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## Research Article

# Body weight had highest correlation coefficient with heart girth around the chest under the same farmers feeding conditions for Arsi Bale sheep

## Abstract

The study was conducted in Adami Tulu Jido Kombolcha and Bora districts from east Shoa zone as well as Kofele and Asasa from west Arsi zone of Oromia regional state. The objective of this study was to determine the best regression model for live weight estimation to be used by farmers without the use of weighing scale for indigenous sheep breed found in East Shoa and West Arsi zone of Oromia Regional State. Purposive and simple random sampling was employed to select the study kebeles and all the sheep for body weight and linear body measurements. Thus body weight and linear body measurements were assessed from 600 heads of sheep. Body weight of the rams and ewes varied across the age groups. Natural pasture, crop residues, crop aftermath local brewery wastes too are paramount importance. The regression analysis to predict body weight from linear measurements indicated body weight is influenced by morphometrical measurements which included body length, chest girth and the other leaner measurements. The body weight had highest correlation coefficient with heart girth (CG) around the chest ( $r > 0.80$ ) compared with other body measurements. The stepwise regression models indicated that heart girth singly accounted highest variation (more than 90%) in body weight for all animals.

## Introduction

Ethiopia has 30.69 million heads of sheep which are distributed all over agro-ecological Zones of the [1]. Arsi-Bale sheep breed is among the diverse indigenous sheep genetic resource distributed in different agro-ecologies of Ethiopia [2]. Indigenous sheep in Ethiopia play multifarious roles viz. sources of income, meat, skin, manure and coarse hairy fleece. They are also means of risk avoidance (during crop failures) especially under marginal productivity under low and erratic rainfall, severe land erosion, frost, and water logging problems [3]. Thus, sheep reared by the smallholder farmers provide support to the economic stability and compliment the crop production [4]. Sheep rearing also play an important role in cultural, social livelihoods and religious values for large and diverse human population [5]. Rearing of sheep can result in enhancement of farm family nutrition by enhancement in productivity at the farm. The low productivity of livestock breeds in general and sheep in particular may be due to different factors such as Reproduction efficiency, poor nutrition (of the animal), prevalence of diseases, especially among livestock reared under challenging conditions [6]. Understanding the genetic performance of livestock is quite relevant for the

developing countries where specific adaptive attributes the livestock genetic resources make them all the more important especially under the unforeseen climate changing [7].

As a result of this knowledge on how to estimate the body weight of sheep under field condition is very crucial for smallholder farmers for any breeding, selection programme, feeding, vaccination and drug dosage in livestock industry. Knowing the body weight of animal for formulating and feeding of the animals according to their nutrient requirements, for appropriate dosages of drug administration, on time culling of under growing animals, for selling of animal to export abattoirs, to evaluate the trend of body weight change of animals over certain periods of time are very important to tackle the problems associated with lack of know ledges on how to estimate the weight of the animals under farmer's management conditions. It helps smallholder farmers to know the body weight of their animal at field conditions in absence of weighing scales. Because of the cost of weighing scale is very high and it is hardly available at farm level. To measure the body weight of sheep for community based sheep genetic improvement program. Therefore if regression model is not developed to estimate the body weight of animal from linear

measurement, knowing of the body weight of animal under farmer management condition is very difficult in absence of weighing scales. As a result of this proper and accurate estimation of body weight is difficult under field condition. Developing of equations for estimation body weight from linear body measurement can help smallholder farmers to know the body weight of their animal when and wherever they want. Estimating of the live weight of sheep using certain linear body measurement is practical, faster, easier and cheaper in the rural areas for smallholder farmers [8]. Measuring of linear dimensions are relatively ease in field conditions to use as an indirect way to estimate body weight [9]. Studies regarding the linear body measurement of sheep have been carried out in other region of the world and their possible use for estimating the animals live weight [9-12]. Estimation of body weight from linear measurement of Horro, Bonga Afar and Menz sheep were studied by ESGPIP and equations to estimate weight using linear measurements for different sexes and age groups of these sheep breeds were developed [9]. Body measurements have been used to predict body weight by several authors in many breeds of sheep [13-18]. They reported that different models might be needed to predict body weight in different environmental conditions and breeds. It also confirm earlier assertion that correlation values obtained between body weight and morphometric traits in a particular region can not be applied for animals in another regions since they differ in body conformation due to probably to different in genetic make-up, health status, feed, management practices [19].

The need to estimate live weight of animals especially sheep from simple and easily measurable morphological variables such as linear body measurements of different parts of the body become evident. Therefore live weight can be predicted via morphometric measurements in pasture [14]. Even though estimation of body weight from linear measurement has many function for smallholder farmers the equation used to estimate the body weight of Arsi-Bale sheep under field condition from linear measurement is not developed yet. Therefore, the current study was performed to determine the best regression model for live weight estimation to be used by farmers without the use of weighing scale.

## Material and Methods

### Description of the study area

Four locations, Adami tulu Jido kombolcha (07° 55'N latitude & 39° 45' E longitude), Bora (8°39'N latitude & 39°5'E longitude), Kofele (07° 00'N latitude & 38 ° 45' E longitude) and Asasa (07°06'N latitude & 39°12'E longitude); the first two representing East shoa Zone and the remaining two representing west Arsi zone of Oromia Regional State of Ethiopia to study about Arsi Bale sheep breeds. The Districts were purposively selected based on the availability of large number of sheep and accessibility of the areas for data collection. In selecting of the district different agro-ecological Zones which are found in high, medium and low altitude were considered to cover at least all the ecological zones in the selected Zones. The study areas were described separately by each district and the map of the study areas were indicated in figure 1 below.

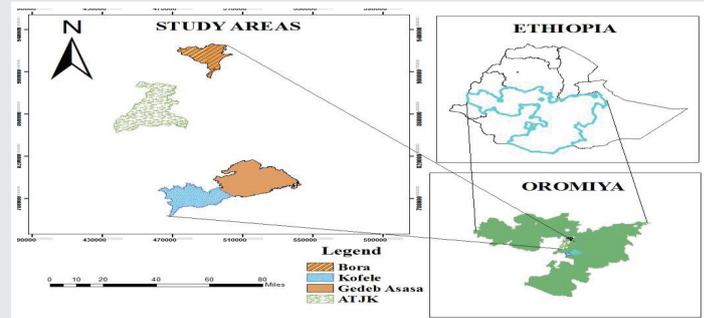


Figure 1: Map that show the study areas.

### Animals and linear body measurements

Based on the total number sheep flocks smallholder farmers who have at least 5 sheep were selected from each selected kebeles in each selected district. Overall 12 kebeles (2 kebeles per district) and a total 600 Arsi-Bale sheep (523 female and 77 male) were examined for linear body measurements to predict body weight. The age and sex of the sheep were considered as independent variables that substantially determine these body traits. The animals were classified into two sex groups as male and female and four age groups as 1PPI, 2PPI, 3PPI and 4PPI which refer for one pair of permanent incisor (1.0-1.5 years), two pair of permanent incisors (1.5-2.0 years), three pairs of permanent incisors (2.5-3.0 years), and four pairs of permanent incisors (above 3 years) respectively. The age categories were determined according their permanent incisors dentition as outlined in ESGPIP [9]. 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 of the sheep were taken using a 50 kg size spring balance early in the morning before allowing the animals for grazing. The following linear body measurements were taken as per the procedures of FAO [20]. Live body weight(BW), heart girth(CG), body length (BL), height at wither (HW), height at rump (HR), chest depth(CD), and cannon bone circumference(CBC) are linear measurements that were taken (Table 1).

### Statistical analysis

The results obtained were expressed as Mean  $\pm$  SEM (Standard Error of Mean). Using the Statistical Package for the Social Sciences (SPSS version 20.0, 2013), Correlations (Pearson's correlation coefficient) between body measurements under consideration were computed within each sex and dentition categories keeping the BW as the dependent variable and the different linear measurements as the independent variables. The stepwise REG procedure of was used to determine the relative importance of live-animal body measurements in a model designed to predict body weight. Live weight was regressed on the body measurements separately for age categories. The choice of the best fitted regression model was assessed using coefficient of determination ( $R^2$ ) adjusted  $R^2$ .

### Prediction models

The full regression model of the measurements (all the six linear body measurements) was defined as:

$$Y = a + b_1X_1 + b_2 X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6$$

Where, Y= dependent variable (body weight), a = intercept, b's = regression coefficients, X's = independent variables (HW, HG, HR, BL, CD, and CBC).

## Results and Discussion

### Major feed sources and feeding environment

During the dry season the predominant feed resource in the study areas is natural pasture (Table 1) which is also in close accordance with the findings of [4,21] (Table 2).

The crop residues and aftermath too are paramount importance; these observations too are in confirmatory with the results of [6,22]. Earlier studies by Alison *et al*, [23], had indicated that natural pastures are shrinking over a period of time which can be correlated with the anthropogenic and agronomic activities in the region activities. The study also indicates that non conventional feed is also provided to the sheep which is in form of local brewery wastes in form of "atella" and they also provide some natural minerals viz. "Bole". These observations are also in close accordance with those of [24,2], where agro industrial byproducts constitute major part of the feed resources of the farm animals. In the wet season the livestock are also allowed to graze on CGL (communal grazing land), non conventional feed (NCF) besides grazing on natural pastures.

### Live body weight and linear body measurements

The results pertaining to the linear body measurements and live body weight of Arsi Bale sheep reared at the study locations as presented in tables 2,3.

The maximum values were observed in age group three and four as compare to age group one and two. These showed that body weight and linear body measurements were increase with

**Table 2:** Proportion of feed resources used in the study areas during rainy and dry seasons.

Feed resources	Overall (%)	Index	Rank
<b>Dry season</b>			
Natural pasture	30.99	0.26	1
Hay	0.22	0.04	7
Crop residues	24.64	0.29	2
Fallow land	7.79	0.11	4
Concentrate	11.08	0.08	6
Crop aftermath	13.56	0.13	3
NCF	11.71	0.09	5
<b>Rainy season</b>			
Natural pastures	52.60	0.64	1
CGL	12.15	0.13	2
Established Pasture	1.81	0.01	7
Crop residues	8.54	0.07	4
Fallow land	7.28	0.05	5
Concentrate	3.34	0.02	6
NCF	13.68	0.08	3

NCF=None conventional feed, CGL= Communal grazing land; Index = sum of [ 3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular feed resource divided by sum of [3 for rank 1+ 2 for rank 2 + 1 for rank 3] for all feed resource.

increase dentition class. According to Mekasha [25], body size and shape of the animal rises until the animal reaches optimal growth.

The skeletal dimension is grossly influenced by the mineral available to the livestock especially calcium and phosphorus [26]. The skeletal dimension also influences the muscle attachment area there by influencing the body weight and also the stability of the animals [27]. The results show also that there were differences in skeletal dimensions and also body weight of the rams and ewes across different age groups. The higher mean numerical BW values observed in the male than in the female might be due to relatively large physical features of the male as a result of natural hormonal variations [28].

It was hardly to find male sheep of this breed with age beyond two year at farm conditions. This was for the reason that male animals older than two year are subjected either for selling or castration. Only few rams are maintained in some farmers for breeding purpose. In the field it was seen that relatively less proportion of male are kept for breeding, and sufficient mature females retained for breeding in a given sheep flock. The same situation was reported in other research works [29]. The male sheep are usually used for breeding purpose in their early age (1- 2 years) and sold when beyond two years age.

### Correlation between body weight and body measurements

The correlation coefficient among body weight and other linear body measurements are presented in table 3. The high positive correlation coefficient of body weight seen in this study with most body measurements demonstrated that the body weight could be predicted more accurately based on the dimension of various body measurements. Similar to

**Table 1:** Methods by which the morphometrical traits and live weight were assessed.

Parameters	Measuring techniques	Measuring Instruments
Heart girth (CG)	Measured by taking the measurements of the circumference of the chest; behind the forelegs	Measuring tape
Height at withers (HW)	Measured as a distance from the surface of the platform to the withers of the animal	Measuring stick
Height at rump (HR)	Measured as a distance from the surface of the platform to the rump of the animal	Measuring stick
Body length(BL)	The distance from the point of shoulder to the pin bone	Measuring tape
Chest depth (CD)	The horizontal distance between the extreme lateral points of the vertebrae of the chest	Dividers
Canon bone circumference (CBC)	The circumference of the lower part fore cannon bone or the smallest circumference of the foreleg	Measuring tape
Live body weight (LW)	Taking early in the morning before feeding the animals	suspended spring balance with 100 kg capacity with ±200g

**Table 3:** Live Body Weight (kg) and six linear measurements (cm) in Arsi Bale Breeds of Sheep. result were presented as Means +SEMs (Standard Error of Mean).

Age	Sex	N	BW	HW	HG	HR	BL	CD	CBC
1PPI	F	57	23.51 ±0.45	61.20 ±0.35	67.06 ±0.53	61.20 ±0.35	60.85 ±0.53	25.17 ±0.14	6.78 ±0.08
	M	32	24.33 ±0.70	61.25 ±0.57	67.84 ±0.77	61.25 ±0.57	59.91 ±0.80	24.57 ±0.20	7.03 ±0.06
	F&M	89	23.80 ±0.38	61.21 ±0.30	67.34 ±0.43	61.23 ±0.30	60.51 ±0.844	24.96 ±0.12	6.87 ±0.06
2PPI	F	90	25.68 ±0.38	61.97 ±0.26	68.99 ±0.38	61.97 ±0.26	60.89 ±0.48	26.01 ±0.19	6.70 ±0.10
	M	25	30.06 ±0.90	62.96 ±0.44	73.04 ±0.72	62.96 ±0.44	64.24 ±0.91	25.66 ±0.35	7.00 ±0.16
	F&M	115	28.87 ±0.38	62.18 ±0.22	69.87 ±0.37	62.47 ±0.24	62.62 ±0.94	25.92 ±0.17	6.76 ±0.08
3PPI	F	146	27.86 ±0.35	62.40 ±0.20	71.66 ±0.32	62.40 ±0.20	62.57 ±0.35	26.99 ±0.14	6.73 ±0.06
	M	12	31.50 ±1.06	64.38 ±0.39	75.91 ±1.36	65.45 ±0.28	64.66 ±0.69	27.83 ±0.29	6.92 ±0.27
	F&M	158	28.13 ±0.34	62.55 ±0.19	71.98 ±0.32	63.99 ±0.20	62.82 ±0.33	27.11 ±0.13	6.74 ±0.06
4PPI	F	230	29.05 ±0.26	62.91 ±0.17	72.91 ±0.25	62.91 ±0.17	63.42 ±0.26	26.61 ±0.14	6.77 ±0.05
	M	8	31.13 ±2.23	63.81 ±1.22	73.87 ±1.67	65.31 ±1.31	66.38 ±1.421	28.31 ±0.14	7.00 ±0.00
	F&M	238	29.11 ±0.26	62.94 ±0.17	72.94 ±0.24	64.27 ±0.18	63.51 ±0.25	27.46 ±0.21	6.77 ±0.04

1PPI= one pair of permanent incisor, 2PPI= two pair of permanent incisor, 3PPI= three pair of permanent incisor, 4PPI= four pair of permanent incisor, F= Female, M=Male, F&M= pooled result of Female & male, BW= Body weight, CG= heart girth, BL= body length, HW=height at wither, HR= height at rump, CD= chest depth, and CBC= cannon bone circumference.

the results of this study, live weight was found to be highly correlated with body dimensional traits in sheep [30,31]. The BL however, recorded the only negative correlation with BW in age group of 3PPI males. This means those male sheep of 3PPI age group, which have relatively low BL, were more likely to have high BW.

Similar to this study the strong positive correlation between the dependent variable body weight and the independent variable chest girth to predict body weight were observed in different previous works on sheep breed. This is in agreement with the report from North Wollo zone, Northern Ethiopia, Habru, Gubalafto district and in Selale Area, Central Ethiopia, Debre Libanos and Wuchale district of sampled sheep reported by Abera et al. [32] and Mohammed et al. [33], chest girth was the best variable for predicting live body weight than other linear body measurements for both male and female sampled sheep population (Table 4).

Correlation coefficient of 0.45 up to 0.87 was reported between body weight and heart girth in three Ethiopian local sheep breeds of Menz, Horro and Bonga [9]. This demonstrated that heart girth could be the best parameter in predicting the live weight of the animals. The higher correlation coefficient of body weight with a given body measurement demonstrates that on the basis of the dimension of various body measurements the body weight could be predicted more accurately.

### Multiple linear regression analysis

The results as presented in table 4 pertaining to the

body weight of rams and ewes of different age categories are important especially in areas where there is lack of weighing scales or the scales may have been inaccurate [14]. Assessment of body weight is important both for commercial purposes and also from the veterinary point of view where the dosages of the medicines are usually provided based on the body weight [34]. In the present finding of the pooled data of the dentition class of oPPI further addition of body length and wither height to heart girth improved the prediction accuracy by 5 and 7%, respectively. Based on the all age group regardless of sex category, it is observed that by considering only heart girth and body length is enough to estimate body weight accurately ( $R^2 = 73\%$ ). Bello and Adama [35], asserted that the presence of muscle and bone around the heart region was responsible for relatively higher and positive relationship between body weight and heart girth when compared to other linear measurements (Table 5).

Increased correlation coefficient was observed as more variables were included in the prediction equation indicating that more precision in the determination of body weight based on these linear body measurements [36]. The study also indicates that the accuracy of the prediction improves when higher numbers of traits are taken into account [7]. Similarly, the findings reported by Edea et al. [11], on Bonga and Horro sheep; and Getachew et al. [12], on Menz and Afar sheep indicated that incorporating of more linear body measurement in the prediction equation has improved prediction accuracy. The inclusion of body length in assessment of weight of a ewe/ram too has been reported by [37], similarly studies have also

**Table 4:** Correlation Coefficient between BW and Six body linear measurements in Arsi Bale sheep Breed.

Age	Sex	N	HW	CG	HR	BL	CD	CBC
1PPI	F	57	0.33*	0.85**	0.32*	0.55**	0.69**	0.53**
	M	32	0.50**	0.83**	0.56**	0.28*	0.56**	0.70**
	F&M	89	0.39**	0.82**	0.41**	0.47**	0.64**	0.53**
2PPI	F	90	0.26*	0.85**	0.33*	0.43**	0.69**	0.41**
	M	25	0.59**	0.88**	0.63**	0.71**	0.73**	0.75**
	F&M	115	0.38**	0.86**	0.42**	0.57**	0.70**	0.54**
3PPI	F	146	0.31*	0.69**	0.29*	0.40**	0.46**	0.49**
	M	12	0.24	0.78**	0.39	-0.11	0.45*	0.34
	F&M	158	0.46**	0.67**	0.45**	0.33**	0.48**	0.52**
4PPI	F	230	0.26*	0.84**	0.26*	0.61**	0.65**	0.70**
	M	8	0.77*	0.91**	0.82**	0.56	0.62	0.58
	F&M	238	0.33**	0.85**	0.33**	0.60**	0.67**	0.69**

1PPI= one pair of permanent incisor, 2PPI= two pair of permanent incisor, 3PPI= three pair of permanent incisor, 4PPI= four pair of permanent incisor, F= Female, M=Male, F&M= pooled result of Female & male, BW= Body weight, CG= heart girth, BL= body length, HW=height at wither, HR= height at rump, CD= chest depth, and CBC= cannon bone circumference.

**Table 5:** Stepwise Multiple Regression Analysis for different body linear measurements in Arsi Bale sheep Breed.

Age	N	Models	R <sup>2</sup>	Adj. R <sup>2</sup>	R <sup>2</sup> change	p-value
1PPI	89	-30.45 + 0.79CG	0.68	0.68	0.68	0.000
		-36.59 + 0.70CG + 1.93CBC	0.73	0.73	0.05	0.000
		-39.59 + 0.60CG + 1.94CBC + 0.39CD	0.74	0.74	.013	0.003
2PPI	115	-29.36 + 0.78CG	0.74	0.74	0.74	0.000
		-37.45 + 0.69CG + 2.15CBC	0.79	0.78	0.05	0.000
		-39.76 + 0.59CG + 2.01CBC + 0.41CD	0.80	0.80	0.02	0.002
		-45.77 + 0.59CG + 1.99CBC + 0.30CD + 0.15HR	0.81	0.81	0.01	0.031
3PPI	158	-27.67 + 0.77CG	0.45	0.45	0.45	0.000
		-31.64 + 0.64CG + 2.1CBC	0.52	0.52	0.08	0.000
		-41.12 + 0.54CG + 2.08CBC + 0.26HR	0.58	0.57	0.06	0.000
4PPI	238	-39.51 + 0.91CG	0.71	0.71	0.71	0.000
		-40.91 + 0.71CG + 2.48CBC	0.78	0.77	0.06	0.000
		-44.73 + 0.66CG + 2.09CBC + 0.16BL	0.79	0.79	0.02	0.000
		-39.78 + 0.68CG + 2.07CBC + 0.18BL - 0.13HW	0.80	0.80	0.01	0.024

1PPI= one pair of permanent incisor, 2PPI= two pair of permanent incisor, 3PPI= three pair of permanent incisor, 4PPI= four pair of permanent incisor, CG= heart girth, BL= body length, HW=height at wither, HR= height at rump, CD= chest depth, and CBC= cannon bone circumference.

indicated that body depth [38], too is a good indicator of BW among the ewes. Assessment of BW taking into account the chest girth have been presented in several studies in the past [3,6,32,33,39,40] which makes it one of the most popular and easily measurable trait.

This implies that considering more parameters of linear body measurements could provide better precision in predicting the body weight using the established equation. However, heart girth parameter is the easiest way to use for live weight prediction in field conditions especially under the small holder farmers as there are hardly any restraining mechanisms available [3]. Studies by [41,42], have also indicated that chest

girth too is correlated with the weight of the animals as the thoracic cavity houses most of the vital organs responsible for the wellbeing of the animals. The weights of the animals are also correlated with the skeletal dimensions as weight of the bones comprises a bulk of the weight of the animals [16]. Thus, the wider and longer the bones, the higher are the weight of the animal [14].

## Conclusion

The live Body weight can be predicted from body measurements with high accuracy to support breed improvement, marketing and husbandry practices of Arsi bale sheep breed. Body weight and the linear body measurements in both sexes increased with increased age (dentition class) up to the fourth age group. Heart girth is the easiest way to use for live weight estimation at farm conditions especially under the small holder farmers. The inclusion of more body measurements on the top of heart girth improved the accuracy of the prediction model. Further research is needed to investigate the relation between the body weight and linear body measurements with carcass composition considering the body conditions and seasons with maximum number of observations.

It is recommended to develop a simple chart that indicates heart girth and corresponding weights to be used by farmers and development agents to support genetic improvement, marketing, feeding and veterinary services.

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