correlated with all other parameters except EL, BL and SNL. FLL is positively correlated with all the other parameters except TT. SNL is positively correlated with all other parameters except HL, BL, HLL, SPL and TC. SPL is positively correlated with all the other parameters except EL and SNL. TL is positively correlated with all other parameters except STL, BL and TT. TT is positively correlated with all other parameters except HFL, FLL and TL. TC is positively correlated with all the other parameters except HFL and SNL (Table 3: upper matrix). There were significant correlations between HL and HLL, HL and SPL, and BL and TC in female.

Pearson's correlation coefficients (r) between the weights of each pair of internal organs revealed positive correlations between all the pairs tested in both male and female. The correlations between the weights of right kidney and the heart; and that between the weights of right and left kidneys are statistically significant (p<0.05) in male (Table 4). In female, there were significant correlations between the weights of heart and lung, right kidney and liver, left kidney and liver, and also left kidney and right kidney (Table 4).

DISCUSSION

Morphological variations is important in the identification, classification and monitoring of species' status over time. Girgiri *et al*. (2015) recorded an average weight of 239.5 ± 28.3 grams. But this study revealed a weight of between 156 and 224 g with an average of 175.23 ± 35.51 grams. It also showed an average tail length of 1.75 ± 0.34 cm and ear length of 2.18 ± 0.22 cm. The ear and tail length is still comparable but the decrease in weight over a period of about 30 years calls for attention. What has happened in that period of time as to decrease the weight so much? Several things might be responsible. This species is usually found in a wide array of habitats in Nigeria (Happold, 1987) and this area has been under the siege of desertification as a result of climate change and deforestation for farmland and industrialization for years. According to Santana *et al.* (2010), it is used in biomedical research and sold in the exotic pet trade. It is regarded as the most preferred pet species of hedgehogs (Chaprazov *et al.*, 2014) and it is being eaten as bush meat and hunted for fertility charms (Okaeme and Osakwe, 1988). All of these can cause sharp decrease in population and prevent the species from reaching their full weight potential.

Sexual dimorphism is common in many animals and this has also been established in *A. albiventris* (Santana *et al.,* 2010). In the present study, the snout length and tail thickness in males were significantly higher than that of females. These features can therefore be used as a distinguishing feature between male and female in this species. Although most mammalian body weight is usually higher in males than in female (Okorafor *et al.,* 2013), the body weight in *A. albiventris* reveals the opposite, being higher in female than male. This is in consonance with Girgiri *et al*. (2015), who also documented higher weights of internal organs in female than in male in this species, as revealed in this study. Most external body measurements were higher in male than in female in this study.

According to Burger *et al*. (1962), the body weight and organ weight parameters in animals are fundamental in experimental biology. Ajayi *et al*. (2012), found a significant correlation between the body weight and testes in the males of African grasscutter. Even though, there is a positive correlation between the body weight and testes in the present study, it is not significant. Only the trunk circumference is significantly correlated with weight in males. Body length, trunk circumference, heart weight and lung weight were significantly correlated with live weight in female. A measure of the trunk circumference can therefore be used as an indication of the weight of both male and female in the animal. Body length, heart weight and lung weight are additional characters for that purpose in female.

In male, the head length and the body length were significantly correlated, indicating that one can be used to predict the other. In female, the head length is significantly correlated with the hind foot length and spine length, also, body length is significantly correlated with the trunk circumference. Hind foot length has been has been used widely in ecology (Martin *et al*., 2013). It has been related to population density and phenotypic fitness (Couturier *et al*., 2010; Taillon *et al*., 2011). In *A. albiventris* the hind foot length can also be used in further ecological studies of the animal since it correlates with some other morphological features that can be used to predict the growth and fitness of the animal. Another feature that can also be used along with the hind foot length, as revealed in this study, is the spine length.

There were significant correlations between the weight of the right and left kidneys in both sexes in this study. This was in agreement with Ajayi *et al*. (2012). In the male, the weight of the right kidney also correlated significantly with the heart weight. In female, the weight of the liver significantly correlated with the right and left kidneys. In general, there are positive correlations among all the internal organs measured.

Conclusion: Morphometrics of *Atelerix albiventris* revealed a reduction in the size of the animal when compared with the previous similar studies. Factors such as climatic change, increased hunting pressure and habitat destruction might have been responsible for this. These might have led to a change in form due to availability of food and changes in aestivation or hibernation patterns and hence a change in body structure of the animal. Little studies have been carried out extensively on the comparison between the morphometry of internal organs and the external organs of the four-toed hedgehog. This study provided information on the correlations among various internal and external morphometries of the animal, which will further contribute to the study of population density and phenotypic fitness in the animal.

ACKNOWLEDGEMENTS

The authors would like to thank Drs Kafilat Quadri and Ibrahim Ibiade (Department of Veterinary Anatomy) for their help in data collection, as well as Mr. Alfred Onafeli (Department of Forest Production and Products, University of Ibadan) for providing technical assistance for the statistical analysis.

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.

BURGER, R. E., LORENZ, F. W., GATES, C. E. (1962). Relationships of organ weight to body weight. *Poultry Science,* 41(6): 1762 – 1773.

CHAPRAZOV, T., DIMITROV, R., YOVCHEVA, K. S. and UZUNOVA, K. (2014). Oral and dental disorders in pet hedgehogs. *Turkish Journal of Veterinary and Animal Sciences*, 38(1): 1 – 6.

COUTURIER, S., OTTO, R. D., CÔTÉ, S. D., LUTHER, G. and MAHONEY, S. P. (2010). Body size variations in caribou ecotypes and relationships with demography. *Journal of Wildlife Management,* 74(3): 395 – 404.

GAILLARD, J. M., FESTA-BIANCHET, M., YOCCOZ, N. G., LOISON, A. and TOIGO, C. (2000). Temporal variation in fitness components and population dynamics of large herbivores. *Annual Review of Ecology and Systematics*, 31(1): 367 – 393.

GIRGIRI, I. A., GAMBO, B. G., IBRAHIM, B. and BWALA, A. (2015). Morphometric studies of some visceral organs and gastrointestinal tract of four–toed African hedgehog (*Atelerix albiventris*). *Journal of Morphological Science*, 32: 29 – 32.

HALTENORTH, T. and DILLER, H. (1988). *The Collins Field Guide to the Mammals of Africa Including Madagascar*. Stephen Green Press, Lexington, Massachusetts.

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

IUCN (2016). *Atelerix albiventris*. The International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Version 2017-3. www.iucnredlist.org Accessed June 21, 2018.

KINGDON, J. (1974). *East African Mammals: An Atlas of Evolution in Africa*. Volume 2A, Academic Press, London, United Kingdom.

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

MARCUS, L. F. (1990). Traditional morphometrics. Pages 77 – 122. *In:* ROHLF, F. J. and BOOKSTEIN, F. L. (Eds.). *Proceedings of the Michigan Morphometric Workshop: Special Publication Number 2*. The University of Michigan Museum of Zoology, Ann Arbor, Michigan.

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.

OKAEME, A. N. and OSAKWE M. E (1988). Gastro-intestinal helminthes and food of the African hedgehog *Atelerix albiventris* (Wagner) in the Kainji Lake area of Nigeria. *African Journal of Ecology* 26(3): 239 – 241.

OKORAFOR, K. A., OKETE, J. A., ELENG, I. E. and ODAIBO, A. B. (2013). Seasonal variation in the mean body weight, length, and capture rate of cane rats (*Thryonomys swinderianus*) in Ibadan, Oyo State, Nigeria. *European Journal of Experimental Biology*, 3: 301 – 306.

ROBBINS, C. B. and SETZER, H. W. (1985). Morphometrics and distinctness of the hedgehog genera (Insectivora: Erinaceidae). *Proceedings of the Biological Society of Washington,* 98(1): 112 – 120.

ROFF, D. A. (2002). *Life History Evolution.* Sinauer Associates Incorporated, Sunderland, Massachusetts, USA.

SANTANA, E. M., JANTZ, H. E. and BEST, T. L. (2010). *Atelerix albiventris* (Erinaceomorpha: Erinaceidae). *Mammalian Species,* 42(1): 99 – 110.

SMITH, A. J. (1992). Husbandry and medicine of African hedgehogs (*Atelerix albiventris*). *Journal of Small Exotic Animal Medicine,* 2: 21 – 28.

TAILLON, J., BRODEUR, V., FESTA-BIANCHET, M. and CÔTÉ, S. D. (2011). Variation in body condition of migratory caribou at calving and weaning: which measures should we use? *Ecoscience,* 18: 295 – 303.