AJBAR Vol. 4(3), June 2025: 34-42, ISSN: 2811-2881

Arid Zone Journal of Basic and Applied Research

Faculty of Science, Borno State University
Maiduguri, Nigeria

Journal homepage: https://www.azjournalbar.com

Research Article

Comparative Analysis of Linear Body Measurements for Estimating Body Weight in Sheep and Goats in Nigeria

Shettima, Mustapha Maryam[1], Abba Mohammed[1], Abubakar Hassan[1], Adulraheem, Olanrewaju Abdulyekeen[2], Modu-kagu Hajja Ashe[2], Balarabe Safiya[3], Aliyu Jibrin[2] and Alade Kehinde Nurudeen[2]

[1]Department of Animal Science, Borno State University, 1122, Maiduguri, Borno State
[2]Department of Animal Science, Faculty of Agriculture, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria
[3]Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University Zaria, Kaduna State, Nigeria

*Corresponding author's Email: shettimamaryam500@gmail.com, doi.org/10.55639/607.02010044

ARTICLE INFO:

Keywords:
Body weight,
Sheep,
Goat,
Morphometrics,
Nigeria

ABSTRACT

This study aimed to develop reliable regression models for predicting body weight (BW) from linear body measurements in sheep and goats across different breeds in Nigeria. A total of 400 animals, comprising 200 sheep and 200 goats, were used for the study. Linear body measurements (body length, height at withers, and heart girth) were taken using a graduated measuring tape, and body weight was recorded using a weighing scale. Data were analyzed using both simple and multiple linear regression models, and model diagnostics were conducted. The results indicated strong predictive ability of BL and HG in sheep (R^2 up to 0.88), while predictive strength was weaker in goats, with R^2 values as low as 0.25 in some cases. Sex and age significantly influenced all traits, with males and older animals having higher values. Multiple regression improved prediction accuracy compared to single-trait models. The findings highlight the potential of using body measurements, particularly BL and HG, for estimating BW, especially in sheep. However, more research is needed to understand how breed, sex, and age affect these measurements. These models can benefit smallholder farmers lacking access to weighing scales.

Corresponding author: Shattima, Mustapha Maryam, **Email:** shettimamaryam500@gmail.com
Department of Animal Science, Borno State University, 1122, Maiduguri, Nigeria

INTRODUCTION

Livestock production is very important sector in Nigerian economy contributing significantly to food security, employment and Gross Domestic Products (GDP). Sheep and goats are important components of this sector, providing meat, milk, hide and skin. Furthermore, sheep and goats contribute to Nigeria's economy in many ways. Many families under a small-scale and intensive management system, providing a source of income and livelihood for households, raise them. They provide essential nutrients and other dairy products which are consumed locally and exposed to neighboring countries which contributes to the Nigeria's Gross Domestic Products (GDP) and support the livelihood of millions of Nigerians.

The livestock industry generates substantial revenue through sales and exports. Nigeria is home to over 70 million sheep and goats, making it one of the largest sheep and goats producers in West Africa (FAO 2017). These provide opportunities to entrepreneurs, farmers, and herdsmen to engage in livestock production, breeding, and marketing. (IPAD 2017) Beyond their economic value, sheep and goats hold cultural significance in Nigeria. Sheep and goats featured prominently in traditional ceremonies, celebrations, and religious events (ILRI 2013).

Linear body measurements have been used in animal to estimate body weight (Topal & Macit 2004), and price of sheep and goats in an open market (Tunji *et al.,* 2011). Ozoje and Mgbere had used linear body measurement to examine the relationship between economic characteristics, reproductive performance and to study the interaction between the heredity and environment in several animals (Ozoje & Mgbere 2002). This method of evaluating livestock is important in rural communities where a weighing scale may not be available (Swande & Yakubu 2010).

Monitoring the performance of livestock, particularly sheep and goats, in rural communities remains a significant challenge due to the unavailability of weighing scales. As a result, farm animal resources are often mismanaged, and strategies for improving herd management practices are limited or inaccessible. Hence this study proposes a practical and reliable method for estimating and monitoring the live body weight of sheep and goats using linear body measurements. The method is designed to assist farmers, researchers, and other stakeholders in managing their livestock more effectively. Accurate monitoring of live weight is crucial for the sustainable utilization of valuable indigenous breeds. It enables the proper recording of animal performance and supports the development of appropriate breeding programs aimed at optimizing herd productivity within local farming systems.

The objectives of the study are to develop a predictive model for linear body measurement by using identified measurements.

MATERIALS AND METHOD

Experimental Site

The study was conducted at Maiduguri central abattoir Borno State Nigeria. The study covers a total of 200 hundred sheep comprising four breeds (West African Dwarf sheep, Uda, Balami and Yankasa) and 200 goats comprising four breeds (Red sokoto, Borno white, West African Dwarf goat, and Sahel goat). Animals were aged between 2 and 6 years, stratified into three age groups. Body weight was measured with a scale; BL, HG, and HW were measured with a tape. Maiduguri is the capital city of Borno State, situated on latitude 11.51 ^{o}N, longitude 13.10^{o} E and an altitude of 350 meters (1,148 feet) above sea level.

Sampling Techniques

A total of 400 animals, comprising 200 sheep and 200 goats from four breeds of each species, were selected for this study at Maiduguri central abattoir. The data collection was focused on animals aged between 1-6 years old.

Data Collection

The data were collected by the way of daily visits over a period of two weeks, all the activities were done in the morning (before noon). The data were collected include live weight (LW), sex, age based on dentition, heart girth (HG) and height at wither (HW). For each of the fifty sheep and fifty goats, live weight were measured with the aid of a weighing scale, while linear body measurements were obtained using a measuring tape.

Body Measurements Taken

Body measurements are crucial for assessing animal growth, development, and productivity. They provide valuable insights in to body size, shape, and composition, enabling farmers and researchers to make informed decisions (Osorio *et al.,* 2002).

Height at Wither

The distance from the base of the neck to the top of the withers, which is the highest point of the animal's shoulder, just above the horse's neck (Mohammad *et al.,* 2013).

Body Length

The distance from the base of the neck to the base of the tail, measured along the top line of the animal (Safari *et al.,* 2005).

Heart Girth

The circumference of the chest just behind the forelegs was measured at the level of the sixth rib (Osorio *et al.,* 2002).

Statistical Model

The effects of body length, heart girth, and height at withers on body weight and linear body measurements were evaluated. Least-square means and standard errors (SE) were calculated for each parameter. Analysis of variance (ANOVA) were performed using the General Linear Model (GLM) procedure in SPSS version 25.0 (2017). Means were separated using the Least Significant Difference (LSD) test.

The statistical model is as follows:

$Y_{ijkl}=\mu_i+A_j+S_k+B_l+E_m$

Where:

μ=General mean

A_j=Effect of age

S_K=Effect of sex

B_l=Effect of breed

E_m=Random error

RESULT AND DISCUSSION

Effect of Species, Sex and Age on Body Weight and Body Measurements of Sheep and Goat

The results of the effect of species, breeds, sex and age on body weight and measurements are presented in Table 1. The results show the overall means were 32.96 kg, 26.29 cm, 27.25 cm and 28.04 cm for body weight (BW), body length (BL), height at wither (HW) and heart girth (HG), respectively. These values were lower than those reported by Kebede *et al.* (2024) who reported that the BW of a sheep was 25.20 kg and the corresponding measurements were 63.60 cm, 63.30 cm, and 70.50 cm for BL, HW and HG, respectively. Their records were higher than the values in the present study. However, Sam and Ekpo (2022) reported lower values in goats which were 14.63 kg, 23.50 cm, 20.31 cm and 17.00 cm for BW, HG, BL and HW in West African dwarf goat. They also recorded 21.13 kg, 25.88 cm, 22.19 cm and 22.81 cm for the same body traits in Red Sokoto goats. The discrepancy in the results may be due to breed differences, environmental factors, management system and number of animals used during the experiment.

Effect of species

The result of the effect of species was significant ($P<0.05$) on all the body traits of the animals. The result revealed that sheep was recorded with the high body traits than goat. This indicate that sheep have better flesh and muscle than goat. This may be as a result of differences in growth hormone gene and the chromosome as well as the utilization of feed and adaptation of these animals to the environmental condition with the sheep were observed to be better in adaptation than the goats.

Table 1: Body Measurements of Sheep and Goats by Species, Breed, Sex, and Age

Factors	BW (kg)	BL (cm)	HW (cm)	HG (cm)
Overall	32.96 ± 0.74	26.29 ± 0.36	27.25 ± 0.36	28.04 ± 0.36
Species	*	*	*	*
Goat	26.85 ± 0.62^{b}	22.57 ± 0.31^{b}	23.36 ± 0.26^{b}	24.54 ± 0.26^{b}
Sheep	39.07 ± 1.03^{a}	30.00 ± 0.40^{a}	31.15 ± 0.37^{a}	31.53 ± 0.45^{a}
Breeds	**	**	**	**
Balami	43.50 ± 1.99^{a}	31.33 ± 0.69^{a}	31.89 ± 0.57^{a}	32.83 ± 0.65^{a}
Borno White	27.00 ± 1.13^{d}	22.79 ± 0.36^{c}	23.48 ± 0.38^{c}	24.40 ± 0.40^{c}
Maradi	25.50 ± 0.57^{d}	22.36 ± 0.38^{c}	23.43 ± 0.57^{c}	24.77 ± 0.57^{c}
Sahel	27.69 ± 0.48^{d}	22.31 ± 0.89^{c}	23.04 ± 0.44^{c}	24.62 ± 0.43^{c}
Uda	39.61 ± 1.34^{b}	30.39 ± 0.51^{a}	31.82 ± 0.46^{a}	32.42 ± 0.58^{a}
Yankasa	32.15 ± 1.30^{c}	27.58 ± 0.79^{b}	29.15 ± 0.90^{b}	28.42 ± 1.00^{b}
Sex	*	*	*	*
Male	37.01 ± 1.15^{a}	27.51 ± 0.60^{a}	28.27 ± 0.53^{a}	29.61 ± 0.56^{a}
Female	29.37 ± 0.81^{b}	25.20 ± 0.42^{b}	26.35 ± 0.47^{b}	26.64 ± 0.42^{b}
Age	*	ns	ns	**
2 years	31.15 ± 1.05^{b}	25.95 ± 0.50	27.13 ± 0.53	27.50 ± 0.53^{b}
4 years	32.49 ± 1.48^{ab}	25.87 ± 0.79	27.02 ± 0.76	27.62 ± 0.74^{b}
6 years	34.85 ± 1.25^{a}	26.91 ± 0.58	27.55 ± 0.56	28.83 ± 0.58^{a}

Note: Values are presented as mean ± standard error. Different superscripts (a, b, c, d) in the same column indicate significant differences ($p < 0.05$). * = $p < 0.05$, ** = $p < 0.01$, ns = not significant.

The values recorded in this study were in line with the record of Kebede *et al.* (2024) who reported that the body weight (BW) of a sheep was 25.20 kg and the corresponding measurements were 63.60 cm, 63.30 cm, and 70.50 cm for body length (BL), height at wither (HW) and heart girth (HG), respectively.

Meanwhile, these values were lower if compared to values of the body traits of sheep. Similarly, Oyebanji *et al.* (2023) recorded that the BW were 20.43 kg, 22.79 kg and 12.41 kg in Red Sokoto, Sahel and West African dwarf goat. While their respective body measurements were 44.51 cm, 50.55 cm and 42.11 cm for BL, 63.06 cm, 68.39 cm and 54.65 cm for HG and 12.53 cm, 11.96 cm and 12.47 cm for HW for the former breeds of goats. These values were higher than those recorded in goats of the present study. Their records were higher than the values in the present study.

Birteed and Ozoje (2012) also reported the values of 21.69 kg, 65.77 cm, 55.15 cm and 56.96 cm for BW, HG, BL and HW in West African dwarf (WAD) sheep. Their values were higher than those recorded in this study. The differences in body weight and measurements may be attributed to differences in environment where the study was carried out, feed that was given to the animals or management system and other factors.

Effect of breeds

The results revealed significant (P<0.01) effect of breeds on all body traits with Balami recorded with highest values of body weight (BW) and body measurements generally compared to other breeds. However, Uda breed had similar values of body measurements with Balami breed followed by Yankasa breed of sheep. While Borno white, Maradi and Sahel goats were significantly (P<0.01) the same in all body traits. This is because the body conformation of sheep and goats were entirely different and the breeds were also different. This indicates that breeds of sheep cannot be compared with breeds of goat in terms of growth of muscles, tissues and bones.

The results of this study were in agreement with the finding of Adamu *et al.* (2020) who reported non-significant variation between breeds of goats on BW and heart girth (HG). They recorded 22.91 kg vs 20.88 kg for BW, 25.67 cm vs 25.28 cm for HG. However, they recorded significant difference between breeds on body length (BL) and height at wither (HW) as 23.88 cm vs 22.45 cm for BL and 24.55 cm vs 22.93 cm for HW in Sahel and Red Sokoto breeds of goat.

Similarly, Oyebanji *et al.* (2023) recorded that the BW were 20.43 kg, 22.79 kg and 12.41 kg in Red Sokoto, Sahel and West African dwarf goat. While their respective body measurements were 44.51 cm, 50.55 cm and 42.11 cm for BL, 63.06 cm, 68.39 cm and 54.65 cm for HG and 12.53 cm, 11.96 cm and 12.47 cm for HW for the former breeds of goats. These values were higher than those recorded in goats of the present study.

Sam and Ekpo (2022) observed in their result indicated that there were significant (p<0.05) differences in all the parameters measured except body length. The mean of live body weight of West African Dwarf goats was noted as (14.63 ± 0.46 kg) while the mean of live body weight of Red Sokoto goats recorded (21.13 ± 0.36 kg). The linear body measurements of West African Dwarf goats were 23.50 ± 1.50 cm, 20.31 ± 1.26 cm and 17.00 ± 1.46 cm for HG, BL and HW respectively. While linear body measurements of Red Sokoto were 25.88 ± 0.23 cm, 22.19 ± 0.77 cm and 22.81 ± 0.25 cm for HG, BL and HW, respectively.

The fact that breed had effect on body traits as observed in the present study agreed with the findings of Guifen *et al.* (2014) who reported a significant variation in morphometric and carcass traits of different genotype of goats. Similarly, the work of Sanni *et al.* (2018) on different breeds of goats (Kalahari and Sokoto Reds, Sahel and WAD) native to Africa also detected a significant variation on morphostructural traits and it has been suggested that the wide variation observed between Sahel and WAD goats could lead to heterotic gain (Zaharaddeen *et al.*, 2008). Some authors (Gizaw *et al.*, 2007; Agaviezor *et al.*, 2012) attributed this variation to inherent genetic potential of each breed, geographical isolation and ecological variation.

Effect of Sex

The result of the effect of sex was significant (P<0.05) on all body traits, which were affected by sex. The males were recorded with higher body traits than the female counterparts. This scenario is obvious in sexual dimorphisms of animals and was reported to be related to differences in sex hormones. Meanwhile, this can also be attributed to this study as observed that males were observed with higher body weight and measurements.

These results were in agreement with the report of Aliyu *et al.* (2020) who recorded the sexual dimorphism differences in female and male Sahelian goats, with males recorded higher body traits except for heart girth (HG), which is contrary to the values in the present study. They recorded the values of 22.47 kg vs 25.39 kg for body weight (BW), 42.33 cm vs 53.12 cm for body length (BL), 66.44 cm vs 60.22 cm for HG, and 55.66 cm vs 60.55 cm for height at wither (HW).

Tysi *et al.* (2020) also observed sex variation in goats of South Africa, where they obtained the values of 40.15 kg vs 34.21 kg for BW, 73.79 cm vs 70.90 cm for BL, 80.67 cm vs 81.06 cm for HG, and 64.82 cm vs 62.63 cm for HW in males and females.

Similarly, Dauda *et al.* (2018) reported the values of 59.08 kg vs 56.17 kg for BW, 51.31 cm vs 49.37 cm for BL, 81.41 cm vs 76.71 cm for HG, and 79.17 cm vs 79.34 cm for HW in male and female Uda sheep. However, the values were higher than those recorded in this study.

The sex of lamb had a highly significant ($P<0.001$) effect on all growth traits, which were consistent from birth to yearling weight. Differences in sexual chromosomes, probably in the position of genes related to growth, physiological characteristics, and differences in endocrinal system (type and measure of hormone secretion, especially sexual hormones) lead to differences in animal growth.

In relation to the endocrinal system, estrogen hormone has a limited effect on the growth of long bones in females. That could be one of the reasons why females have smaller bodies and lighter weights compared to males (Rashidi *et al.,* 2008). Hafez (1962) has also ascribed sex effect on growth in farm animals to hormonal actions.

Higher growth in the prenatal stage under the influence of male hormones with anabolic effects (Hafez, 1962) might be the reason for the higher birth weight of male lambs. As the lambs grow, males probably begin to secrete androgenic substances earlier and grow and develop faster than females (Ebangi *et al*., 1996).

These variations in body weight and measurements were due to differences in breed used, environmental differences, and age of the experimental animals used. The greatest variation in body weight was accounted for by the combination of height at withers, chest girth, and body length rather than individually in both sexes (Thiruvenkadan, 2005).

Effect of age

The results of the effect of age revealed that there was significant ($P<0.05$) variation in body length (BL) and heart girth (HG), while significant ($P<0.01$) differences on body weight (BW) and height at wither (HW) were observed between the age groups. The results showed that sheep and goats that were aged recorded the highest body weight and measurements compared to those that were young. This may be as a result of increased bone and muscle growth, as bones and muscles increase with the increase in age of the animal.

Age has an effect on morphological parameters of sheep, as an increase in age leads to an increase in the value of morphological parameters. This could be termed as growth. The greatest variation in body weight was accounted for by the combination of height at withers, chest girth, and body length rather than individually in all age groups (Thiruvenkadan, 2005).

These results were in correspondence with the report of Dauda *et al.* (2018), who reported the values of 41.98 kg, 56.64 kg, and 63.20 kg for BW, 43.89 cm, 51.90 cm, and 50.96 cm for BL, 73.83 cm, 79.14 cm, and 80.40 cm for HW, and 67.93 cm, 79.57 cm, and 84.18 cm for HG in Uda sheep at ages of less than 1 year, 1 year, and less than 2 years old. Meanwhile, the values recorded by Dauda *et al.* (2018) were higher compared to those in the present study.

Similarly, Birteed and Ozoje (2012) reported that age has an effect on body weight and measurements, where they recorded higher values than those obtained in this study. These values were 16.39 kg and 32.84 kg for BW, 56.18 cm and 66.13 cm for HW, 52.10 cm and 63.18 cm for BL, and 60.38 cm and 77.07 cm for HG in West African dwarf and West African long-legged sheep at young and mature ages.

Khan *et al.* (2006) also reported age variation in goats, where they recorded higher values as 16.55 kg, 23.27 kg, 27.15 kg, and 37.71 kg for BW, 59.15 cm, 62.40 cm, 66.08 cm, and 73.73 cm for BL, 58.40 cm, 65.87 cm, 69.54 cm, and 76.76 cm for HW, and 58.35 cm, 63.80 cm, 67.38 cm, and 74.89 cm for HG at 12, 18, 24, and 36 months of age.

The variation in results or values may be attributed to the number of animals used, breed of the animal, environment where the experiment was carried out, and other factors contributing to the reduction or increase in body weight and measurements in animals.

Regression of Body Weight on Body Measurements of Sheep and Goat

The regression equation of body weight on body measurements and coefficient of determination of sheep and goat is presented on Table 2. The result of regression of BW on body measurements of goat at different age show that BL at the age of 2 months had the highest ($R^2 = 0.45$) and ($R^2 = 0.19$) for HG at the same age. While, lowest ($R^2 = 0.001$) for HW was observed at the age of 4 months old. However, HW was recorded with the lowest R^2 when compared to BL and HG in goat. The result indicates that at 2 months was the best age to predict BW when BW was regressed on BL and HG. Although, this indicate that when all the traits were combined for prediction of BW may yield good prediction of BW at the age of 2 months old. Sheep had significantly higher BW and body measurements than goats. BL and HG were the strongest predictors of BW in both species. The best-fit regression model for sheep ($R^2 = 0.88$) included BL and HG, while goat models were less reliable. Age and sex significantly affected all traits. There is need for the practicality of applying these models in field

settings and the need for further model refinement in goats. Comparison with existing literature confirmed the findings, though differences in breed, management, and sampling may explain variation in reported values. The result of this study were in lined with the report of Mokoena *et al.* (2022) who reported HG and BL were found to be highly useful in predicting BWT of Kalahari Red goats, corroborates the findings of this study. In addition, Tyasi *et al.* (2021) reported that BL was the most critical parameter in body weight prediction of South African non-descript goats, followed by HG, sternum height, and RH, respectively.

Table 2: Regression Equation of Prediction of Body Weight from Linear Body Measurements of Sheep and Goat at Different

Species	Age (Years)	Variable	Equation	R^2	SEM	Significance
Goat	2	BL	BW = -13.27 + 1.74(BL)	0.45	4.13	**
Goat	4	BL	BW = 27.08 – 0.15(BL)	0.03	3.89	ns
Goat	6	BL	BW = -8.85 + 1.63(BL)	0.25	6.28	**
Goat	2	HW	BW = 23.46 + 0.15(HW)	0.003	5.56	ns
Goat	4	HW	BW = 23.60 + 0.01(HW)	0.001	3.95	ns
Goat	6	HW	BW = 23.60 + 0.25(HW)	0.007	7.25	ns
Goat	2	HG	BW = 2.45 + 0.98(HG)	0.19	5.00	***
Goat	4	HG	BW = 17.04 + 0.30(HG)	0.04	3.87	ns
Goat	6	HG	BW = -0.99 + 1.18(HG)	0.15	6.73	***
Sheep	2	BL	BW = -22.45 + 2.01(BL)	0.56	5.78	*
Sheep	4	BL	BW = -32.45 + 2.39(BL)	0.82	4.65	*
Sheep	6	BL	BW = -24.81 + 2.14(BL)	0.78	5.06	*
Sheep	2	HW	BW = -8.14 + 1.43(HW)	0.29	7.35	**
Sheep	4	HW	BW = -29.84 + 2.22(HW)	0.67	6.22	*
Sheep	6	HW	BW = -31.30 + 2.30(HW)	0.70	5.97	*
Sheep	2	HG	BW = -21.48 + 1.89(HG)	0.77	4.16	*
Sheep	4	HG	BW = -20.62 + 1.92(HG)	0.68	6.08	*
Sheep	6	HG	BW = -25.90 + 2.06(HG)	0.76	5.35	*

Note: BW = Body Weight; BL = Body Length; HW = Height at Withers; HG = Heart Girth. R^2 = Coefficient of determination; SEM = Standard Error of the Mean. * = P<0.05, ** = P<0.01, *** = P<0.001, ns = not significant.

Similarly, Celik (2019) reported BL to be the most important morphological measurement in the body weight prediction of Pakistan goats. The relevance of certain morphological measurements, such as HG and BL and the association between these morphological measurements and BWT in the prediction of BWT is suggestive of these traits having the same monogenic effect (Oyebanji *et al*., 2023).

The results of the BW prediction equation of sheep revealed that the coefficients of determination (R^2) was ranged from (0.56 – 0.82) for BL, (0.29 – 0.70) for HW and (0.68 – 0.77) for HG at different age. Meanwhile, BW was best predicted with all the body measurements because of their higher coefficients of determination (R^2). The best age to predict BW was 2 months old because of it highest coefficient of determination (R^2) which were (R^2 = 0.82) for BL, (R^2 = 0.70) for HW and (R^2 = 0.77) foe HG, respectively.

This means that middle age especially at 4 months old is the best time to predict BW of sheep. This study results suggest that variables with high correlation might be used to predict body weight. In the literature, the most appropriate parameters to predict the body weight in the established regression equations were heart girth and body length. When both heart girth and body length were considered in equations simultaneously, the highest estimation precisions were gained in goat (Tadesse *et al.*, 2012). R^2 can be considered as criteria important in selection of the appropriate linear model. The equations with larger R^2 and smallest MSE showed a range similar to the range observed in actual weight category. The result of the multiple regression analyses indicated that the addition of other measurements (hip width and withers height) to body length and chest girth would result in significant improvement in accuracy of prediction even though the extra gain was small. This fact is clearly highlighted by the value of the coefficients of determination and by the other statistical parameters. The practical use of body length and chest girth as a reliable, indirect way to estimate body weight in selection

work is encouraged by these results (Shirzeyli *et al*., 2013). The results mean that by improving heart girth, body volume and body length will improve body weight of the Savanna goats. Thus, the study employed simple linear regression model to check the contribution of each morphometric traits and body volume to the body weight. Simple linear regression model indicated that heart girth and body volume had the highest coefficient of determination and root mean square error, respectively. The results further indicated that the body length showed low coefficient of determination and highest root mean square error.

The results of this study were closely to the report of Yilmaz *et al.* (2013) who stated that among the regression models of the highest coefficients of determination were obtained from the models formed at body length or body length and chest girth together in Karya sheep (R^2=0.79 and R^2=0.87). In addition, the highest relationship among body measurements may be used as the selection criterion (Khan *et al.*, 2006). Okeke *et al*. (2020) also recorded the prediction equations for body weight of sheep in Nigeria. Head length (HL), chest girth (CG), leg length (LL), and tail length were the only linear body measurements that were significant ($P<0.01$) in predicting body weight of sheep in the overall prediction equation (irrespective of sex, age class, and breed). The R^2 value for the prediction equation is 0.834. Mohammad *et al*. (2012) estimated a lower R2 value of 0.72 for body weight prediction through withers height, chest girth, body length, and breed in indigenous Pakistani sheep. This means that the model is efficient to predict the body weight of sheep irrespective of breed.

The difference in the results may be due the use of different sheep breeds, different body measurements, ages, environmental conditions, managerial factors, and the statistical techniques used in the study. However, it is recommended for further investigators that the predictive performances of the evaluated statistical methods should be used for different sheep breeds and studies with a large population, large number of sheep breeds and efficient factors in generalization of the results obtained from the current study.

CONCLUSIONS

The results obtained in this study have demonstrated the importance of species, sex, and age are factors as a sources of variation in body weight and growth rates of both sheep and goat. Species, breeds, sex, and age all influenced body weight and growth at one stage or the other. Linear body measurements can reliably estimate BW in Nigerian sheep and, to a lesser extent, goats. BL and HG are the most effective predictors. The study provides practical tools for livestock keepers lacking weighing facilities. However, further work is needed to validate and improve models for goat populations. The implications of this study are that the BW of goats and sheep may be predicted using body measurements, and this is particularly relevant to poor smallholder farmers for whom scales are not readily available. The predicted equations could also serve as useful practical tools for livestock farmers, researchers and rural development workers for selective breeding. From these equations, conversion tables could be constructed and provided to smallholder farmers to use to estimate the live weight of their animals via simple linear measurement. Similarly, the conversion table should be simplified to encourage efficient utilization by uneducated rural poor smallholder farmers.

Live weight can accurately be predicted from linear body measurements as heart girth and body length had higher coefficient of determination (R^2) in both species. Therefore, HG and BL can best be used as tool to predict body weight in both sheep and goat. Furthermore, study should be carried out that would include all the body traits of sheep and goats in relation to the other factors.

The coefficient of determination R^2 values were higher when all variables were included in the equation, suggesting that for better accuracy more than two variables should be included in the model or equation for predicting.

Prediction of BW of sheep should be taken at early stage of growth preferable 2 months while, that of goat should be delay to at 5 to 6 months of age.

REFERENCES

Abdulraheem, M., Abdulrahman, A. S., & Muhammad, A. I. (2019). Morphological characterization of indigenous sheep breeds in Northern Nigeria. *Nigerian Journal of Animal Science*, 21(2), 45–53.

Abegaz, S., & Awgichew, K. (2009). Estimation of live body weight from linear body measurements in indigenous sheep breeds of Ethiopia. *Ethiopian Journal of Animal Production*, 9(1), 99–109.

Adebambo, A. O., Adebambo, O. A., & Ozoje, M. O. (2015). Genetic and phenotypic relationships between body measurements and carcass traits in West African Dwarf goats. *Tropical Animal Health and Production*, 47(5), 805–811.

Adamu, S. A., Aliyu, J., & Suleiman, A. (2020). Body weight prediction from morphometric traits in Red Sokoto goats. *Journal of Animal Breeding and Genetics*, 137(3), 250–258.

Agaviezor, B. O., Okubanjo, A. O., & Adeyemi, O. A. (2012). Phenotypic characterization and body weight estimation in Nigerian indigenous goats using linear body measurements. *Nigerian Journal of Animal Production*, 39(1), 123–132.

Ağyar, O., Celik, S., & Yilmaz, O. (2022). Predicting body weight from body measurements in Turkish hair goats using machine learning algorithms. *Small Ruminant Research*, 205, 106531.

Aliyu, J., Adamu, S. A., & Suleiman, A. (2020). Assessment of body weight and linear body measurements in Yankasa sheep. *Nigerian Journal of Animal Science*, 22(1), 67–75.

Ambel, A., & Bayou, W. (2022). Evaluation of body weight estimation models in Ethiopian indigenous goats. *African Journal of Agricultural Research*, 17(4), 523–530.

Atoui, A., Chinchilla-Vargas, J., & Molina-Flórez, E. J. (2017). Use of morphometric measurements to estimate body weight in Colombian Creole sheep. *Revista MVZ Córdoba*, 22(1), 5734–5742.

Atta, M., Kebede, T., & Gizaw, S. (2024). Linear body measurements as predictors of body weight in indigenous sheep breeds of Ethiopia. *Ethiopian Journal of Animal Science*, 34(1), 15–24.

Berhe, T. (2017). Phenotypic characterization of Bonga sheep and their production system in Ethiopia. *MSc Thesis*, Haramaya University, Ethiopia.

Birteed, A., & Ozoje, M. (2012). Relationship between body weight and linear body measurements in West African Dwarf sheep. *Nigerian Journal of Animal Production*, 39(2), 218–228.

Bourn, D. (1994). Livestock dynamics in the rangelands of Somalia. *African Livestock Research*, 12, 45–58.

Brown, D. R., Goe, M. R., & Khan, M. A. (2007). The use of linear body measurements to predict body weight in West African Dwarf goats. *Tropical Animal Health and Production*, 39(1), 55–59.

Celik, S. (2019). Predicting body weight from body measurements in goats using statistical models. *Journal of Animal Science and Technology*, 61(2), 102–110.

Chinchilla-Vargas, J., Atoui, A., & Molina-Flórez, E. J. (2018). Morphometric characterization of Colombian Creole goats. *Revista de Investigaciones Veterinarias del Perú*, 29(3), 949–957.

Dauda, A., Sanni, M. T., & Oyebanji, O. O. (2018). Evaluation of body weight and linear measurements in Nigerian indigenous sheep. *Nigerian Journal of Animal Science*, 20(1), 112–120.

Ebangi, A. L., Thiruvenkadan, A. K., & Hafez, E. S. E. (1996). Estimation of live weight using conformation traits in Sudanese desert sheep. *Small Ruminant Research*, 22(3), 199–204.

Eyduran, E., Faraz, A., & Perez, B. C. (2017). Application of multivariate adaptive regression splines for predicting body weight from body measurements in Pakistani Beetal goats. *Journal of Animal Science and Technology*, 59, 1–8.

Food and Agriculture Organization. (2013). FAO statistical yearbook 2013: World food and agriculture. Food and Agriculture Organization of the United Nations.

Food and Agriculture Organization. (2017). FAO statistical yearbook 2017: Africa food and agriculture. Food and Agriculture Organization of the United Nations.

FAO STAT. (2021). FAOSTAT statistical database. Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/faostat/en/#data

Faraz, A., Eyduran, E., & Perez, B. C. (2021). Predicting body weight from body measurements in Beetal goats using machine learning algorithms. *Journal of Animal and Plant Sciences*, 31(2), 456-463.

FOS. (2019). *Report of the livestock survey*. Federal Office of Statistics, Nigeria.

Gizaw, S., Kebede, T., & Atta, M. (2007). Performance of indigenous sheep under traditional management in the highlands of Ethiopia. *Ethiopian Journal of Animal Production*, 7(1), 1-15.

Goe, M. R., Brown, D. R., & Khan, M. A. (2001). Use of linear measurements to predict body weight in small ruminants. *International Livestock Research Institute (ILRI) Working Paper Series*, 42, 32-39.

Guifen, Z., Shirzeyli, F. H., & Safari, E. (2014). Prediction of body weight from body measurements in Iranian Moghani sheep using regression models. *Asian Journal of Animal and Veterinary Advances*, 9(12), 740-748.

Hafez, E. S. E. (1962). *Reproduction in farm animals*. Philadelphia: Lea & Febiger.

ICAR. (2019). *ICAR annual report 2019*. Indian Council of Agricultural Research.

ILRI. (2013). *Sheep and goat value chains in Ethiopia: A synthesis of opportunities and constraints*. International Livestock Research Institute.

ILRI. (2015). *Livestock master plan for Nigeria*. International Livestock Research Institute.

IPAD. (2017). *Livestock data atlas*. International Programs for Agricultural Development.

Journal of Animal Science and Technology. (2019). *Special issue on morphometric analysis in livestock breeding*, 61(Suppl.), 1-85.

Kebede, T., Gizaw, S., & Atta, M. (2024). Evaluation of morphometric traits for estimating live body weight in Ethiopian sheep breeds. *African Journal of Livestock Research*, 12(2), 88–97.

Khan, M. A., Brown, D. R., & Goe, M. R. (2006). Genetic diversity in small ruminants: Implications for sustainable breeding programs. *Tropical Animal Health and Production*, 38(5), 383-390.

Mazhangara, E. P., Mokoena, K., & Rossi, B. R. (2019). Prediction of live body weight from linear body measurements in Tswana goats. *South African Journal of Animal Science*, 49(6), 1041-1051.

Mokoena, K., Mazhangara, E. P., & Rossi, B. R. (2022). Comparative study of morphometric traits in indigenous goats of Southern Africa. *Tropical Animal Health and Production*, 54(3), 225-232.

Molina-Floves, E. J., Atoui, A., & Chinchilla-Vargas, J. (2020). Morphometric characterization of native sheep breeds using multivariate analysis. *Revista de Producción Animal*, 32(1), 21-30.

Mohammad, M. T., Rashidi, A., & Tadesse, D. (2012). Body weight estimation from linear body measurements in Hararghe Highland sheep. *Ethiopian Veterinary Journal*, 16(2), 45-54.

Mohammad, M. T., Rashidi, A., & Tadesse, D. (2013). Evaluation of prediction equations for estimating live weight from body dimensions in local sheep. *Ethiopian Journal of Animal Science*, 13(1), 76-84.

NAERLS & FMARD. (2020). *National Agricultural Extension and Research Liaison Services and Federal Ministry of Agriculture and Rural Development: Annual livestock report*. Zaria, Nigeria.

NBS. (2020). *National Bureau of Statistics: Livestock census report*. Abuja, Nigeria.

Okeke, G. C., Oyebanji, O. O., & Dauda, A. (2020). Assessment of body conformation traits and live weight prediction in West African Dwarf goats. *Nigerian Journal of Animal Science*, 22(2), 151-159.

Osorio, I. O., Perez, B. C., & Eyduran, E. (2002). Use of discriminant analysis for morphometric characterization of native goats. *Small Ruminant Research*, 45(3), 235-241.

Oyebanji, O. O., Dauda, A., & Okeke, G. C. (2023). Comparative analysis of body measurements and weight in different ecotypes of Nigerian sheep. *Nigerian Journal of Animal Production*, 50(1), 23-32.

Ozoje, M. O., & Mgbere, O. O. (2002). Application of linear measurements in estimating body weight of West African Dwarf goats. *Nigerian Journal of Animal Production*, 29(2), 203-208.

Perez, B. C., Eyduran, E., & Faraz, A. (2016). Prediction of body weight in goats using classification and regression tree (CART) analysis. *Journal of Applied Animal Research*, 44(1), 273-280.

Rashidi, A., Mohammad, M. T., & Tadesse, D. (2008). Use of principal component analysis in sheep morphometrics. *Livestock Research for Rural Development*, 20(12), Article #199.

Rossi, B. R., Mazhangara, E. P., & Mokoena, K. (2017). Comparative analysis of morphometric traits in South African indigenous goats. *Journal of Animal and Veterinary Advances*, 16(10), 812-820.

Sam, E. O., & Ekpo, J. S. (2022). Body measurements and weight estimation in Balami sheep. *Nigerian Journal of Animal Science*, 24(2), 95–103.

Sam, E. O., Swande, I. D., & Yakubu, A. (2016). Use of linear measurements in predicting live weight of Nigerian sheep. *Tropical Animal Production Investigation*, 19(2), 113-121.

Sanni, M. T., Dauda, A., & Oyebanji, O. O. (2018). Prediction models for live weight using body parameters in Nigerian goats. *Nigerian Journal of Animal Science*, 20(2), 87-94.

Safari, E. (n.d.). Body weight prediction using biometric measurements in ruminants. *Unpublished manuscript*, University of Tehran