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Live Body Weight prediction from Linear body Measurement in Indigenous Goat of South Western Ethiopia

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Abstract

The study was conducted to investigate the relationship between body weight and body measurements and to predict live body weight from body measurement in indigenous goat in Meanit Goldiya and Guraferda districts. For this purpose, data on body weight and body measurements such as body length, chest girth, head length, head width, rump width, rump length, pelvic width, horn length, ear length and scrotum circumference were collected from 660(600 female and 60 male) indigenous goats in the study areas. A correlation and regression analysis between body weight as a response variable and body measurement as predictor was conducted. The highest and significant ($p<0.01$) correlation was recorded between body weight and chest girth (0.94) for male and (0.93) for female goats in Guraferda and 0.92 for male and 0.91 for female goats in Meanit Goldiya district. Chest girth alone has explained the variation in body weight with coefficient determination of 0.94 and 0.94 for male and females in Meanit Goldiya, respectively. Whereas the coefficient determination of Guraferda goats is 0.88 and 0.87 for males and females, respectively. Therefore, chest girth is used to predict live body weight with regression equations of male and female indigenous goat in Meanit Goldiya district is y = -42.47+0.97chest girth and -40.23+0.94chest girth, respectively. Whereas in Guraferda district y=-70.56+1.39 chest girth and -55.19+1.18chest girth for male and female, respectively. Thus, chest girth could be laid high realistic to estimate live body weight of goat to assist marketing, genetic improvement, feeding and other routine husbandry practices in the farm conditions.

Keywords: Live body weight; Body measurement; Chest Girth; Body weight prediction

Introduction

Goat is playing a vital role in the economy of the country and the smallholder at large. They provide numerous functions for their holders as a source of income, food, fiber and skin, manure, insurance against crop failure and socio-cultural value [1, 2]. Special features of goats as compared to cattle are small body size, less space requirement, low feed requirement, use poor quality forage and fast turnover make them widely acceptable species in tropical harsh climatic condition [3].They possess unique genetic traits that enable survival in those diverse range of production environments and developed specific indispensable features to deal with harsh conditions such as severe feed and water scarcity, disease challenge, extreme hot and cold environments and unpredictable long drought periods in which temperate breed could not possess.

Body weight becomes a reference, which is very indispensable in predicting profit and loss because it is directly linked to feed consumption and maintenance efficiency. Accurate determination of live body weight of goats is required for sound husbandry routine practices including health care, genetic improvement, feeding and marketing [4] and it enables breeders to describe appropriate medicinal doses for remedy of animal, its feed amount per day and for marketing [5,6]. Now a day, the prediction of body weight is undertaken by evaluating the body measurement traits of the animal. Body measurements have a crucial role in predicting body weight where the accuracy can be up to 90% of the actual body weight. Goat body size will increase when it gets older and its body weight increases [7]. Solid understanding of body measurement and body weight relationship is determined breed traits and a good selection scheme and also developing prediction equation of body weight from body measurement without weigh bridges [8, 9]. Such type of grass root information is not available to small holder poor goat keepers where weigh bridges are not available.

Therefore, the farmers count on non-accurate evaluations of their animal body weight which is leads to inappropriate genetic improvement strategies and feeding schemes. Recently, several scholars have been revealed that prediction of body weight from different body measurement with respect to animal species, which are of great implication in sense of breeders [9]. Within this regard, it is important to predict precisely body weight using statistical analysis tools like Pearson correlation coefficient, simple regression equation among the most suitable methods is a practically statistical tool to define the liner relationship between body weight and body measurement [10]. However, information on body weight and liner body measurement of goats in the study areas is scarce. The information on the relationship between body weight and liner body measurements of goats in the study areas are vital for the estimation of size and shape of goats suitable for breeding and meat consumption. Therefore, the current research work was designed to determine the relationship between body weight and liner body measurements of goats in the study areas and to predict live body weight from linear body measurements in goats.

Material and methods

The study area

The study was conducted in Guraferda and Meanit Goldiya dis-

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tricts of Bench Maji zone in South-west Ethiopia. Bench Maji Zone is geographically located between 34°45′ to 36°10′E longitude and 5°40′ to 7°40′N latitude. The altitude ranges from 500 to 3000 m above sea level. The annual average temperature ranges from 15.1 to 27.5°C, while the annual rainfall ranges from 400 to 2 000 mm. The major livestock species include 354,198 goats,462,775 sheep,2,964,880 cattle,848,610 chickens,27,283 horses,12,073 mules,9,033 donkeys.

Data Collection Procedures

Data was collected from small holder keepers by considering the presence of indigenous population, potential of goat production and location of the study area. Both men and women headed households were sources of data. Based on breed morphological characteristics descriptor list of [11] 660(600 adult female and 60 adult male) goats were randomly selected from the Guraferda and Meanit Goldyia districts for the development of an estimator formula. Data were recorded on the prepared format adopted from the standard description lists developed by [11]. Body weight was measured using hanging balance having 50 kg capacity with 0.2 kg precision in the morning to avoid the effect of feeding and watering on the animal size [11], while a tailor measuring tape was used to obtain the needed body measurement that the animal was made to stand upright on a flat area. Specific body measurements(cm) obtained using the tailor measuring tape included: body length, chest girth, head length, head width, rump width, rump length, pelvic width, horn length, ear length and scrotum circumference (for males only), whereas scrotum circumference (SC) was excluded for the analysis means of parameters measured on female goats. Pregnant animals were excluded because pregnancy has effects on some morph metric parameters especially those of the thoracic and rump regions [12].

Statistical Analysis

Correlations of live body weight with different body measurement under consideration were computed for each sex using Pearson correlation coefficient. Stepwise REG procedure of SAS was employed to predict live weight from body measurement by pooled age group using PROC REG procedure [13]. The multiple regression model was followed to estimate body weight from body measurement for male and females in a separate analysis.

$$Yj = \alpha + \beta 1X 1 + \beta 2X 2 + \beta 3X 3 + \beta 4X 4 + \beta 5X 5 + \beta 6X 6 + 7X 7 + \beta 8X 8 + ej$$ for males

$$Yj = \alpha + \beta 1X 1 + \beta 2X 2 + \beta 3X 3 + \beta 4X 4 + \beta 5X 5 + \beta 6X 6 + \beta 7X 7 + ej$$ for females

Where: Yj= The response variable; body weight; α= the intercept

X1, X2, X3, X4, X5, X6, X7and X8 are the explanatory variables CG, BL, RH, PW, HW, RW, RL, EL and SC (for male only), respectively and β1, β2... β8 is regression coefficient of these variables ej= the residual random error.

Results

Phenotypic correlation between Body weight and Body measurements

Pearson coefficient of correlation coefficients (r) obtained between the live weight and body measurements of across the studied areas are presented in Table 1 for Meanit Goldiya and Guraferda districts. Coefficient of correlation between body weight and linear body measurement in this study varied from strong (0.94) to low (-0.002) and highly significant (*P<0.01*) to non- significant (*P>0.05).* However, higher correlation coefficients were observed for chest girth and body length with r^2 values of 0.94 and 0.90 for males and 0.93 and 0.86 for females in Guraferda district, respectively. Whereas 0.92 and 0.88 for males and 0.91 and 0.83 for females in Meanit Goldiya, respectively. From these measurements chest girth has showed the highest correlation for both males (0.94) and females (0.93) in Guraferda and 0.92 and 0.91 for males and females in Meanit Goldiya, respectively (Table 1). This shows that body weight can be better predicted from chest girth than the other measurements. Higher correlation coefficient between chest girth and body weight were observed in male than female in both

Table 1: Coefficient of correlations between body weight and linear body measurements foreach district within sex (Above diagonal for male (N=30) and below diagonal for female (N=300).

		BW	RH	EL	HOL	BL	CG	HW	CW	PW	HL	SC
Guraferda	BW		.74**	.43*	.67**	.90**	.94**	.79**	.004^{ns}	.74**	.54**	.81**
	RH	.42**		.46*	.60*	.54**	.82**	.91**	-.08^{ns}	.77**	.38*	.85*
	EL	.21*	.12*		.41*	.31ns	.52*	.54*	-.16^{ns}	.33^{ns}	.09^{ns}	.58*
	HOL	.32**	.64**	.13*		.46*	.68**	.68**	.003^{ns}	.48*	.42*	.59*
	BL	.86**	.37**	.27**	.28**		.54**	.54*	.19^{ns}	.61*	.43*	.66**
	CG	.93**	.45**	.20*	.33*	.71*		.87*	.053*	.75*	.55*	.83*
	HW	.45**	-.01^{ns}	.21^{ns}	-.16*	.45**	.41**		.09^{ns}	.82*	.44*	.86**
	CW	.16*	.26**	.013^{ns}	.45**	.07^{ns}	.21*	-.42**		.14^{ns}	.29^{ns}	.03ns
	PW	.54**	.27**	.29**	.35**	.55**	.50**	.11n	.41**		.54*	.88**
	HL	.31**	.11^{ns}	.016^{ns}	.15*	.27**	.31**	.13*	.03^{ns}	.36**		.39*
		BW	RH	EL	HOL	BL	CG	HW	CW	PW	HL	SC
Meanit Goldiya	BW		.76**	.16^{ns}	.43*	.88**	.92**	.81**	.22^{ns}	.77**	-.19^{ns}	.81**
	RH	.63**		.08^{ns}	.23^{ns}	.56**	.79**	.84**	.18^{ns}	.74**	.14^{ns}	.75**
	EL	.26**	.25**		.28*	-	.37**	.06^{ns}	.16^{ns}	-.17^{ns}	.07^{ns}	.40*
	HOL	.71**	.56**	-.002^{ns}		.28*	.51**	.22*	.26*	.13^{ns}	-.31*	.39*
	BL	.83**	.70**	.13*	.62**		.65**	.62**	.21^{ns}	.71**	-.28*	.58**
	CG	.91**	.51**	.29**	.66**	.68**		.78**	.26*	.66**	-.08^{ns}	.87**
	HW	.46**	.58**	.03n	.57**	.68**	.33**		.04^{ns}	.85**	.03^{ns}	.76**
	CW	.72**	.63**	.26**	.73**	.55**	.71**	.59**		.18^{ns}	-.18^{ns}	.33*
	PW	.48**	.39**	.26**	.47**	.25**	.53**	.44**	.80**		-.06^{ns}	.71**
	HL	.59**	.60**	.13*	.61**	.47**	.55**	.44**	.65**	.45**		-.06^{ns}

P<0.05; ** P<0.01; BW=Body weight, CG=Heart girth, HW= Height at whither; RH= Rump height; BL= Body length; EL= Ear length; PW= Pelvic width; HOL= Horn length; CW=Chest width; HL= Head length; SC = Scrota circumference, N=Number of animals

districts. There was also positive correlation between body weight and SC with r^2 of 0.81 and 0.83 in Guraferda and Meanit Goldiya districts, respectively.

Live Body weight prediction from other body measurement

Linear body measurements (Body length, Wither height, Chest girth, Rump height, Head length, Ear length, Horn length, Pelvic width, Chest width, Scrotum circumference) were included in model and through stepwise elimination procedure, CG was consistently selected and entered into the model in both sex in the study areas. Body length and rump height in Meanit Goldiya district and body length and horn length in Guraferda district were best fitted accounting for round about above 80% of the live body weight in both sex goats. The number of variables entered in each step, parameter estimates, and their contribution in terms of coefficient of determination (R^2), AIC, C (P), SBC and mean square error (MER) for each district and sex are presented in **(Table 2)**. The higher R^2 value and smaller MSE, AIC, C (P), SBC obtained in this result using a single and multiple measurements used as independent variables were good estimator of live body weight in goats **(Table 2)**. Chest girth was the first variable to explain more variation than other variables in both sexes (96% and 88% for males and 94% and 87% for female in Meanit Goldiya and Guraferda districts, respectively). R^2 value was higher for both sexes in Meanit Goldiya district than Guraferda district. ComparableR^2 value of males and females was obtained across the studied areas. The result of the multiple regression analyses indicated that the addition of other measurements to CG would result in significant improvements in accuracy of prediction even though the extra gain was small. Besides the statistical concept and precision, we should consider simplicity of measurement in order to select independent variables. Firstly, addition of more variable under field condition increase error incurred by the individual taking measurements and secondly some variables are more affected by the animal posture so it is difficult to measure such variables accurately. It was recognized that chest girth is among the variables least affected by the animal posture and easy to measure than other measurements like wither height and body length. Thus, under field conditions, live weight estimation using chest girth alone would be preferable to combinations with other measurements because of difficulty of the proper animal restraint during measurement. Hence, it is better to predicted live body weight for male and female indigenous goat in Meanit Goldiya district using chest girth as = -42.47+0.97chest girth(R^2=0.96) and -40.23+0.94chest girth (R^2=0.94), respectively. Whereas in Guraferda district using chest girth as=-70.56+1.39 chest girth (R^2=0.88) and -55.19+1.18chest girth (R^2=0.87) for male and female, respectively. Therefore, chest girth is the best fitted body trait used to estimate live body weight with realistic accuracy.

Discussion

The high correlation of different measurements with body weight would imply these measurements can be used as indirect selection criteria to improve live weight [9] or could be used to predict body weight [14,8,15]. The highest correlation between LBM and body weight was observed between body weight and chest girth for both districts in each sex with different correlation coefficient. Therefore, chest girth is the best parameter to estimate body weight due to high correlation estimates similar to the previous reports [16] for Hararghe high land goats, [17] for short-eared Somali goats, [18] for Amhara region goat, [19] for Hararghe highland goats, [20] for Horro Guduru goat, [21] for Woyto-Guji goats, [22] for Afar goats. This may indicate that the higher association of body weight with chest girth due to relatively larger contribution to body weight of chest girth, which consists of bones, muscles and viscera [4].

On Begayit goat, [20,23] on Woyto-Guji goat, [19] on Harerghe Highland goats and [24] on Abergelle goats who reported that higher correlation coefficients between chest girth and body weight in males than females which is in agreement with the current finding. This variation may be explained due to the difference in fat deposition variation between male and female goats. In this result body length had a strong correlation with body weight next to chest girth in both populations. Similarly [25] indicate that there were higher association between body weight and body length (r=0.73) in Amhara region goat population which is comparable with the current study result. In male's scrotal circumference had positive and strong correlation with body weight with correlation coefficient of 0.81 for both districts. This work shows that scrotal circumference-based selection could be used to improve genetically the male goats. It was reported that, the evaluation of breeding males is essential to measure SC [26-28] and. Males with large SC

Table 2: Simple and multiple regression analysis of live body weight on different body measurements for goat by district and sex.

District	sex	Model	I	β1	β2	β3	β4	β5	β6	β7	R^2	C(p)	AIC	MSE	SBC
Meanit Goldiya	Male	CG	-42.47	0.97							0.96	1162.7	-20.2	0.47	-17.4
		CG+BL	-53.41	0.76	0.43						0.99	57.4	-98.6	0.03	-94.4
		CG+BL+RH	-57.03	0.7	0.41	0.15					0.99	40.27	-104.6	0.02	-99.1
		Cg+BL+RH+HW	-58.48	0.66	0.42	0.12	0.09				0.99	32.3	-107.8	0.02	-100.8
	Female	CG	-40.23	0.94							0.94	19116	-86.2	0.72	-79.02
		CG+BL	-48.04	0.73	0.38						0.99	656.2	-915.3	0.03	-904.5
		CG+BL+RH	-50.57	0.72	0.35	0.07					0.99	399.5	-1003	0.02	-988.6
		CG+BL+RH+HOL	-49.45	0.71	0.35	0.06	0.08				0.99	249.7	-1071	0.01	-1053
		CG+BL+RH+HOL+HW	-46.42	0.7	0.38	0.06	0.11	0.08			0.99	32.2	-1222	0.01	-1200
		CG+BL+RH+HOL+HW+PW	-46.85	0.71	0.36	0.07	0.11	-0.06	-0.04		0.99	18.8	-1235	0.01	-1209.8
		CG+BL+RH+HOL+HW+PW+HL	-46.53	0.71	0.37	0.06	0.11	-0.07	-0.03	0.02	0.99	15.1	-1238	0.01	-1209.9
Guraferda	Male	CG	-70.56	1.39							0.88	185.4	50.19	4.99	53
		CG+BL	-62.85	0.93	0.4						0.97	23.55	7.43	1.16	11.6
		CG+BL+HOL	-57.85	0.87	0.42	-0.1					0.98	12.6	0.29	0.84	8.7
	Female	CG	-55.19	1.18							0.87	2405	22.1	2.6	24
		CG+BL	-52.11	0.74	0.45						0.99	58.2	-49.3	0.08	-46.2
		CG+BL+HOL	-56.43	0.93	0.41	-0.51					0.99	21.3	-63.2	0.04	-59.9

BW= Body weight; BL= Body length; CG= Chest girth; PW=Pelvic width; EL=Ear length; RH=Rump height; TC=Tail circumference;TL=Tail length; R^2 = R- square; MSE= Mean square of error; C (p) =Mallows C parameters; AIC =Alkaike's Information Criteria; SBC=Schwarz Bayesian Criteria.

tend to sire daughters that reach puberty at an earlier age and ovulate more ova during each oestrus period [29].

The estimating animal body weight using body measurements have been extensively used when weighing equipment is not readily available [20]. The accuracy of functions used to predict live weight or growth characteristics from live animal measurements is of immense financial contribution to livestock production enterprises. The prediction of body weight and its relationship to other body measurements produces applicable knowledge for breeding investigation with regard to meat production per animal [30]. Using measurement obtained readily and offered accurate prediction of body weight might be considered as a framework for recording system in rural areas [31]. Many studies conducted by scholars leads to study the relationship of body weight with chest girth in goats in various ecological zones. Chest girth is the most reliable variable to predict body weight under field conditions which is consistent with the earlier reporte of [32-34, 12, 24] reported CG as an important body measurement for predicting LW. The same is true [16to18,27, 20, 35,36] reported that chest girth was selected first for predication of live body weight of animals which is in line with this finding, because chest girth consists of bones, muscles and viscera. In addition to this BL is the most useful body measurement parameter for predicating LW of goat breed in Abergelle in, North, Ethiopia [6]. According to [6, 37] reported that R^2 value improved with increasing number of regressors in the predication model. However, the use of interdependent explanatory variables should be treated with caution since multicollinearity has been shown to be associated with unstable estimates of regression coefficient and representation the estimation of the unique effects of the predictors impossible. This justifies the use of principal component factor scores for predication [38to41].

Conclusion and Recommendation

Body weight could be estimated from linear body measurement with high realistic precision to enhance genetic improvement and regular practices of goats in the study areas. Positive and highly significant correlations were observed between body weight and most of the body measurements. Among those chest girth was the variable which explained more variation than other variable in both males and females in both districts. Thus, chest girth could be used as the easiest way to estimate live body weight especially under filled condition with reasonable accuracy. And therefore, it is recommended to develop a simple chart that indicates chest girth and corresponding weights to be used by goat keepers and extension agents to help breeding improvement and husbandry practices activities.

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