DEVELOPMENT OF PREDICTIVE MODEL FOR ESTIMATING BODY WEIGHT IN SHEEP AND GOAT USING LINEAR BODY MEASUREMENTS

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Target Audience: Researchers, livestock breeders, animal production scientists, veterinary professionals, students, and policy makers in animal agriculture

ABSTRACT
Body weight estimation in small ruminants such as sheep and goats is essential for making informed decisions related to nutrition, health management, selection, and breeding. In many rural and resource-limited settings, direct weighing is impractical due to lack of facilities. This study aimed at developing and validating a predictive model to estimate live weight in sheep and goats using linear body measurements. A total of 200 animals were assessed, with data collected on live weight, body length (BL), height at withers (HW), and heart girth (HG). Multiple linear regression models were developed and evaluated. The results analyzed using SPSS v20 demonstrated a strong relationship between these morphometric traits and body weight ($R^2 = 0.85$, $p < 0.05$). Among the traits, heart girth and body length were the most consistent and significant predictors of body weight. The study presents a practical, cost-effective tool for farmers, extension workers, and animal scientists for rapid estimation of live weight in field conditions, thereby reducing dependence on conventional weighing equipment and improvement livestock management decisions.

Keywords: Body weight, linear body measurements, Predictive model, Sheep, Goat, Regression analysis, Morphometric traits

DESCRIPTION OF PROBLEM
Small ruminants such as sheep and goats are vital components of the agricultural economy in Nigeria, contributing significantly to food security, income generation, and rural livelihoods. Nigeria hosts approximately 73.8 million goats and 42.1 million sheep, highlighting their importance to livestock production (1). However, in rural farming systems, weighing animals is a major challenge due to the unavailability of weighing scales, inadequate infrastructure, and limited technical knowledge (2). Estimating body weight through linear body measurements offers a viable alternative (3). This study addresses the need for an accurate, non-invasive, and cost-effective method for predicting body weight using measurable anatomical traits.

MATERIALS AND METHODS
Study location
The study was conducted at the Maiduguri Main Abattoir, Borno State, Nigeria, located at latitude 11.51°N, longitude 30.05°E, with an altitude of 354 meters above sea level. The region lies within the Sahelian ecological zone characterized by arid conditions, a short rainy season (July-September), and average annual rainfall of 645.9 mm (4).

Sample size and sampling technique
A total of 400 small ruminants (200 sheep and 200 goats) of various breeds, ages, and sexes were randomly selected. The animals were sourced from multiple regions within the state and represented commonly raised breeds.

Data collection
Four primary parameters were measured: Body weight was measured using a weighing scale in kilogram (kg) whereas the linear body traits were measured using a tailor’s measuring tape in (cm) and was repeated thrice for accuracy.

- Body Weight (BW): Measured using a weighing scale via the difference method (human-animal subtraction technique).

- Body Length (BL): Measured from the point of the shoulder to the base of the tail.
- Height at Withers (HW): Vertical distance from the highest point of the shoulder to the ground.
- Heart Girth (HG): Circumference of the chest behind the forelimbs.

Statistical analysis

Data were analyzed using SPSS v20. Descriptive statistics and Analysis of Variance (ANOVA) were conducted. Least significant difference (LSD) was used for mean comparism. Regression analysis was applied to evaluate the relationship between body weight and morphometric traits. The model used: $Y_{ijkl} = \mu + A_i + B_j + D_k + E_{ijkl}$ Where: Y_{ijkl} = Observed value μ = Overall mean A_i = Effect of age, B_j = Effect of sex, D_k = Effect of species, E_{ijkl} = Random error

RESULTS AND DISCUSSION

Influence of Genetic and Non-Genetic Factors

Breeds showed significant variation (P < 0.01) in body traits (Table 1). Balami and Uda breeds exhibited higher body weight (indicate the values here) and measurements than others, suggesting superior growth potential, possibly linked to better skeletal development and muscle conformation. Breed differences in body composition can be explained by genetic makeup and adaptation to specific environmental conditions, which affect growth performance and development.

Sex also had a significant (P < 0.01) impact on body weight and morphometric traits. This portrayed sexual dimorphism. Male animals consistently exhibited higher values across all parameters than females, which is attributed to hormonal influences such as testosterone that promote muscle development and overall larger body size. The expression of secondary sexual characteristics in males further supports greater linear dimensions, especially in body length and heart girth.

Age showed a progressive increase in body weight and size measurements, indicating that these parameters grow in tandem with the physiological maturity of the animal. Younger animals had lower values compared to older ones due to bone and muscle development over time. The impact of age is crucial, as it determines the optimal time for weight estimation using linear traits, particularly for production and market readiness.

Table 1: Means and Standard Errors of Means of Body Weight and Some Linear Measurements as affected by genetic factors of seep and goat

FACTORS	BW	BL	HW	HG
Overall Means	29.29±0.51	25.77±0.24	27.78±0.53	27.50±0.24
Breeds	**	**	*	**
Balami	40.33±1.32^a	30.56±0.44^a	31.68±0.36^a	32.10±0.46^a
Borno white	23.51±0.83^d	22.30±0.26^c	24.33±0.64^b	24.13±0.30^c
Maradi	25.50±0.57^d	22.36±0.38^c	23.43±0.57^b	24.77±0.57^c
Sahel	23.28±0.72^d	22.09±0.45^c	23.60±0.29^b	24.17±0.32^c
Sokoto	19.76±0.77^e	22.07±0.36^c	28.78±4.79^a	23.88±0.34^c
Uda	36.69±0.97^b	30.36±0.35^a	31.36±0.31^a	32.09±0.36^a
Yankasa	30.60±0.83^c	27.40±0.46^b	29.18±0.50^a	28.53±0.54^b
Sex	*	*	*	*
Male	32.98±0.76^a	26.83±0.37^a	29.24±1.04^a	28.68±0.36^a
Female	25.80±0.60^b	24.77±0.29^b	26.39±0.29^b	26.39±0.29^b
Age	***	**	ns	***
2	28.21±0.91^b	25.43±0.40^b	26.85±0.40	26.94±0.41^b
4	28.85±1.06^b	25.41±0.54^b	26.80±0.48	27.14±0.50^b
6	31.45±0.96^a	26.34±0.42^a	29.56±1.56	28.28±0.41^a
8	27.46±1.13^b	25.78±0.58^{ab}	27.30±0.55	27.43±0.63^b

^{a,b,c,d} Means within the same columns with different superscript are significant at * = P<0.05, ** = P<0.01, and ns non-significant. BW = Body Weight, BL = Body Length, HW = Height at winter and HG = Heart Girth.

Regression equations were derived to predict body weight based on BL, HW, and HG. Among these, HG and BL had the highest predictive power (R^2 = 0.67 - 0.71), especially at 8 months of age (Table 2). This implies that animals at this stage possess the most consistent and measurable conformation traits suitable for accurate prediction models. The regression models revealed that body measurements could explain a significant proportion of the variation in body weight. Heart girth showed the highest correlation with body weight. This may likely due to the fact that it encompasses the thoracic cavity which holds vital organs and reflects the animal's capacity for feed intake and overall condition. Body length followed closely, indicating structural growth that aligns with weight.

These results align with earlier research by Yakubu (5), Tadesse *et al.* (6), Mokoena *et al.* (7), and reinforcing the reliability of morphometric predictors. The variability in prediction accuracy across age and breed groups. This however, suggests that more refined, breed-specific models could further improve predictive accuracy. Furthermore, prediction accuracy might be influenced by management practices, nutritional status, and health conditions of the animals. Hence, predictive models should ideally be validated under varying conditions and among different production systems to ensure broader applicability.

This study underscores the practical significance of using simple, non-invasive measurements in livestock systems where resources are limited. For instance, smallholder farmers can utilize measuring tapes to determine heart girth and body length, which can then be applied to established regression models to estimate body weight. This enables timely decisions related to sales, dosing of medications, breeding selection, and feed rationing, all of which are critical for enhancing productivity and profitability in small ruminant farming.

Table 2: Regression equation for prediction of body weight from linear body measurements of sheep and goat at different age

Age	Variables	Regression	R^2	SEM	Significant
2	BL	BW = - 19.61 + 1.88	0.66	5.39	*
4		BW = - 10.31 +1.54	0.61	6.93	*
6		BW = - 18.79 + 1.91	0.70	6.02	*
8		BW = - 15.10 + 1.65	0.71	4.99	*
2	HW	BW = - 12.15 + 1.50	0.44	6.98	**
4		BW = - 17.64 + 1.73	0.63	6.81	*
6		BW = 28.28 + 0.09	0.021	10.87	ns
8		BW = - 19.47 + 1.72	0.69	5.18	*
2	HG	BW = - 20.63 + 1.81	0.65	5.52	*
4		BW = - 17.14 + 1.69	0.64	6.68	*
6		BW = - 22.10 + 1.89	0.65	6.53	*
8		BW = - 12.54 + 1.46	0.67	5.35	*

Significant at * = P<0.05, ** = P<0.01 and ns non-significant. BW = Body Weight, BL = Body Length, HW = Height at winter and HG = Heart Girth.

CONCLUSIONS AND APPLICATIONS

- The study confirmed that breed, sex, and age significantly influence body weight and linear measurements in sheep and goats.
- Linear body measurements, especially heart girth and body length, were reliable predictors of body weight.
- Predictive models offered a simple, low-cost method for live weight

estimation, particularly useful in field and resource-limited settings.

- Further studies are recommended to validate these models across larger populations and diverse agro-ecological zones.
- Incorporating additional parameters such as body condition score or breed-specific calibrations could enhance model precision.

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