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Relationship among Liveweight and Body Dimensions of the Greater Cane Rat (*Thrynomys swinderianus*)

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Authors' contributions

This work was carried out in collaboration among all authors. Author AKD designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors AES and OHO managed the analyses of the study, funding acquisition and supervision of the study. Author OEF managed the literature searches, writing review and editing. All authors read and approved the final manuscript.

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ABSTRACT

The objective of this study was to predict the live weight (LW) of domestically kept Grasscutters from some morphological parameters. The study was carried out at the Grasscutter section of FAK Farms, Apata, Ibadan. Data were recorded on body length (BL), tail length (TL), heart girth (HG), wither height and head length (HL) and body weights of 45 animals (25 females and 20 males) selected at random. Body weights and linear body measurements were recorded for the animals at 3, 6, 9 and 12 months of age using the simple kitchen digital weighing balance and traditional tape measure respectively and the data obtained were subjected to descriptive statistics, Pearson correlation and regression analysis (P=0.05). Mean body length, tail and head lengths, heart girth and wither height were 51.38±3.03cm, 16.76±1.05cm, 10.01±0.42cm, 28.90±1.39cm and 13.66±0.75cm respectively for the male Grasscutters and 45.92±10.01cm, 14.62±0.84cm, 9.40±0.42cm, 28.06±1.41cm and 13.83±0.78cm respectively for the female Grasscutters. The correlation coefficients between LW and body measurements ranged from 0.251 to 0.909 for the male grasscutters and 0.347 to 0.945 for the female grasscutters with the highest correlation of

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0.909 and 0.945 for the association between liveweight (LWT) and HG for males at 12 months of age and females at 9 months indicating sexual dimorphism.
The coefficients of determination (R^2) for the prediction equations recorded highest for heart girth {LWT= -0.101+0.095HG (82.6%)} at 12 months and {LWT= -2.671+0.148HG (89.4%)} at 9 months for the male and female Grasscutters respectively. Using the linear function from the R^2 value, BL, WH and HG were better predictors of LW than TL and HL. The best predictor of body weight was heart girth for both the male and the female.
In conclusion, the use of BL, WH and HG in a given function explained better the variation in LW than the use of just one body measurement and can provide a basis for selection.

Keywords: Body parameter; grasscutter; sexual dimorphism; selection; prediction.

1. INTRODUCTION

Knowledge of the live weight of livestock including Grasscutter is important, as it is required in determining their feed requirement, breeding management, correct administration of drugs and marketing of the animals. Responses to genetic selection could be greatly determined by using the live weight and changes in live weight of livestock [1]. The accepted method of measuring live weight of animals is the use of calibrated electronic or mechanical scales [2]. However, in most rural communities and villages in developing countries like Nigeria and Ghana, where the majority of Grasscutter farmers are found, poverty rates are very high. It is estimated that about 30% of the populace, mostly rural inhabitants, live on less than $1.00 a day. In these communities, weighing scales are either non available or unaffordable. Also in cases where cheap scales are present, farmers complain of frequent breakdowns of these scales. This results in frequent purchasing of these scales making them eventually expensive. Most Grasscutter farmers have therefore resorted to the use of visual appraisal in the marketing of their animals. This has led to either underpricing or overpricing of animals during their sale [2,3].

Morphological body measurements can be used as indicators of sexual dimorphism in animals [4], and also in predicting the live weight of livestock. Farmers who cannot afford expensive weighing scales or frequently purchasing scales will still be in a position to estimate the approximate weight of their animals for whatever husbandry practices they need the weight for using simple measuring tapes. Linear body measurements have been used to predict live weight of several livestock species including goats, sheep, cattle, rabbits and pigs by several individual researchers. It was however reported by [2]; Udeh and Okonta, [5] that information is scanty with respect to predicting live weight of Grasscutters using their morphological traits.

Measurements of qualitative traits are vital tools for decision making in both plants and animal genetic resources. Growth and maturity rates of different body parts of animals for instance, provide a better assessment of conformation upon which productivity of all meat animals including chickens largely depend [6]. Body measurements and other conformation values have been used to assess growth performance in animals [7] and the use of body measurements in the prediction of weight and productivity of animals have been reported by Jibir et al. [8] and Fouriere et al*.,* [9], respectively. Measurement of bodyweight had also been used as a criterion in the prediction of abdomen circumference in sows [10]. Likewise, the strength of relationship between growth traits using simple correlation procedure on rabbits has been reported by Obasi et al., (2019).

However, without some objective measurement, such as weighing, producers have no accurate method of identifying the heaviest, lightest and average weight of a single Grasscutter or a group of Grasscutters. They could (and often try to) estimate weight by eye – but most farmers are poor judges of animal weights. In making direct measurement of a Grasscutter's weight with a scale balance, however, a significant amount of time and labor is required to obtain the measurement. As manual weighing with a scale balance cannot be performed frequently enough, a farmer could effectively use, if available, a relatively inexpensive, non-invasive and simple to use tape measure.

Useful information could be provided on the suitability of animals for selection and animal improvement and for evaluating the characteristics of various breeds of animals by making use of morphometric measurements

[11,12,13,14,15,16]. According to Riva et al., [17], the outcome of genetic improvement programs could also be evaluated. One of the prerequisites for genetic improvement is the knowledge of genetic parameters for important economic traits [18]. Improvement of economic characters in animals requires estimates of genetic, environmental and phenotypic parameters for the various traits of interest. Chineke, 1996 concluded that in order to achieve this genetic goal, proper measurement of growth traits and important economic characters is required. The relationships among quantitative traits such as body weight, body length, ear length, tail length and limb lengths etc have been investigated among domestic rabbits (Chineke et al., 2002). Chineke (2005) observed positive and significant relationship between body weight and body measurements in rabbit breeds and crosses.

2. MATERIALS AND METHODS

2.1 Study Area and Management of Animals

The research was carried out at the Grasscutter session of FAK Farms, Apata Ibadan Oyo State located on 7.3872^0N and 3.8355^0E. The ambient temperature during the period ranged from 26.9°C to 27.1°C with an average relative humidity of 80%, while the vegetative site was an inter-phase between the tropical rainforest and the derived savannah. Forty five (45) adult Grasscutters were sampled. Morphological data was taken from the Grasscutters, including twenty males and twenty five females. The animals include 5 each of the male Grasscutters at 3, 6, 9, and 12 months old, and 6 each of the female Grasscutters at 3, 6, and 9, months old while female Grasscutters at 12 months old contained 7 sample animals. The experimental animals were fed *ad libitum* on forages and whole maize. The randomly selected animals were banded at the end of the research and their body weights and body linear measurements were taken as a single measurement.

2.2 Data Collection

The following morphometric traits were measured, using a Digital Kitchen Precision Scale and a tape measure. Measurements were taken with the assistance of one operator, while the operator held the animals, the experimenter takes the measurements. Measurements were recorded in kilograms (kg) for body weight and centimeters (cm) for body parameters. All measurements were taken in the morning before the animals were fed and watered. The linear body measurements were defined by Annor et al., [2].

1. **Body weight (WT):** Animals were weighed on a scale and their weights read and recorded. The animals were weighed on the same day by the same operator.
2. **Body length (BL):** This is the distance between the tip of the nose to the tip of the tail.
3. **Head length (HL):** Distance from the tip of the nose to the level of the 7th cervical vertebrae.
4. **Heart girth (HG):** Circumference of the body measured behind the forelimbs round the chest.
5. **Height at withers (HW):** Distance from the surface of a platform to the withers
6. **Tail length (TL):** This is the distance from the base of the tail close to the body of the Grasscutters to the tip of the tail.

2.3 Statistical Analysis

Data obtained were subjected to descriptive statistics, correlation and regression analysis using SPSS 20.

$Y = a + bx$

Y_i is body weight or dependent variable;

a is the constant of a regression equation

b, is the coefficient of regression or slope defined as the change in Y_i resulting from a unit change in X_i;

X_i is the independent variable represented by Body Length, Tail Length, Head Length, Heart Girth or Wither Height.

3. RESULTS

Table 1 and 2 shows the descriptive statistics of live weight (in kg) and linear body measurements (in centimeters) of the male and female Grasscutters respectively. Males were higher than females in most of the traits studied.

Tables 3 and 4 present the phenotypic correlation among all the traits studied. Live weight of Grasscutter was positive and significantly correlated with all the linear body measurements in both sexes. Generally, the

correlations between LW and BL or HG were stronger for both sexes than those between LW and TL or HL. Body length is positive and significantly correlated with all the studied traits ($p<0.05$). The Correlations between TL, HL and HG were all low and not significant ($p>0.05$).
Tables 5 and 6 shows LW prediction from BL, TL, HG or HL using linear functions.

There were generally high coefficients of determination (R^2) for both the males and the females for all the linear functions. The use of BL, WH and HG in predicting LW using linear functions yielded the highest R^2 values. With the exception of models involving TL and HL, all the models under the linear functions were highly significant ($P<0.01$).

4. DISCUSSION

The descriptive analysis summarizes comparisons of approximately normally distributed scale variable considering the sex and age of the intensively kept Grasscutters. The mean, standard error, standard deviation and variances of the body parameters were compared across sex and ages. The comparison in this study was mainly across sex and different age groups taken at 3, 6, 9 and 12 months old on morphometric traits dimensions which provide evidence and boost knowledge of the existing relationship between live weight and linear body measurements. The male outperformed the female Grasscutters in LW and all the linear body measurements. Other researchers have also reported similar findings in this same species [19,20,21,2]. This confirms the general notion that sexual dimorphism in body weight and body measurements indeed exist in animals including Grasscutters. In Grasscutters, where sex determination is a major challenge [22], farmers could use differences in their linear body measurements to determine the sexes of animals of similar ages especially animals above 1-day old [8]. According to Salako [23], body measurements in addition to weight measurements describe more completely an individual or population than the conventional methods of weighing and grading the result of this study showed that the male Grasscutter had the highest value for live weight with 2.04 ± 0.21cm and the female 1.57 ± 0.13cm, which is both lower than the 2.90 ± 0.09cm and 2.36 ± 0.08cm for male and female Grasscutter respectively reported by [3] for Grasscutters between the ages 12 and 18. The mean body length of the male Grasscutters was 51.38±3.03cm and the female was 45.92±2.00cm, which were within the range of 42-58cm reported by Schrage and Yewadan [24]. All the mean linear body measurements for both male and female Grasscutters were slightly higher than those reported by Annor et al*.,* [2] for 180-day old Grasscutters. The differences in the trait means could be due to the age, environmental variation and population differences of the animals.

Table 1. Descriptive statistics of live weight (in kg) and linear body measurements (in centimeters) of the male Grasscutters

Parameters	N	Mean±S.E	Std. Deviation	Variance	Min	Max
Live Weight	20	2.04±0.21	0.95	0.91	0.35	3.30
Body Length	20	51.38±3.03	13.55	183.47	22.20	64.80
Tail Length	20	16.76±1.05	4.70	22.05	7.80	22.70
Heart Girth	20	28.90±1.39	6.23	38.80	15.70	37.90
Head Length	20	10.01±0.42	1.86	3.47	5.80	13.20
Wither Height	20	13.66±0.75	3.35	11.24	6.70	19.80

N = Number of Grasscutter; S.E = Standard Error

Table 2. Descriptive statistics of live weight (in kg) and linear body measurements (in centimeters) of the female Grasscutters

Parameters	N	Mean±S.E	Std. Deviation	Variance	Min	Max
Live Weight	25	1.57±0.13	0.68	0.45	0.45	2.60
Body Length	25	45.92±2.00	10.01	100.29	26.50	58.30
Tail Length	25	14.62±0.84	4.18	17.51	7.50	23.10
Heart Girth	25	28.06±1.41	7.04	49.56	13.40	42.20
Head Length	25	9.40±0.42	2.12	4.50	5.80	13.10
Wither Height	25	13.83±0.78	3.90	15.19	7.80	23.20

N = Number of Grasscutter; S.E = Standard Error

Table 3. Correlation between live weight (Kg) and linear body measurements (cm) of the male Grasscutters

Age	Body length				Tail length				Heart girth				Head length				Wither height			
	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
Live weight	0.896*	0.808	0.786	0.785	0.264	0.587	0.603	0.368	0.898	0.825	0.903*	0.909*	0.806	0.251	0.631	0.450	0.800	0.801	0.651	0.789
Body length	1	1	1	1	0.072	0.351	0.200	0.860	0.985**	0.573	0.873*	0.720	0.490	0.240	0.876*	0.855	0.602	0.296	0.901*	0.881*
Tail length					1	1	1	1	0.001	0.093	0.262	0.395	0.574	-0.621	-0.043	0.865	0.269	0.546	0.107	0.624
Heart girth									1	1	1	1	0.522	0.722	0.869*	0.260	0.693	0.789	0.823*	0.536
Head length													1	1	1	1	0.880*	0.225	0.830*	0.864
Wither height																	1	1	1	1

*** Correlation is significant at the 0.01 level (2-tailed)*

** Correlation is significant at the 0.05 level (2-tailed)*

Table 4. Correlation between live weight (Kg) and linear body measurements (cm) of the female Grasscutters

	Body length				Tail length				Heart girth				Head length				Wither height			
	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
Live weight	0.751	0.695	0.649	0.758	0.523	0.347	0.623	0.455	0.922**	0.730*	0.945*	0.942**	0.384	0.639	0.594	0.753	0.615	0.380	0.881*	0.861*
Body length	1	1	1	1	0.787	0.210	0.075	0.660	0.802	0.620	0.645	0.555	0.481	0.532	0.708	0.606	0.843*	0.716*	0.594	0.953**
Tail length					1	1	1	1	0.648	-0.035	0.526	0.315	-0.151	0.537	0.186	-0.054	0.942**	0.064	0.537	0.540
Heart girth									1	1	1	1	0.353	0.250	0.795	0.753	0.619	0.124	0.684	0.732
Head length													1	1	1	1	-0.027	0.662	0.212	0.793
Wither height																	1	1	1	1

*** Correlation is significant at the 0.01 level (2-tailed)*

** Correlation is significant at the 0.05 level (2-tailed)*

Table 5. Linear regression equations for estimating live weight (LW) from body length (BL), tail length (TL), heart girth (HG), head length (HL) and wither height (WH) for male Grasscutter

Body parameter	Age	Prediction equation	R^2	P Value
Body length	3	LWT= -0.272+0.033BL	0.803	<0.0001
	6	LWT= -4.607+0.116BL	0.653	<0.0001
	9	LWT= 1.357+0.020BL	0.619	<0.0001
	12	LWT= 0.935+0.035BL	0.616	<0.0001
Tail length	3	LWT= 0.229+0.052TL	0.070	<0.0001
	6	LWT= 0.007+0.085TL	0.345	<0.0001
	9	LWT= 1.773+0.042TL	0.364	<0.0001
	12	LWT= 2.529+0.027TL	0.135	<0.0001
Heart girth	3	LWT= -0.526+0.062HG	0.807	<0.0001
	6	LWT= -0.271+0.065HG	0.680	<0.0001
	9	LWT= 1.694+0.027HG	0.815	<0.0001
	12	LWT= -0.101+0.095HG	0.826	<0.0001
Head length	3	LWT= -0.555+0.161HL	0.650	<0.0001
	6	LWT= 0.965+0.066HL	0.063	<0.0001
	9	LWT= 1.973+0.055HL	0.399	<0.0001
	12	LWT= 2.588+0.043HL	0.202	<0.0001
Wither height	3	LWT= -0.527+0.136WH	0.641	<0.0001
	6	LWT= 0.790+0.056WH	0.641	<0.0001
	9	LWT= 1.711+0.054WH	0.424	<0.0001
	12	LWT= 1.153+0.129WH	0.623	<0.0001

Table 6. Linear regression equations for estimating live weight (LW) from body length (BL), tail length (TL), heart girth (HG), head length (HL) and wither height (WH) for female Grasscutter

Body parameter	Age	Prediction equation	R^2	P Value
Body length	3	LWT = -0.172+0.026BL	0.564	<0.0001
	6	LWT= -0.695+0.045BL	0.484	<0.0001
	9	LWT= -1.070+0.061BL	0.422	<0.0001
	12	LWT= -1.061+0.062BL	0.575	<0.0001
Tail length	3	LWT= 0.343+0.027TL	0.273	<0.0001
	6	LWT= 0.987+0.035TL	0.120	<0.0001
	9	LWT= 0.730+0.084TL	0.388	<0.0001
	12	LWT= 1.581+0.033TL	0.207	<0.0001
Heart girth	3	LWT= 0.208+0.021HG	0.851	<0.0001
	6	LWT= -0.798+0.084HG	0.532	<0.0001
	9	LWT= -2.671+0.148HG	0.894	<0.0001
	12	LWT= 0.504+0.048HG	0.887	<0.0001
Head length	3	LWT= 0.256+0.052HL	0.147	<0.0001
	6	LWT= -0.501+0.225HL	0.409	<0.0001
	9	LWT= 0.561+0.132HL	0.353	<0.0001
	12	LWT= 0.632+0.143HL	0.567	<0.0001
Wither height	3	LWT= 0.305+0.031WH	0.379	<0.0001
	6	LWT= 1.047+0.035WH	0.745	<0.0001
	9	LWT= -1.007+0.190WH	0.775	<0.0001
	12	LWT= 1.050+0.067WH	0.741	<0.0001

Correlations among body traits are very important in the study of morphometric characters because they serve as indicators of the magnitude and direction of change in one trait as affected by another. In the present study, the pearson correlation coefficient among live weight and body measurements were mainly medium to high positive, with few very low correlations. This agrees with results of Annor et al (2011) and Jayeola et al (2009) who stated that the correlation among linear measurement in Grasscutters was positively very high and

significant. This suggests that body measurements could be used as predictors of live weight of mature Grasscutters. Heart girth and body length will however be better predictors of live weight than tail length, head length and wither height at the respective ages under study due to their relatively high correlation coefficient with live weight.

The medium to high positive correlations among BL, WH and HG for the male Grasscutters at the various ages under study suggests that these traits could be used in predicting and genetically improving each other, therefore a causative relationship is implied. For the female Grasscutters, medium to high correlations were recorded among BL, WH and HG for the ages studied, which also suggests that these traits could be used in genetic improvement for each other.

The high positive correlations between BL, WH and HG also suggest that these traits could be used in predicting each other. Likewise, selection for one trait could lead to the corresponding improvement in the other traits and the older females (12 months) are more likely to respond to this selection than the males of the same age, which is contrary to the report of Hagan et al*.,* [25], which stated that the males are more likely to respond to this selection. This difference may be due to the sample size used for the studies. The moderate to high phenotypic correlation between live body weight and most morphological traits indicates that one trait can be used to predict the other [20,8,26]. The high relationship of heart girth, wither height and body length with Live weight proved that these parameters are good indicators of body weight which confirms the findings of other works such as Annor et al*.,* [2] who found heart girth as the best predictor of body size followed by body length in Grasscutters. In the present study, the correlation of heart girth was found to increase asymmetrically as the animal advances in age, whereas the other parameters increase and decrease in a non-particular manner. This may be due to the fact that the environmental conditions the animals are subjected to were not uniform. Also, there may be intangible variations and unexplainable maternal genetic differences in play on these animals, as they are not all from the same parents.

The coefficients of determination (R^2) were used as measures of the goodness of fit for the models used in predicting live weight from body measurements. Heart girth was found to be the best predictor of body weight (LWT= -0.101+0.095HG) for the males and LWT= -2.671+0.148HG for the females) because it is part of tissue measurements, while other measurements are related to skeletal measurements [27]. This was followed by body length (LWT= -0.272+0.033BL) and then wither height (LWT= -1.007+0.190WH). A similar trend was observed for the correlations between body measurements and live weight. This suggests that body measurements predict live weight perfectly in the female Grasscutters as well as the male counterparts. This does not collaborate with the findings of Hagan et al*.,* [3], Annor et al*.,* [2], Ozluturk et al*.,* [28], Daffour-Oduro and Naazie [29] and Tsegaye et al*.,* [30] in Grasscutter, Grasscutter, cattle, pigs and goats respectively who all reported that body measurements predict live weight better in the male animals. This difference may be attributed to the environment and measurement error that may have been encountered during these studies. In summary, the prediction equation with the highest R^2 value was the linear equation involving HG to predict LW at 6 months old in male grasscutters (LW = -0.101+ 0.095HG) and at 9 months old in the female grasscutters (LW = -2.671+0.148HG). In adopting this method of prediction of the greater cane rat, age is an important factor to consider because of different stage of tissue and bone development

5. CONCLUSION

The estimation of body weight using morphometric parameters is very important for smallholder livestock and Grasscutter farmers who rarely keep records. Measurements of various morphometric traits are of value because of their relative ease of usage. In this study, Correlation coefficients indicated that to a large extent, selection program that is aimed at improving body weight will also produce a positive correlated response in body parameters. Consequently, Prediction of live weight using a simple linear model was found to be possible as measured variables had high R^2 values indicating that more than 50% of the body weight can be explained using those parameters.

In conclusion, linear body measurements could be used in predicting the live weight of Grasscutters with heart girth and body length being the best predictors of live weight. Better accuracy can be estimated using both parameters in predicting live weight than using the parameters singly. Male Grasscutters were also found to have longer body, head and tail

lengths, larger heart girth and taller height-at-withers than the females.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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