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Application of Body Measurements of Blackhead Somali Sheep as Parameters for Estimation of Live Weight

Research Article

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ABSTRACT

Sheep and goat have a great role in the economy of the pastoral communities which have inhabited in the lowland parts Ethiopia. The study was conducted in Borana low land southern Ethiopia to predict the body weight of blackhead Somali (BHS) sheep using linear body measurements under farm condition. A total of 478 heads (301 female and 177 males) were measured for linear body measurements and body weight. Data obtained on withers height (WH), chest girth (CG), body length (BL), chest depth (CD), pelvic width (PW), cannon bone circumference (CC), tail circumference (TC), scrotal circumference for male (SC) and body weight (BW) were fitted into linear, and multiple regression models to predict live weight from the body measurements. The animals were categorized into two groups as males and females; and four age groups, based on the pair of permanent incisor (PPI), as 0 PPI, 1 PPI, 2 PPI and 3 PPI. The result showed that, live body weight of BHS sheep breed obtained in the present study was lower comparing with the recommended body weight of 30 kg at yearling age. Based on stepwise regression procedure, CD, CG, WH and TC for females and CG, CD, CC, BL and WH for males were better for predicting live weight in multiple linear regression models. The magnitude of correlation coefficient (r) indicated that CG had the highest correlation with live weight (r=0.90 for males) and (r=89 for females). Hence, the study concluded that body weight prediction from chest girth alone or in combination with other body measurements would be a practical option under field conditions with reasonable accuracy.

KEY WORDS blackhead Somali sheep, body measurements, live weight, regression equations.

INTRODUCTION

The broad genetic variability of African small ruminant breeds enables them to survive under stressful environmental conditions, including high disease incidence, poor nutrition, and high temperature. Environmental pressure also maintains a wide range of genotypes, each adapted to a specific set of circumstances (Getachew *et al.* 2010). Ethiopia is home for an estimated 29.33 million of sheep (CSA, 2015) and about 14 traditional sheep populations (Gizaw, 2011). Diverse indigenous sheep breeds are found distributed across diverse ecology, production systems and communities or ethnic groups (Solomon *et al.* 2005). Among indigenous sheep breeds, Blackhead Somali (BHS) sheep breed is the most promising for its better adaptability under low input extensive production systems in its production environment in arid and semi-arid, where scarcity of feed and water are the two major constraints (Wendimu *et al.* 2016). Blackhead Somali Sheep is a widely distributed sheep breed throughout the arid and semiarid areas in the south eastern parts of Ethiopia, including the Borana lowland.

Knowledge of weight estimation in sheep production has a notable importance as it is useful in the control and management of the herd during the entire rearing process. In the area where there is a shortage of weighing scale measurement of linear body parameters would play a crucial role to estimate live body weight of livestock (Hamito, 2009).

Hamito (2009) documented that measurement of linear body parameters have been used to estimate necessary information (like weight and size) in sheep, while other information are estimated by observing certain parameters such as age estimation from the number and shape of teeth (incisors).

Previous studies documented the importance of body measurements to estimate animals' live body weight in a situation where weighbridges are not available (Edea, 2008; Hamito, 2009; Getachew *et al.* 2010). Therefore, the present study was aimed to develop regression equations for estimating live weight of BHS sheep from body measurements for the purpose of breed characterization and selection for genetic improvement.

MATERIALS AND METHODS

Description of the experiment area

Animals used for live weight and body measurements were sampled among the smallholder pastoral and agro-pastoral community of Borana low land mainly in habited by Borana Oromo, southern Ethiopia. The location falls within between 3 ˚36-6 ˚38'North latitude and 3 ˚43'- 39 ˚30'East longitude.

The rainfall pattern is highly erratic, spatial and shows temporal variability in quantity and distribution (AFD, 2010). The average rainfall varies from 300 mm to 900 mm annually (Kamara *et al.* 2004) and it has bimodal pattern of rainfall with mean annual temperature 19 ˚C (AFD, 2010). The Borana production system is a pastoral/agro-pastoral system (Desta and Coppock, 2002; Angassa and Oba, 2007), which has been adapted to the variation of the changing seasons, climate variability and spatiotemporal heterogeneity of forage production (Desta and Coppock, 2004; Angassa and Oba, 2007). Livestock production is the main livelihood of the people, with increasing engagement in crop production and other livelihood strategies.

Data collection methods

A total of 478 BHS Sheep (301 female and 177 male) were examined based on the format adopted from the standard description list developed by FAO (2011) and of international livestock research institute (ILRI) breed descriptor list (Ayalew *et al.* 2004).

The traits considered were: body length (BL), wither height (WH), pelvis width (PW), chest girth (CG), tail length (TL), tail circumference (TC), ear length (EL), scrotal circumference (SC), for males and fore cannon bone circumference (CC).

Body measurements were made by using measuring tape, while body weight (BW) was measured using portable weighing scale (Table 1). Age and sex were considered as independent variables that could substantially determine these body traits.

Ages of the animals were estimated by dentitions and information acquired from sheep owners. Accordingly, the sampled sheep population were classified into 4 age groups based on the pair of permanent incisor (PPI), namely 0PPI, 1PPI, 2PPI, and ≥ 3PPI to represent age less than 15 months, 15.5 to 22 months, 22.5 to 27 months and above 39 months respectively, based on Wilson and Durkin (1983) for African sheep breeds.

The animals were measured in their standing position under field conditions using plastic measuring tape and measuring stick and at the same time the body weight was taken using a 50 kg size spring balance early in the morning. All measured male animals were intact. Male and female animals were measured separately. The following linear body measurements were taken according to the procedures of Hamito (2009).

Statistical analysis

Correlations (Pearson's correlation coefficient) among body measurements under consideration were computed for males and females. The stepwise regression procedure of SAS (2009) was used to determine the relative importance of live-animal body measurements in a model designed to predict BW. Live weight was regressed on the body measurements separately for both sexes. Due to inadequate sample size of males in each dentition classes, dentition 3 and 4 were pooled together. Similarly, in female dentition 3, 4 and 5 were pooled. The choice of the best fitted regression model was assessed by using coefficient of determination (R^2).

$$Y_j = \alpha + \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + e_j$$

Where:

Y_j: dependent variable body weight.

α: intercept.

X_1, X_2, X_3 and X_4: independent variable CG, CD, WH, and TC respectively were body measurement best fitted the model accounting for 82% of the variation.

β_1, β_2, β_3 and β_4: regression coefficient of the variables X_1, X_2, X_3, and X_4.

e_j: residual error.

Multiple linear regression models for males

$$Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + ej$$

Where:
Y_j: dependent variable body weight.
α: intercept.
X_1, X_2, X_3, X_4, X_5 and X_6: independent variable CG, BL, CD, CC and WH, respectively, were LBMs that best fitted the model contributing about 85% of the variation in live body weight.
β_1, β_2, β_3, β_4, β_5, and β_6: regression coefficient of the variables X_1, X_2, X_3, X_4, X_5, and X_6.
e_j: residual error.

RESULTS AND DISCUSSION

Body weight and linear body measurements

The live body weight and body measurements are presented in Table 2.

BW, WH, CG and CG of 26.57 kg, 58.94 cm. 28.47 cm and 66.37 cm were reported for the overall sample (females and males). As compared to indigenous sheep breeds, the BHS sheep adult breeding females had higher body weight than Afar and Menth sheep (Tesfaye, 2008) and lower body weight than Horro and Bonga sheep breed (Edea, 2008).

The value obtained for BL, CG and WH was higher than Afar and Menth and lower than Horro and Bonga sheep. The present study also indicated that males BHS sheep had BW, CG, WH and BL of 26.76, 68.55, 59.13 and 64.86, respectively.

This showed that BHS sheep was superior than Afar and Menz sheep and it was lower than Horro and Bonga sheep breeds. The higher body weight in female than male noted in this study could be explained by the hormonal difference and different growth trends of the two sexes.

Table 1 Body measurements for estimating the live Blackhead Somali weight

Quantitative measurements	Description
Body weight (BW)	Live body weight (kg)
Body length (BL)	Measured as the horizontal distance from the point of shoulder to the base of the tail
Chest girth (CG)	The circumference of the body immediately behind the shoulder blades in a vertical plane perpendicular to the long axis of the body
Wither height (WH)	The height of an animal from the bottom of the front foot to the highest point of the shoulder between the withers
Chest depth (CD)	Measures the distance from the backbone at the shoulder to the brisket between the front legs
Ear length (EL)	The length of the ear of the external side from its root on the poll to the tip
Pelvic width (PW)	The distance between pelvic bones across the dorsum
Cannon circumference (CC)	The circumference of fore limb (cm)
Scrotum circumference (SC)	Pushing the testicles to the bottom of the scrotum and the greatest circumference measured
Tail circumference (TC)	Circumference of the base of the tail
Tail length (TL)	Distance from the base to the tip of the tail on the outer side of the tail

Table 2 Mean (±SD) for body weight (kg) and linear body measurements (cm) for blackhead Somali sheep breed of Borana Zone, southern Ethiopia

Age	Sex	BW (kg)	CG (cm)	WH (cm)	BL (cm)	CD (cm)	CC (cm)	PW (cm)	TC (cm)
	F and M	26.57±4.5	68.95±4.46	58.94±3.74	66.37±5.31	28.47±2.53	6.67±0.44	17.92±3.18	45.83±10.5
Overall	F	26.92±0.31	69.45±0.32	58.82±0.24	66.66±0.38	28.17±0.16	6.62±0.03	17.82±0.23	43.7±0.75
	M	26.76±0.47	68.55±0.65	59.13±33	64.86±0.76	29.48±0.26	6.77±0.06	17.76±0.33	53.79±1.1
	F	22.81±0.8	65.22±0.79	55.94±0.64	60.75±1.5	26.59±0.45	6.39±0.08	14.75±0.56	42.31±1.83
0PPI	M	21.09±0.43	63.29±0.43	56.57±0.35	62.44±0.51	27.15±0.14	6.55±0.04	16.65±0.30	47.83±1.0
	F and M	21.98±0.45	64.29±0.45	56.27±0.37	61.63±0.53	26.88±0.25	6.47±0.04	15.69±0.32	45.07±1.04
	F	26.4±1.1	68.79±0.65	59.11±0.53	65.7±0.77	27.89±0.37	6.67±0.06	17.4±0.46	43.38±1.51
1PPI	M	24.73±0.7	66.90±0.69	59.23±0.88	63.85±0.83	29.36±0.39	6.76±0.07	18.05±0.49	51.59±1.62
	F and M	25.57±0.48	67.84±0.47	59.16±0.39	64.78±0.56	28.63±0.27	6.72±0.05	17.73±0.34	47.48±1.11
	F	28.64±0.66	71.34±0.69	60.32±0.57	69.78±0.83	28.58±0.39	6.73±0.07	19.52±0.32	46.58±1.62
2PPI	M	26.87±1.1	68.88±0.11	58.94±0.91	65.44±1.4	29.31±0.63	6.69±0.11	17.38±0.80	55.13±2.62
	F and M	27.65±0.65	70.02±.64	59.78±0.53	67.74±0.76	28.97±0.36	6.72±0.06	18.7±0.46	51.35±1.5
	F	29.82±0.34	72.44±0.33	60.17±0.27	69.6±0.39	29.14±0.15	6.73±0.03	18.94±0.24	42.54±0.78
3PPI	M	34.36±1.2	75.21±1.2	62.57±0.97	67.71±1.4	32.7±0.67	7.13±0.11	18.79±0.85	60.29±2.8
	F and M	32±0.69	74.52±0.68	61.31±0.56	68.32±0.81	30.77±0.37	6.92±0.07	19.01±0.48	52.6±1.59

PPI: pair (s) of permanent incisors; SD: standard deviation; F: female; M: male; BW: body weight; CG: chest girth; WH: wither height; BL: body length; CD: chest depth; CC: cannon circumference; PW: pelvic width and TC: tail circumference.

Body weight of BHS sheep breed reported in the present study was lower to achieve recommended body weight of 30 kg at yearling age (Markos, 2006). In north western Ethiopia, body weight of 32.5 kg at 13 to 18 months age were reported for Gumuz ram (Solomon, 2008); and 33.1 kg for Washera ram and 26.1 kg for Washera ewe (Mengiste, 2008) at the age when sheep had 3 PPI, under farm management. Small body size of BHS sheep and reduced productivity in the present finding might be attributed to the fact that these could be used as means of survival in the harsh and stress full environmental situation (Silanikove, 2000; Kosgey *et al.* 2004).

Relationship between BW and linear body measurements

The correlation coefficient (r) between the BW and the linear body measurements are presented in Table 3.The high correlation of LBMs with BW would imply this fact that body measurement can be used as indirect selection criteria to improve live weight (Khan *et al.* 2006; Solomon, 2008) or could be used to predict BW (Atta and El khidir, 2004; Afolayan, 2006; Fasae *et al.* 2005). The highest correlation was observed between BW and CG (Table 3). For both sexes, CG had the highest significant correlation with BW (P<0.01). This could explain about 89% and 90% of the variation of BW in females and males, respectively. The better association of BW with CG was possibly due to relatively large contribution in body weight by heart girth which consists of bones, muscles and viscera (Thiruvenkadan, 2005).

Similarly, Afolayan (2003) reported a higher genetic correlation between BW and CG in *Bos taurus* cattle. This implies that measurement of CG could fairly be used to estimate BW in BHS sheep. In the present finding, the highest correlation of CG with BW was in agreement with other studies (Atta and El khidir, 2004; Thiruvenkadan, 2005; Afolayan, 2006; Fasae *et al.* 2005; Solomon, 2008; Wendimu *et al.* 2016). This would imply that CG is the best variable for predicting live weight than other linear body measurements.

In males, there was a positive correlation between BW and SC (Table 3), though the association of SC with BW was affected by breed, physiological status, nutrition and management (Söderquist and Hulten, 2006). This finding was in agreement with previous reports of Bonga sheep breed (Edea, 2008).

The observed highly significant correlation between BW and SC in this study suggested that selection for SC would lead to males with high potential for sperm production. According to Söderquist and Hultén (2006), males with large SC tend to sire daughters that reach puberty at an earlier age and ovulate more ova during each oestrus period. Decrease in SC resulted in increase in morphologically abnormal sperm (Söderquist and Hultén, 2006) and SC strongly correlated with age at first puberty of females, semen traits and libido (Toe *et al.* 2000). Higher heritability of SC was observed by Toe *et al.* (2000). Measurement of SC is thus an essential part of the breeding soundness evaluation (Mekasha, 2007) and selection could be based on testicular circumference (Toe *et al.* 2000).

Table 3 Coefficient of correlations[1] between body weight and linear body measurements of blackhead Somali sheep

Trait	BW	BL	CG	HW	PW	CD	CC	TC
BW	1	0.41**	0.89**	0.48**	0.39**	0.57**	0.44**	0.42**
BL	0.41**	1	0.39**	0.45**	0.55**	0.48**	0.22*	0.11*
CG	0.90**	0.41**	1	0.40**	0.35**	0.57**	0.42**	0.35**
HW	0.64**	0.39**	0.63**	1	0.71**	0.32**	0.32**	0.22**
PW	0.46**	0.48**	0.43**	0.49**	1	0.42**	0.28**	0.3**
CD	0.65**	0.39**	0.66**	0.56**	0.48**	1	0.35**	0.28**
CC	0.53**	0.24**	0.51**	0.43**	0.37**	0.43**	1	0.24**
TC	0.37	0.13*	0.33**	0.38**	0.37**	0.43**	0.33**	1
SC	0.35**	0.39**	0.37**	0.37**	0.41**	0.46**	0.29**	0.40**

[1] Coefficient of correlations above and below the diagonal are for females (n=301) and males (n=177), respectively.
BW: body weight; HG: chest girth; BL: body length; HW: height at withers; PW: pelvic width; TC: tail circumference; CD: chest depth; CC: canon circumference and SC: scrotal circumference.
** (P<0.01) and * (P<0.05).

Table 4 Regression equation for female BHS sheep

Equations	Intercept	β_1	β_2	β_3	B_4	R^2	SE
CD	-5.24±2.79	1.18±0.10	-	-	-	0.78	2.24
CD + CG	-35.41±1.95	0.20±0.07	0.82±0.03	-	-	0.8	2.14
CD + CG + WH	-41.64±2.23	0.16±0.06	0.77±0.03	0.18±0.03	-	0.81	2.08
CD + CG + WH + TC	-40.33±2.21	0.14±0.06	0.75±0.03	0.17±0.03	0.04±0.01	0.82	2.07

CD: chest depth; CG: chest girth; WH: whither height and TC: tail circumference.
SE: standard error.

Table 5 Regression equation for male BHS sheep

Equations	Intercept	β1	β2	β3	β 4	β 5	R^2	SE
CG	-40.18±2.14	1.23±0.41	-	-	-	-	0.84	2.58
CG + CD	-41.36±2.17	1.15±0.40	0.90±0.04	-	-	-	0.84	2.48
CG + BL + CD	-41.76±2.15	1.07±0.40	0.82±0.05	0.28±0.09	-	-	0.85	2.46
CG + BL + CD + HW	-42.97±2.23	1.19±0.40	0.81±0.05	0.26±0.09	0.19±0.09	-	0.85	2.44
CG + BL + CD + CC + WH	-45.44±2.71	1.12±0.40	0.78±0.06	0.26±0.09	0.18±0.09	0.72±0.45	0.85	2.43

CG: chest girth; BL: body length; CD: chest depth; CC: canon circumference and WH: wither height.
SE: standard error.

Variables such as BL and WH, which are directly related to the size and weight of the animal, displayed medium to moderate positive correlations with each other both in female and males animals.

The present results are in agreement with the findings of Firew (2008) and Wendimu *et al.* (2016). Looking at the correlation coefficients, males showed higher tendency of relationship between BW and linear body measurements compared with females.

Prediction of BW from linear body measurements

The regression equation for live body weight based on the body measurements (LBMs) are given in Tables 4 and 5. Multiple regression equations were developed for predicting BW from linear body measurements for male and female BHS sheep separately. Stepwise multiple regressions were carried out in order to get best fitted regression models.

In estimation of BW from LBMs in female and male BHS sheep four and six body measurements, respectively were considered. In females BHS sheep, four body measurements that best fitted the model were CD, CG, WH and TC accounting for 82% of the variation in live weight. In males, the LBMs that best fitted the model were CG, CD, CC, BL and WH contributing about 85% of the variation in live weight.

The findings of Firew (2008) in BHS sheep was in agreement with the present findings. Sowande and Sobola (2008) suggested the use of combination of CG, head length and width of hindquarter measurements for selection and breeding in West Africa dwarf sheep.

Despite better prediction of BW from combinations of LBMs, having these multiple variables to predict BW possess a practical problem under field settings due to the higher labor and time needed for measurement. The higher association of BW with CG in the present study relatively would have large contribution in estimating BW by CG. Measuring heart girth with tape is easy, cheap and rapid. Thus, it can be concluded that BW prediction from CG alone or in combination with other body measurements would be a practical option under the field conditions with a reasonable accuracy.

CONCLUSION

The live BW of the BHS sheep breed could be estimated based on the linear body measurements. The pattern of relationships observed in the present study indicated that for a breeder or pastoralists to have a fairly good knowledge of the live weight of BHS sheep, measurement of CG will be useful. Selection and breeding based on these body measurements could result in improved live weight in BHS sheep. Such measurements would also aid in characterizing and describing the complex relationships that contribute to the adaptation of BHS sheep to stress full arid environment and its functional efficiency.

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