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Full Length Research

Relationship of linear body measurements with live body weight in West African Dwarf sheep raised in Tropical Rainforest of Nigeria

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ABSTRACT: The relationship between live body weight and some linear body measurements was studied in 130 (98 females and 32 males) West African Dwarf (WAD) sheep under field conditions in Obio Akpa. Body measurements studied included Body Length (BL), Hearth Girth (HG), Height of Wither (HAW), Neck Length (NL), Rump Width(RW), Ear Length (EL), Neck Width (NW), Shoulder Width (SW) and Tail Length(TL). The data collected were subjected to t-test analysis to determine the effect of sex on each of these parameters. The data were also fitted into linear and multiple regression models to predict live body weight from the body measurements. Correlations between body weight and linear body measurements were also calculated. The results indicated that the linear body measurement of the West African Dwarf sheep was significantly higher in males than in females except in shoulder width. In all the three categories studied; male, female and pooled male/female, the correlation coefficient (r) was significantly and positively high in the relationship between live body weight with BL and HG. The correlation coefficient (r) computed were 0.742, 0.842 and 0.579 for body length in pooled male/female, males, and females respectively, while between body weight and HG were 0.704, 0.811 and 0.539 for pooled male/female, males and females respectively. Based on the stepwise regression procedure, BL, HAW, HG, SW, and NL were better for predicting live body weight in linear regression model for males and pooled males/females while BL, SW, HG, TL, HL were best for females. It was concluded that BL and HG were of great importance in the selection program targeting the live body weight of WAD sheep especially, in the study area.

Keywords: Body weight, correlation, body measurements, regression, sheep.

INTRODUCTION

Nigeria is blessed with a large number of small ruminants, but most of which their full potentials have not been fully utilized. Small ruminants form an integral and important component of the pattern of animal production in Nigeria (Alphonsus *et al*., 2010a). The sheep population in Nigeria have been reported to be 42.1 million (Sam, 2012). Most sheep in Nigeria are indigenous breeds used for meat and hides. Their faeces are used as fertilizer in some farming communities and their by-products are used in the poultry industry to produce feed (Alphonsus *et al*., 2010b). Among the indigenous breeds, the West African Dwarf sheep is the most predominant meat-type found mostly in the tropical rainforest zone of Nigeria. The West African Dwarf sheep are very strong and hardy animals. They are also highly tolerant of trypanosome (N'Goran *et al*., 2019).

This breed of sheep is yet to undergo the desired selection program for improved carcass yield. Genetic improvement of its live body weight is key to increasing carcass yield from this breed. It has been reported that the main factors that determine profitability in meat-type animals are body weight and morphometric traits (Hamito, 2009). Body weight is very important in sheep production because it is used in the control and management of the flock throughout the production period. Major decisions such as market prices for live animals, determining correct dosages in drug administration, determining animals' feed requirements for growth, maintenance and production all require the knowledge of live body weight. In some areas, especially rural communities (under field conditions) where there is no weighing scale, measurements of morphemetric parameters could be used to estimate body weight (Feyissa *et al*., 2018). Measurement of morphometric traits of sheep is very important in judging the quantitative characteristics of meat and useful in developing suitable selection criterion (Kumar *et al*., 2017). Body measurements are valuable in indicating breed standards (Riva *et al*., 2002; Verma *et al*., 2016) and give information about the morphological structure and developmental ability of the animals (Kumar *et al*., 2017). Linear body measurements are used as growth indicators in animal life (Goe *et al*., 2001) and are also helpful in predicting body weight and carcass traits (Atta and El-Khidir, 2004; Thiruvenkadan, 2005).

The use of linear body measurements in estimating live body weight in small ruminant have been reported by several authors for goats (Sam *et al*., 2016; Fajemilehin and Salako, 2008; Adeyinka and Mohammed, 2006; Nsoso *et al*., 2004; Attah *et al*., 2004), and sheep (Solomon, 2008; Sowande and Sobola, 2008; Antobam, 1983; Tadesse and Gebremariam, 2010; Birteeb *et al*., 2012). However, very little work has been done on the prediction of live sheep weight based on body measurements in the tropical rainforest zone of Nigeria. Therefore, this study was undertaken to obtain prediction equations that could be used in estimating the live weight of West African Dwarf sheep raised in the rainforest zone of Nigeria.

MATERIALS AND METHODS

Study location

The animals used for this experiment were sourced from smallholder farmers in Obio Akpa, Oruk Anam Local Government Area of Akwa Ibom State in Nigeria. Obio Akpa is located between latitudes 5° 17'N and 5° 27'N and between longitudes 7° 27'N and 7° 58'E with an annual rainfall ranging from 3500 - 5000 mm and average monthly temperature of 25°C, and relative humidity of 60-90%. It is in the tropical rainforest zone of Nigeria. The people in the study areas depend mainly on livestock and crop production (Sam *et al*., 2016).

Experimental animals and management

A total of 130 WAD sheep (98 females and 32 males) were selected and used for live body weight and body measurements among the smallholder flocks. The estimated age of the animals was between 12 and 36 months based on dentition as describe by FAO (1994). The sheep were managed intensively, browse plants and grasses were given to them daily.

Data collection

Live body weight (kg) of individual sheep was determined before feed was given in the morning to minimize error due to gut-fill using Measuretec^R hanging scale. Body measurements were made using measuring tape calibrated (cm) after restraining and holding the animals in standing position. Body measurements were determined according to methods described by Sowande and Sobola (2008).

Statistical analysis

The data obtained were insert for analysis using the statistical package for social sciences (SPSS) version 23.0. T-test was used to compare means of body weight and body measurements between the male and female sheep. Correlations (Pearson's correlation coefficients) between body weight and different body measurements were computed separately for males and females (sex-specific), and for the pooled data (not sex-specific). The stepwise elimination procedure of the same package was used to determine the relative importance of animal body measurement in a model designed to predict BW. Live body weight was regressed on the body measurement separately for males, females, and pooled data (male and female combined).

The choice of best fit regression model was assessed by using coefficient of determination R^2. The following models were used:

$Y= +\alpha + \beta x$ ………………………………… (linear)

$Y= +\alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots \beta_n x_n$ ……… (Multiple linear)

Where Y= Live body weight; α = Intercept; X = Body measurements; β= Regression coefficient of Y on X; n = nth no of body measurements.

RESULTS AND DISCUSSION

Body weight and linear body measurement

The live body weight and linear body measurement of male and female West African dwarf goats are presented in Table 1. The male sheep used in this research were of significantly higher mean live body weight than the females. This trend was observed in all the body measurements studied. The differences observed in live body weight and body measurements of rams and ewes indicate that these traits are sex dependent. Sowande and Sobola (2008) had earlier reported sexual dimorphism in population of sheep studied. It has been reported that ewes have slower rate of growth and reach a lower size at maturity due to the effect of estrogen restricting the growth

Table 1. Average live body weight and body measurement of male and female WAD sheep.

Parameters	Male	Female	LOS
LBW	28.80±1.59	24.75±0.76	**
BL	49.47±2.52	41.24±1.39	**
HG	68.03±2.65	58.84±1.74	**
HAW	64.55±0.89	55.41±0.71	**
NL	26.93±0.66	21.78±0.47	**
RW	17.12±0.52	13.44±0.18	**
EL	11.32±0.29	9.25±0.19	**
NW	7.89±0.30	6.78±0.16	**
SW	13.60±0.25	13.24±0.22	NS
TL	26.37±0.55	23.75±0.27	**

LOS = Level of significance, *= Significant, NS= Not Significant.

Table 2. Correlation between LBW and morphometric traits in pooled male/female WAD sheep

	LBW	BL	HG	HAW	NL	RW	EL	NW	SW	TL
LBW	1									
BL	0.742**	1								
HG	0.704**	0.569**	1							
HAW	0.240	0.379**	0.300*	1						
NL	0.143	0.162	0.235	0.416**	1					
RW	0.263**	0.418**	0.400**	0.606**	0.594**	1				
EL	0.185	0.197	0.172	0.582**	0.490**	0.459**	1			
NW	0.055	0.052	-0.048	0.299*	0.140	0.280*	0.234	1		
SW	-0.323*	-0.106	-0.078	0.078	-0.007	0.122	0.110	0.107	1	
TL	-0.066	-0.214	0.283*	0.283	0.264	0.304	0.369**	0.394	0.290*	1

of the long bones of the body (Sowande and Sobola, 2008). The values of BWT, HG, BL were within the range reported by Sowande and Sobola (2008) and Hall (1991).

Relationship between body weight and linear body measurement

The correlation coefficient (r) between BWT and linear body measurements in the pooled male and female are presented in Table 2 while that of sex-specific male and female are shown in Table 3. The results indicated that BL and HG had the highest correlation with BWT in male, female (sex-specific) and pooled male and female (not sex-specific) sheep measured. The correlation coefficient between BWT and other body measurements was positive though low in the three categories. However, a negative coefficient of correlations was observed in the relationship between body weight (BW) and SW, TL in the pooled male/females, males, and females.

The results obtained here indicate that BL and HG can be used as indirect selection criteria to improve the live body weight in sheep. The highest correlation coefficient (r) was observed for BL, with 74%, 84% and 57% correlation in pooled males/females, male and female respectively. The relationship between body weight and heart girth was also high indicating about 70, 84 and 53% correlation between body weight and HG in pooled males/females, males, and females respectively. This result is in line with the findings of Tadesse and Gebremariam (2010) who obtained a higher correlation between body weight and linear body measurements in male highland sheep than the females. Sam *et al*. (2016) also had similar results in West African dwarf goats raised in Obio Akpa. The correlation coefficient between BW and HG in this study is in line with the report of Feyissa *et al*. (2018) who also reported a better association of BW with HG. A higher genetic correlation between BW and HG in Bos taurus cattle was also reported by Afolayan *et al*. (2003). This indicates that the measurement of BL and HG could be used to estimate BW in West African dwarf sheep.

Prediction of body weight (BW) from linear body measurements

The regression equation for live body weight based on body measurements of males, females and pooled males/females are presented in Tables 4, 5 and 6. Multiple

Table 3. Correlation between LBW and morphometric traits in male WAD sheep (above diagonal) and in female WAD sheep (below diagonal).

	LBW	BL	HG	HAW	NL	RW	EL	NW	SW	TL
LBW	1	0.842**	0.839**	-0.136	0.103	-0.008	0.058	-0.199	-0.367	-0.504**
BL	0.579**	1	0.811**	0.176	0.284	0.171	0.169	-0.180	-0.400	-0.694**
HG	0.539**	0.281	1	0.055	0.408	0.157	0.193	-0.390	-0.139	-0.535**
HAW	0.110	0.159	0.062	1	0.290	0.154	0.088	0.037	-0.374	-0.557**
NL	-0.236	-0.378*	-0.220	-0.238	1	0.470**	0.564**	-0.396	-0.149	-0.322
RW	0.108	0.290	0.283	0.225	-0.225	1	0.206	-0.010	-0.116	-0.082
EL	-0.098	-0.228	-0.245	0.323	-0.083	-0.233	1	-0.531*	-0.126	-0.403
NW	0.007	-0.087	-0.132	-0.020	-0.047	-0.085	0.310	1	-0.191	0.165
SW	-0.431**	-0.056	-0.182	0.106	-0.108	0.172	0.109	0.192	1	0.541*
TL	-0.076	-0.384*	-0.298	0.089	0.030	-0.234	0.414**	0.281	0.119	1

Table 4. Multiple regression equations for estimating live body weight from body measurement male WAD Sheep.

Equation	Intercept	ß1	ß2	ß3	ß4	ß5	R^2	SE	p-value
BL	2.500	0.842					0.708	3.950	0.000
BL HAW	34.454	0.893	-0.293				0.790	3.436	0.019
BL HAW HG	24.490	0.109	0.181	0.103			0.843	3.072	0.036
BL HAW HG SW	56.871	0.234	-0.586	0.312	-1.694		0.892	2.636	0.020
BL HAW HG SW NL	61.883	0.192	-0.479	0.393	-1.804	-0.515	0.926	2.259	0.024

BL-Body length, HAW-Height at wither, HG-Heart girth, SW-Shoulder width, NL-Neck length.

Table 5. Multiple regression equations for estimating live body weight from body measurement female WAD Sheep

Equation	Intercept	ß1	ß2	ß3	ß4	ß5	R^2	SE	p-value
BL	11.605	0.074					0.336	3.952	0.000
BL SW	30.139	0.557	-0.399				0.495	3.494	0.002
BL SW HG	20.723	0.463	-0.342	0.347			0.602	3.144	0.004
BL SW HG TL	-2.046	0.562	-0.362	0.406	0.304		0.677	2.875	0.008
BL SW HG TL NL	-9.142	0.576	-0.378	0.303	0.368	0.253	0.724	2.698	0.024

BL-Body length, SW-Shoulder width, HG-Heart girth, TL-Tail length, NL-Neck length.

Table 6. Multiple regression equations for estimating live body weight from body measurement pooled male/females WAD Sheep.

Equation	Intercept	ß1	ß2	ß3	ß4	ß5	R^2	SE	p-value
BL	7.348	0.742					0.550	4.021	0.000
BL HAW	0.509	0.504	0.418				0.668	3.484	0.000
BL HAW HG	15.116	0.489	0.402	-0.228			0.720	3.232	0.002
BL HAW HG SW	6.422	0.523	0.398	-0.275	0.174		0.746	3.103	0.021
BL HAW HG SW NL	4.410	0.604	0.451	-0.260	0.259	-0.217	0.776	2.294	0.011

BL-Body length, HAW-Height at wither, HG-Heart girth, SW-Shoulder width, NL-Neck length.

regression equations were developed for predicting body weight from linear body measurements for male, female, and pooled male/female West African dwarf sheep separately. Stepwise multiple regressions were carried out to get best fit regression models.

In the estimation of BW from linear body measurements in male, female, and pooled male/female; five body measurements were considered. In male West African dwarf sheep, the body measurement that best fitted the model were BL, HAW, HG, SW, and NL accounting for 92% variation in body weight. In females, the linear body measurements that best fitted the model were BL, SW, HG, TL, and NL leading to a 72% of variation in live weight. When males and females West African dwarf sheep were considered together, the linear body measurements that best fitted the model were BL, HAW, HG, SW, and NL like that of the male contributing about 78% of the variation in live body weight.

It was observed that the coefficient of determination (R^2) value in the three categories of WAD sheep studied (male, female, and pooled male/female) increased as the number of variables increased while the standard error (SE) values decreased with increased number of variables. It has been reported that the higher the coefficient of determination (R^2), the better the prediction of body weight based on linear body measurements (Sam *et al*., 2016). Topal *et al*. (2003) reported that R^2 may be confidently applied to investigate the fitting state of simple and multiple regression models to actual data for the estimation of body weight in livestock.

All ten body measurements were fitted into the model and through a stepwise elimination procedure, five of the measurements were considered unfit in the model. The reports from this study indicate that the prediction of body weight from linear body measurements were more accurate for males than females and pooled males/females. This is in line with the reports of Sam *et al.* (2016) who observed similar trends in WAD goats in Obio Akpa. Bassano *et al*. (2003) had earlier explained that these variations in predicting body weight in males and females could be due to varying deposition of fat in the two sexes.

The findings from this study are in agreement with the study of Firew (2008) and Wendimu *et al*. (2016) on Blackhead Somali sheep. This work is also in line with the findings of Sowande and Sobola (2008) who reported that HG gave the best coefficient of determination, although they suggested the use of a combination of chest girth (heart girth), head length and width of hind quarters for selection and breeding in West African dwarf sheep. The present work has shown that better predictions of BW may be obtained by combining different body measurements of at least any of these five (BL, HG, SW, TL, HL, RW) depending on the sex.

However, in practical conditions, measurement of all these parts may be laborious, thus the higher association of BW with BL and HG in the present study would contribute largely to estimating body weight. Body length and heart girth fitted into all the models of three categories of sheep studied (males, females, and pooled male/female).

Therefore, it could be concluded that body weight prediction from heart girth and body length or in combination with other body measurements would be a practical option under field conditions with good accuracy.

Conclusion

The live body weight and linear body measurements of males WAD sheep showed significantly higher values than the females. There were positive correlations between body weight with body length (BL) and heart girth (HG) in all the classes of sheep measured (male, female and pooled male/female). The live body weight of WAD sheep was estimated accurately based on the combination of body length (BL), heart girth (HG), height at wither (HAW), shoulder width (SW), neck length (NL), tail length (TL), and rump width (RW). The study indicated that to predict body weight of West African dwarf sheep, measurement of body length and heart girth are of great importance. Selection programmes targeted on these body measurements could lead to improvement in live weight of West African dwarf sheep.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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