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Prediction of Live Weight and Carcass Characteristics from Linear Body Measurements of Yearling Male Local Sheep

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ABSTRACT

Measurements of the body structure in sheep are worthy of judging the quantitative features of meat and useful in developing appropriate selection requirements. The current study was aimed to predict live weight and hot carcass weight from linear body measurements of yearling male local sheep. 84 days feeding period fortnightly taken data on 24 local sheep for body weight, body length, heart girth, wither height, sub-sternal height, tail length, tail width, scrotal circumference, and scrotal length were analyzed to study the relationship between linear body measurements and body weight. At the end of the trial all sheep were slaughtered to measure the relationship between body measurements, and hot carcass weight. Microsoft Excel 2010 was used for data analysis. The relationships between the various body measurements were calculated using pearson's correlation coefficient. The backward stepwise multiple regression procedure was used for the determination of the most suitable model for the prediction of the live weight and hot carcass weight. Hot carcass weight was highly correlated ($P<0.01$) with body weight and scrotal circumference. Besides, it was significantly ($P<0.05$) correlated with tail width. Body weight was significantly ($P<0.05$) correlated with all body measurements except tail length and scrotal length. It is concluded that the body weight of the local sheep can be predicted with heart girth, sub-sternal height and tail width; the equation is LW= -97.2 + 0.36HG + 2.1SBSH + 0.57TW with a better coefficient of determination; $R^2 = 0.55$ and the hot carcass weight can be predicted with sub-sternal height and tail width; the equation is HCW= -75.66 + 1.75SBSH + 0.85TW with a coefficient of determination; $R^2 = 0.33$. But, hot carcass can be predicted with body weight, the equation is HCW= -9.39+0.85BWT when weighing scales are affordable with a better coefficient of determination; $R^2= 0.557$.

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Introduction

Sheep meat production is vital to meet the protein needs of the consumers all over the globe. Most scientific studies concerning growth, one of the critical characteristics of sheep production have been conducted to raise meat production per sheep. Monitoring the development of sheep and estimation of genetic correlation between body weight and body measurements require evidence of body weight with related body measurements (Mohammad et al., 2012).

Body weight is a paramount trait in meat animals due to its direct implication for profit (Cam et al., 2010). Body measurements are significant in terms of manifesting the breed information (Riva et al., 2004; Verma et al., 2019) and necessary in providing data about the anatomy and physical performance of the breed. Measurements of various morphological structures are valuable in determining the quantitative traits of meat and are also essential in establishing suitable selection criteria (Sharaby & Suleiman, 2013; Islam et al., 1991).

The physical performance of animals can be showed by linear body measurements (Goe et al., 2001; Attah et al., 2004) and are also important in estimating body weight and carcass traits (Atta & El Khidir, 2004; Thiruvenkadan, 2005). Besides, body weight estimation is required for deciding the appropriate medicinal prescription, feed amount, and selling of the animals (Eyduran et al., 2013).

Body weight is rarely measured by the owners in rural areas due to inaccessibility of weighing scales and difficulty of weighing in field conditions, even though it is a requisite in economic feasibility decisions. As a result, marketing of animals is mostly carried out by negotiation based on their physical look, visual judgment, and loin-eye-area palpation which is biased (Grum et al., 2012) and technically imprecise (Otoikhian et al., 2008).

Many research works have been reported on the prediction of body weight and carcass characteristics based on linear body measurements. However, breed, gender, birth type, dam age at lambing, and management system affect body weight (Yilmaz et al., 2012).

Hence the present study is carried out to establish the relationship between live body weight and hot carcass weight with some linear body measurements in local sheep as a step towards establishing a prediction equation to estimate the live body weight and hot carcass weight of sheep under field conditions without using a weighing scale.

Materials and Methods

Description of the Study Area

The study was conducted at Habru district Sirinka Agricultural Research Center, breed evaluation and distribution site in the eastern Amhara region of Ethiopia. The site is located about 508 km northeast of Addis Ababa at the geographical location between 11°45'0.42"N latitude and 39°36'52.21"E longitude. The map of the study area was presented in Figure 2.

The center is situated at an elevation of 1850 meters above sea level; a bi-modal type of rainfall receiving a mean annual rainfall of about 950 mm. Habru is one of the thirteen districts in the North Wollo zone. It is situated at an altitude ranging from 1200-2350 m.a.s.l at 11°35'N latitude and 39° 38'E longitude. Its mean annual maximum and minimum temperatures were 28.5 °C and 15 °C, respectively. Whereas, the mean annual rainfall of the district varied from 750 to 1000 mm (Mohammed et al., 2014).

Ethical Approval Certificate

This experiment was approved by Amhara Agricultural Research Institute research review forum and decision was obtained from Sirinka Agricultural Research Center for the study using live animals and before slaughtered sheep was used for the experiment with decision number 495/0020/2024 and date 22/01/2024.

Data Collection Methods

Twenty-four yearling intact local sheep with a mean initial body weight of 23.9 ± 1.9kg were purchased from a local market and housed in individual pens with raised slatted floors.

The animals were examined for their linear body measurements and the exact points at which the body measurements were taken [body length (F-G); height at withers (A-B); heart girth (C-D); sub-sternal height (D-E); tail length (J-K); tail width (L-M); scrotal length (H-I); scrotum circumference (N-O)] showed in Figure 1.

The experimental animals were grouped into six blocks with four male lambs in each block based on the initial body weight. Body weights and other body measurements of the animals were taken at the beginning of the trial and every fortnight during the 84 days of the feeding period. All animals were weighed in the morning hours after overnight fasting using a suspended weighing scale with a 50 kg capacity of 200 g precision and other body measurements were taken using a plastic measuring tape. At the end of the experiment all sheep were slaughtered to measure hot carcass weight. Linear body measurements that were measured and their description are mentioned in Table 1.

Data Analysis

Microsoft Excel 2010 was used to analyses the average of fortnight body measurements taken during 84 days of the feeding period. The relationships between the various body measurements were calculated using pearson's correlation coefficient. The backward stepwise multiple regression procedure was used for the determination of the most suitable model in the prediction of the live weight and hot carcass weight using various body measurements and this enabled to establish regression equations. In the analysis process, both body weight and hot carcass weight were considered as dependent variables. In addition, body weight was considered as independent variable to predict hot carcass weight in the presence of weighing scales or following live weight estimation.

The model for the analysis of multiple linear regressions was:

$$Yi = Bo + \beta 1x1 + \beta 2x2 + \beta 3x3 + \beta 4x4 + \beta 5x5 + \beta 6x6 + \beta 7x7 + \beta 8x8 + ei$$

Where:

Yi = the response variable; body weight and hot carcass weight

Bo = the intercept

x1, x2, x3,..., and x8 are the explanatory variables body length, heart girth, wither height, sub-sternal height, tail length, tail width, scrotal circumference and scrotal length, respectively

β1, β2, β3.. and β8 are regression coefficient of the variables x1, x2, x3... x8

ei = the residual random error.

NB: Body weight will be explanatory variable to predict hot carcass weight in the presence of weighing scale or following live weight estimation. But, it will be dependent variable in the absence of weighing scales. As a result, the multiple regression model will be adjusted in accordance with the predictive explanatory factors.

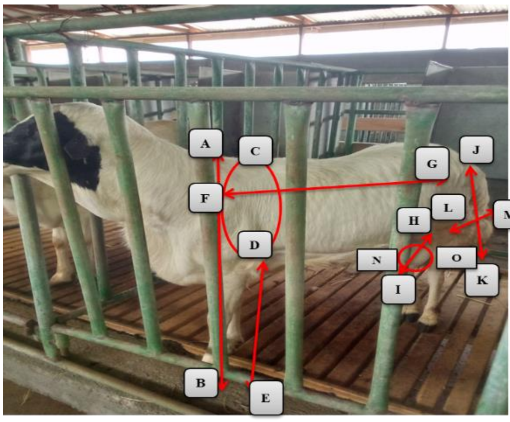

Figure 1. Displaying the exact locations of the body measures of yearling local male sheep

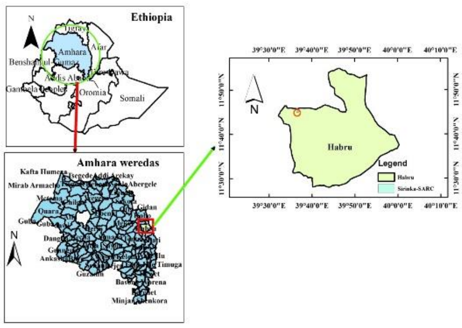

Figure 2. The Map of Study Area

Table 1. Linear body measurements measured in the experiments

Parameters	Descriptions
Body length (F-G)	Distance from the anterior shoulder point to the posterior extremity of the pin bone (cm)
Height at withers (A-B)	Vertical distance from the highest point of the shoulder (withers) to the ground surface at the level of the forelegs (cm)
Heart girth (C-D)	The body circumference at a point immediately posterior to the front leg and shoulder and perpendicular to the body axis (cm)
Sub-sternal height (D-E)	The height from the ground to the underside of the front body (cm)
Tail length (J-K)	Distance from the base to the tip of tail (cm).
Tail width (L-M)	Diameter at the midst of tail (cm)
Scrotal length (H-I)	Distance from the base to the tip of scrotum (cm)
Scrotal circumference (N-O)	Circumference at midst point of scrotum (cm)

cm: centimeter

Table 2. Pearson correlation coefficients between hot carcass weight and other linear body measurements

Variables	HCW	BWT	BL	HG	WH	SBSH	TL	TW	SC	SL
HCW										
BWT	0.759^{**}									
BL	0.367^{ns}	0.447*								
HG	0.285^{ns}	0.430*	0.196^{ns}							
WH	0.388^{ns}	0.515*	0.742**	0.273^{ns}						
SBSH	0.306^{ns}	0.412*	0.457*	-0.249^{ns}	0.601**					
TL	0.063^{ns}	0.130^{ns}	0.080^{ns}	0.140^{ns}	0.058^{ns}	-0.137^{ns}				
TW	0.429^{*}	0.409*	0.025^{ns}	0.440*	0.145^{ns}	-0.303^{ns}	0.397^{ns}			
SC	0.547^{**}	0.459*	0.208^{ns}	-0.055^{ns}	0.420*	0.420*	0.217^{ns}	0.242^{ns}		
SL	0.379^{ns}	0.199^{ns}	0.331^{ns}	-0.040^{ns}	0.535**	0.437*	0.143^{ns}	0.096^{ns}	0.507*	

ns= non significant, *= significant, **= highly significant, HCW= hot carcass weight, BW= body weight, BL= body length, HG= heart girth, WH= wither height, SBSH=sub-sternal height; TL= tail length, TW= tail width, SC= scrotal circumference, SL=scrotal length

Table 3. Prediction of body weight from linear body measurements in yearling male local sheep

Eq. No	Prediction equations	Adj. R^2
1	BW= -99.84 + 0.27BL + 0.4HG - 0.26WH + 2.11SBSH - 0.09TL + 0.54TW + 0.34SC - 0.38SL	0.52
2	BW= -101.85 + 0.26BL + 0.4HG - 0.25WH + 2.13SBSH + 0.52TW + 0.33SC - 0.39SL	0.55
3	BW= -92.7 + 0.14BL + 0.35HG + 1.82SBSH + 0.49TW + 0.31SC - 0.49SL	0.56
4	BW= -96.76 + 0.38HG + 2.04SBSH + 0.5TW + 0.3SC - 0.45SL	0.57
5	BW= -90.54 + 0.38HG + 1.81SBSH + 0.47TW + 0.21SC	0.55
6	BW= -97.2 + 0.36HG + 2.1SBSH + 0.57TW	0.55

BW= body weight, BL= body length, HG= heart girth, WH= wither height, SBSH=sub-sternal height; TL= tail length, TW= tail width, SC= scrotal circumference, SL=scrotal length and R^2= coefficient of determination

Result and Discussion

Body Measurements, Body Weight and Hot Carcass Weight Relationships

The pearson correlation coefficients between hot carcass weight and other linear body measurements are described in Table 2.

Hot carcass weight was highly correlated ($P<0.01$) with body weight and scrotal circumference. Besides, it was significantly ($P<0.05$) correlated with tail width. Body weight was significantly ($P<0.05$) correlated with all body measurements except tail length and scrotal length. The high correlation would imply measurements can be used as an indirect selection trait to advance body weight or could be used to estimate body weight (Ra et al., 2018), (Fasae et al., 2005) and (Gebremichael, 2008). The high correlation coefficients between live weight and body measurements suggest that either of these variables or their combination could provide a good prediction for estimating body weight of local sheep.

Prediction of Body Weight and Hot Carcass Weight from Linear Body Measurements

Prediction of Body Weight from Linear Body Measurements

Several regression equations were constructed using a backward stepwise regression procedure for the prediction of live weight from linear body measurements in Table 3.

When all the body measurements were included in the prediction equation the accuracy of the prediction was 0.52 (Eq. No.1). The results indicated that as all linear body measurements were included in the prediction equation a lesser coefficient of determination (R^2) was obtained. However, the body weight of the sheep can be predicted with only HG, SBSH and TW; the equation is LW= -97.2 + 0.36HG + 2.1SBSH + 0.57TW with better coefficient of determination, R^2 = 0.55. The same accuracy of prediction was obtained by incorporating seven and four traits (Eq. No. 2 and 5).

Table 4. Prediction of hot carcass weight from linear body measurements in Yearling male Local sheep (in absence of weighing scales)

Eq. No	Prediction equations	Adj. R^2
1	HCW= -78.78 + 0.46BL + 0.31HG -0.6WH + 1.43SBSH - 0.48TL + 0.67TW + 0.55SC + 0.37SL	0.39
2	HCW= -80.05 + 0.44BL + 0.29HG - 0.5WH + 1.46SBSH - 0.45TL + 0.67TW + 0.6SC	0.41
3	HCW= -90.16 + 0.4BL + 0.29HG - 0.48WH + 1.57SBSH + 0.57TW + 0.56SC	0.40
4	HCW= -70.45 + 0.16BL + 0.19HG + 0.9SBSH + 0.49TW + 0.48SC	0.38
5	HCW= -75.78 + 0.23HG + 1.18SBSH + 0.5TW + 0.48SC	0.39
6	HCW= -58.6 + 1.14SBSH + 0.66TW + 0.43SC	0.38
7	HCW= -75.66 + 1.75SBSH + 0.85TW	0.33

HCW= hot carcass weight, BL= body length, HG= heart girth, WH= wither height, SBSH=sub-sternal height; TL= tail length, TW= tail width, SC= scrotal circumference, SL=scrotal length and R^2= coefficient of determination

Table 5. Prediction of hot carcass weight from linear body measurements after live weight estimation or when weighing scale is available

Eq. No	Prediction equations	Adj. R^2
1	HCW=-10.93+0.68BWT+0.28BL+0.04HG-0.43WH+0.003SBSH-0.42TL+0.3TW+0.32SC+0.63SL	0.541
2	HCW=-10.81+0.68BWT+0.28BL+0.04HG-0.43WH-0.42TL+0.3TW+0.3SC+0.63SL	0.571
3	HCW=-8.86+0.7BWT+0.28BL-0.41WH-0.42TL+0.32TW+0.3SC+0.62SL	0.597
4	HCW=-5.84+0.75BWT-0.22WH-0.36TL+0.26TW+0.25SC+0.61SL	0.592
5	HCW=-4.65+0.82BWT-0.22WH-0.32TL+0.27TW+0.79SL	0.591
6	HCW=-9.72+0.82BWT-0.21WH+0.18TW+0.74SL	0.592
7	HCW=-6.19+0.89BWT-0.23WH+0.76SL	0.598
8	HCW=-15.51+0.79BWT+0.56SL	0.595
9	HCW=-9.39+0.85BWT	0.557

HCW= hot carcass weight, BWT= body weight, BL= body length, HG= heart girth, WH= wither height, SBSH=sub-sternal height; TL= tail length, TW= tail width, SC= scrotal circumference, SL=scrotal length and R^2= coefficient of determination

It was observed that the heart girth, sub-sternal height, and tail width were useful and trustworthy traits in body weight prediction for sheep. Heart girth as an important indicator of live weight was also reported by Atta & El Khidir (2004) in Nilotic sheep, Kumar et al. (2017) in Harnali sheep, Cam et al. (2010) in Karayaka, Tadesse and Gebremariam (2010) in Highland, Musa et al. (2012) in Sudanese Shogun , and Ravimurugan et al. (2013) in Kilakarsal sheep.

The estimation of live body weight based on heart girth augmented the coefficient of determination similar to that reported by Atta & El Khidir (2004), Johanson & Hildman (1954), and El-Khidir (1980). Lawrence & Fowler (1997) observed that skeletal measurements (wither height and body length) were less variable to estimate body weight compared to heart girth in agreement with this study.

Prediction of Hot Carcass Weight from Linear Body Measurements

Several regression equations were constructed using a backward stepwise regression procedure for the prediction of hot carcass weight from linear body measurements in Table 4.

When all the body measurements were included in the prediction equation the accuracy of prediction was 0.39 (Eq. No.1). The results indicated that as all linear body measurements were included in the prediction equation a better coefficient of determination (R^2) was obtained. However, the hot carcass weight of the local sheep can be predicted with only SBSH and TW; the equation is HCW= -75.66 + 1.75SBSH + 0.85TW with the coefficient of determination; R^2 = 0.33. The better accuracy of the prediction was obtained by incorporating other body measurements in addition to sub-sternal height and tail width.

In addition, alternative regression equations were constructed to predict hot carcass weight when weighing scales are available or following live weight estimation (Table 5). The results indicated that as all linear body measurements were included in the prediction equation a lesser coefficient of determination; R^2= 0.541 was obtained. Therefore, the alternative hot carcass weight prediction model can be with body weight; the equation is HCW= -9.39 + 0.85BWT with a better coefficient of determination; R^2 = 0.557. The better accuracy of the prediction was obtained by incorporating other body measurements in addition to body weight.

Table 6 shows the differences obtained between measured and estimated live weight and hot carcass weight (kg) with prediction equations of LW= -97.2 + 0.36HG + 2.1SBSH + 0.57TW; HCW= -75.66 + 1.75SBSH + 0.85TW and/or HCW= -9.39 + 0.85BWT. This result indicates that a maximum of 3kg difference from measured and predicted live weight and a maximum of 3.2kg difference from actual and predicted hot carcass weight were obtained in the absence of weighing scales. Whereas, a maximum of 3.6kg difference from actual and predicted hot carcass weight was obtained in the presence of weighing scales.

Table 6. The actual and predicted live weight and hot carcass weight of experimental animals

S.No	MLW	PLW	D	MHCW	PHCW-1	D	PHCW-2	D
1	26.5	26.9	0.4	11.9	12.6	0.7	13.1	1.2
2	27.9	26.7	1.2	12.9	14.1	1.2	14.3	1.4
3	23.7	26.7	3.0	10.8	13.9	3.1	10.8	0.0
4	24.9	25.0	0.1	12.0	12.0	0.0	11.8	0.2
5	25.7	26.0	0.4	11.2	12.4	1.2	12.4	1.2
6	30.3	28.0	2.3	14.6	14.1	0.5	16.3	1.7
7	26.2	25.8	0.3	12.1	13.0	0.9	12.8	0.7
8	27.1	27.5	0.4	11.2	13.3	2.1	13.7	2.5
9	27.7	28.1	0.4	13.8	15.4	1.6	14.2	0.4
10	25.7	24.3	1.4	12.0	11.0	1.0	12.4	0.4
11	28.0	27.2	0.8	13.0	13.9	0.9	14.4	1.4
12	25.2	25.5	0.4	12.0	12.9	0.9	12.0	0.0
13	25.0	27.0	2.0	12.2	13.5	1.3	11.8	0.4
14	26.8	27.0	0.2	12.8	14.7	1.9	13.4	0.6
15	27.7	26.2	1.5	14.0	12.7	1.3	14.2	0.2
16	27.4	28.3	0.8	13.6	13.3	0.3	13.9	0.3
17	25.0	25.8	0.8	11.2	12.8	1.6	11.9	0.7
18	28.6	30.2	1.6	13.6	16.3	2.7	14.9	1.3
19	28.6	27.2	1.4	15.8	13.7	2.1	14.9	0.9
20	23.8	24.8	1.0	14.4	12.1	2.3	10.8	3.6
21	28.0	27.7	0.4	16.0	15.0	1.0	14.4	1.6
22	27.0	27.7	0.7	13.8	12.8	1.0	13.5	0.3
23	30.1	29.8	0.3	18.8	16.3	2.5	16.2	2.6
24	31.1	29.9	1.3	19.0	15.8	3.2	17.0	2.0

HCW= Hot carcass weight; MLW: Measured live weight; PLW: Predicted live weight; D: Difference; MHCW: Measured HCW; PHCW-1: Predicted HCW (absence weighing scales); PHCW-2: Predicted HCW (presence weighing scales)

Conclusion

It is concluded that live weight of sheep can be predicted with heart girth, sub-sternal height and tail width under field conditions. Hot carcass can be predicted with the sub-sternal height and tail width of the animals in the absence of weighing scales. But, hot carcass weight can be predicted with body weight when weighing scales are affordable and after live weight estimation using prediction equations. This prediction method could be used for various purposes such as record keeping, estimating sheep's economic value, selection and genetic resource conservation. This result demonstrates that the same research efforts need to be undertaken with large sample size and incorporating other important morphological traits.

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Conflict of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

Data Availability

Data used to support the findings of this study are available from the corresponding author upon request.

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