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Characterization of Indigenous Goats Type Using Morphological Characters in South West Shewa Zone, Oromia, Ethiopia

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Abstract

This study was conducted in South west Shewa zone, to describe phenotypic characterization of indigenous goat type in Tole and Becho districts. Morphological and Linear body measurement were carried out to collect necessary raw data during the current study. Morphological characters and linear body measurements were collected from a total of 460 adult goats. Data collected from each site were coded and entered into the computer (Excel 2016 and SPSS, V21, 2013) computer software to facilitate for further analysis. Data collected through Morphological and linear body measurements were analyzed using (SPSS, V21, 2013 and SAS, release 9.2, 2008). Most frequently observed coat color pattern in study was plain 62.8%. Multiple correlations between body weight and linear body measurements were computed for the population within each sex and correlations among body weight and linear body measurements were positive for both sexes. The strong, positive and significant correlation between heart girth and body weight was observed (r = 0.97, 0.93) for male and female population, respectively. Generally, this study was aim to describe phenotypic characterization of indigenous goat type in the study area. The Most observed body color type was plain in the study area so its need investigation because farmers need plain color rather others.

Keywords: Phenotypic, Characterization, Indigenous, Morphological, Linear body

Introduction

Ethiopia has the largest livestock population in Africa and is a homeland of large number of goat populations which are kept in various production systems and different agro-ecological zones of highlands, sub-humid, semi-arid and arid environments [9]. Goats in the highlands are widely distributed in the mixed crop-livestock production systems with very small flock size [21]. Almost all goat population is managed by resource poor smallholder farmers and pastoralists under traditional and extensive production systems [19].

According to CSA (2018/2019) [5], the number of goats reported in the country is estimated about 32.7 million and with respect to breed, almost all of the goats are indigenous which account for 99.97 %. While, a genetic study that used microsatellite markers showed only eight distinctively different types of goats in Ethiopia [21]. However, the current molecular study on the domestic goats by Getinet (2016) [9] does not support the former classifications of the indigenous goat populations. After detailed analysis of the goat population based on production systems, agro-ecologies, goat families, admixture and phylogenetic network analyses classified the 12 Ethiopian goat populations in to six goat types.

Phenotypic characterization of Ethiopian goats was done by Farm Africa. Based on the analysis of morphological data along with geographic distribution, fourteen distinct goat populations were identified across Ethiopia and Eritrea [8]. These were categorized into four major families including the Nubian (Nubian, Barak), Rift valley (Worre, Afar, Abergelle, Arsi-Bale, Woyto-Guji), Somali (Hararghe highland, short eared Somali, long-eared Somali) and the small East African (central highland, western Highland, western lowland, Keffa) goat families [14].

Halima, et al., (2012) [11] identified six morphologically distinct indigenous goat populations in the Amhara region, namely: Gumuz, Begia-Medir, Agew, Bati, Central Abergelle and Abergelle. Gumuz and Agew were distributed in both Amhara and Benishangul Gumuz regions. Similarly, in the southwestern part of Ethiopia, Tegegne (2012) [20] defined two goat ecotypes: Meanit and Sheko which are most likely ecotypes of Keffa goats previously characterized in the adjoining area [14]. Moreover, different researchers have used different terms (breed, population, ecotypes, type) to describe different phenotypic variants of goats, leading to a lack of clarity in the distinctions between breeds, populations and ecotypes [15].

Characterization studies are essential for planning improvement, sustainable utilization and conservation strategies of a breed at local, national, regional and global levels [12]. Identification, characterization and documentation of goat breeds are important for any type of development or improvement work. Without such documentation it would be difficult to know the animals and their potential [14]. Appropriate design of breeding programmes is impossible for breeds/types that have not been adequately characterized either phenotypically and/or genetically (Mwacharo et al., 2006).

Despite the wide distribution and large size of the Ethiopian goat population, the productivity per unit of animal and the contribution of this sector to the national economy is relatively low. This might be due to different factors such as poor nutrition, prevalence of diseases, lack of appropriate breeding strategies and poor understanding of the production system as a whole [22]. To increase and sustain the productivity of goats so as to respond to the growing domestic and foreign demands for live goats and products, improvement programs are necessary and should be crafted, especially for countries like Ethiopia where extensive system of husbandry is the commonest type [12]. Therefore, assessing the production system, indigenous knowledge of managing the breed, understanding current breeding practices, definition of breeding objectives and evaluating performance levels of the breed in their habitat with full participation of the community are prerequisite to set up breeding strategy at small holder level (Kosgey et al., 2006).

Characterization of the production systems and the available genetic resources is necessary to design livestock improvement programs in the future; studies devoted to morphological characterization of goats has not been done so far particularly for indigenous goat found in South west Shewa Zone. Besides, study of Hulunim et al. (2017) [13] show that Husbandry practices and phenotypic characteristics of indigenous goat populations in Ethiopia he studies around four administrative zone were did not included South

West Shewa and neighbors' zones and phenotypic characterization, husbandry practices and breeding practices were used for better utilization and conservation program for the breed was not incorporated in that study.

In general, the information obtained from phenotypic characterization is useful for designing appropriate breeding and selection schemes for indigenous goats' improvement and sustainable conservation. Therefore, this study was aim to describe phenotypic characterization of indigenous goat type in the study area.

Materials And Methods

Description of the Study Area

The study was conducted in South west Shewa, which is one from 24 zones of Oromia region in Ethiopia. According to the data from the South West Shewa Zone Agricultural Office the Zone, lies between 8^0 37'33" North latitude and 38^0 14' 7" East longitudes with an elevation ranging 1600-3576 meters above sea level. The wide range of agro-ecology (highland, midland and lowland) found in the zone. The mean annual temperature of the zone ranges between 10^0C and 35^0C and the mean annual rain fall ranges 900-1900mm. The climate of the area is characterized by a long rainy season (June-September) accounting for 75% of the annual rainfall having a peak fall in July and August (South West Shewa Zone Agriculture Office, 2020).

Tole district Part of the South west Shewa Zone, the woreda administrative city Bantu is found S77km far away from the zonal city Woliso and 80km far away from Addis Ababa. It is bordered on the south by Sedan sodo, on the west by Becho, on the north by Elu and Sebata Hawas and on the east by Karsa malima. According to the data from the woreda Agricultural Office the district, lies between 8°37' North latitude and 38°22' East longitude of with an elevation of 2234 meters above sea level (TDAO).

Becho district Part of the South west Shewa Zone, the woreda administrative city Tulu bolo is found 29 km far away from the zonal city Woliso and 85km far away from Addis Ababa. It is bordered on the south by sedan Sodo on the west by Woliso, on the north Dawo, and on the east Elu and Tole. According to the data from the woreda Rural Development Office, the woreda, lies between 8°40'N latitude and 38°13'E longitude with an elevation of 2193 meters or 7195 feet above sea level (BDAO).

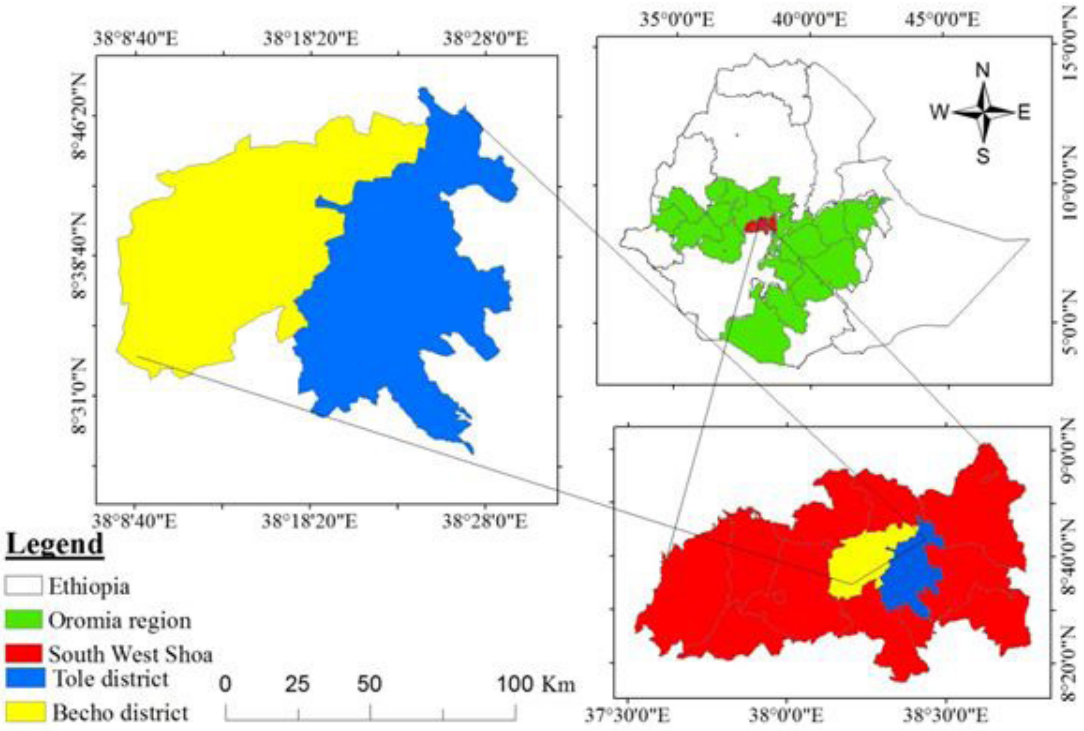

Figure 1: Map of the study areas

Sampling Techniques and Data Collection Procedures

Sampling Techniques: The study districts (Tole and Becho) are found in South west Shewa administrative zones. Three kebeles were selected in each district purposively based on their goat production potential. For linear body measurements, a total of 460 adult goats (400 females and 60 male) were selected randomly within selected district according to FAO (2012) guidelines to be considered for qualitative and quantitative studies, but pregnant female and castrated male were not included to avoid inaccuracy for body weight and linear body measurements (LBMs).

Data Collection: Secondary data sources and linear body measurement were carried out to collect necessary raw data during the current study.

Morphological characters and linear body measurements were collected from a total of 460 adult goats. Data was recorded based on breed morphological characteristics descriptor list of FAO (2012) for phenotypic characterization of goat. Each experimental animal was identified by sex, site, and estimated age group (1PPI, 2PPI, and ≥3PPI). Morphological characters like coat color pattern, coat color type, hair type, horn shape, horn orientation, ear orientation, head profile, back profile, rump profile, wattle presence, and bear presence, was observed. Linear body measurements like heart girth (HG), body length (BL), wither height (WH), ear length (EL), horn length (HoL), scrotum circumference (SC), and rump height (RH) were measured using tailors measuring tape while body weight (BW) was measured using suspended spring balance having 50kg capacity with 0.2kg precision.

Data Management and Statistical Analysis

Data Management: Data collected from each site were coded and entered into the computer software (Excel 2016 and SPSS, V21, 2013) to facilitate for further analysis. Data collected linear body measurements were analyzed using (SPSS, V21, 2013 and SAS, release 9.2, 2008).

Statistical Analysis

Qualitative Data: All qualitative data (qualitative trait observed) were analyzed using the descriptive statistics

Quantitative Data: Quantitative data gathered through animal measurement were subjected to analysis of variances using PROC GLM in SAS (2008). For the measurement analysis effect of age group, sex, district and the interaction effect of age*sex on body weight and different linear body measurements other two ways and their way interaction effects were not significant so that were removed from the model. When analysis of variance declared significant difference, least squares means were separated by using Tukey's HSD (Honestly Significance Difference). Only significant test interaction among fixed effect was discussed. The model employed for analyses of body weight and other LBMs except SC and SL was:

$$\mathbf{Y_{ijkl}=\mu+Ai+Sj+Dk+Ai^{*}Sj+e_{ijkl}}$$

Where: $_{Yijkl}$ = the observed l (body weight or LBMs) in the i^{th} age group, j^{th} sex and k^{th} woreda

μ= overall mean,
A_i = the effect of i^{th} age group (i_1 = 1 PPI, i_2 =2 PPI, and i_3 =≥3 PPI)
S_j = the effect of j^{th} sex (j_1 = male, and $j_{2=}$ female)
Dk = the effect of K^{th}woreda (K_1 = Tole, and $K_{2=}$Becho)
Ai*Sj = age by sex interaction and
Eijkl = random residual error

Model used to analyze scrotal circumference (SC) and scrotal length (SL) was:

Yikl = μ + Ai + Dk + eijk

Where: Yikl = the observed l in the i^{th} age group and k^{th} woreda
μ = overall mean
A_i = the effect of i^{th} age group (i_1 = 1 PPI, i_2 =2 PPI, and i_3 =≥3 PPI)
Dk = the effect of K^{th}woreda (K_1 = Tole, and $K_{2=}$Becho)
Eijkl= random residual error

Multiple correlations were used to estimate the correlation between body weight and linear body measurements. Multiple linear regressions were employed to estimate body weight of goats in the study area from other linear body measurements. Best fitting models were selected based on higher coefficient of Adjusted R^2 and smaller the Mallows C Parameters C (P), Alkaike's Information Criteria (AIC), Root Mean square of error (R MSE) and Schwarz Bayesian Criteria (SBC) by using Stepwise regression procedure of SAS.

The following models were used for the estimation of body weight from linear body measurements.

Multiple Linear Regression Models for Females

Yj = β0 + β1X1 + β2X2 + β3X3j + β4X4 +β5X5 +β65X6

Where: β0 is the intercept, Yj = the response variable body weight and β1, β2, β3, β4, β5 and β6 are coefficients of the variables X1, X2, X3, X4, X5 and X6, respectively and X1, X2, X3, X4, X5 and X6 are the independent variables; heart girth, height at wither, Rump height, ear length, horn length, and body length, respectively.

ej = the residual error

Multiple Linear Regression Models for Males

Yj = β0 + β1X1 + β2X2+β5X5+β3X3+β6X6+β4X4+jβ7X7 + β8X

Where: β0 is the intercept, Yj = the response variable body weight and are β1, β2, β3, β4, β5 and β6are coefficients of the variables X1, X2, X3, X4, X5, X6, and X7, respectively and X1, X2, X3, X4, X5, X6 and X7 are the independent variables; heart girth, height at wither, Rump height, ear length, horn length, body length, and Scrotum circumference respectively.

ej = the residual error

Results And Discussion

Phenotype Characterization of Indigenous Goat

Qualitative Characterization of Indigenous Goat: Description of the physical characteristics of livestock breeds is very important for developing a breeding strategy in a particular production system. The major qualitative traits of sample goat population in the study area are presented in Table 1 In both Body Coat pattern and body hair color type there were significance difference between districts P (0.00). The observed body Coat pattern was plain (67.0), patchy (21.3) and spotted (11.7%) and plain (58.7), patchy (38.3)

and spotted (3.0%) in Tole and Becho districts respectively. The difference between districts might be due color preference in the districts. The overall dominant body color types in the study districts were plain which followed by patchy and stopped. This result move toward Ahmed (2013), reported that the majority of goat population in Horro Guduru Wollega zone had plain coat color pattern. Unlikely to current finding Bekalu (2014) reported that nearly half of goat population in West Gojam zone had patch coat color pattern. The body hair type color were black (16.7%), Black and white (15.9%), Red (4.3%), white (22.6%), Brown (15%), white and brown (21.1 %), and white and red (4.3%). The mostly dominant body hair type colors in study area were white, brown and white and black. The hair type was smooth (91.7%) and long straight (8.3%).

All goats selected for field measurements were horned. The previous studies by FARM Africa (1996) and Alubel (2015) revealed that the majority (90.38%) of Abergele and Central Highland goats were horned. The most observed horn shapes in the study area goat population were straight (75.9%) and curved (24.1%). As study reported by Hulunim (2014), the dominant horn shape in Bati indigenous goats was straight (96.7%). This result also in line with Solomon (2014) who stated that almost all males and females of Abergelle goats had horns and around 5% of Western Lowland goats were polled. In contrast to this result in Gurawa district incidence of polled goat was higher than horned (Mahilet, 2012). The majority (93.7%) of goat population had back ward horn orientation and (6.3%) of goat population had obliquely upward horn orientation. The Ear orientation of goat population was significance difference P (0.003).

	Districts			Test	
Variable	Tole N (%)	Becho N (%)	Overall N (%)	X^2	P-value
Body Coat pattern				24.116	0.00
Plain	154(67.0)	135(58.7)	289(62.8)		
Patchy	49(21.3)	88(38.3)	137(29.8)		
Spotted	27(11.7)	7(3.0)	34(7.4)		
Body coat color					0.00
Black	44(19.1)	25(10.9)	69(15.0)		
Black and white	30(13)	42(18.7)	73(15.9)		
Red	10(4.3)	10(4.3)	20(4.3)		
White	45(19.6)	59(25.7)	104(22.6)		
Brown	55(23.9)	43(18.3)	97(21.1)		
White and Brown	40(17.4)	37(16.1)	77(16.7)		
White and Red	6(2.6)	14(6.1)	20(4.3)		
Hair type				41	0.00
Smooth	230(100)	192(83.5)	422(91.7)		
Long straight	0	38(16.5)	38(8.3)		
Horn					
Present	230(100)	230(100)	460(100)		
Absent					
Horn shape				8.616	0.003
Straight	188(81.7)	161(70)	349(75.9)		
Curved	42(18.3)	69(30)	111(24.1)		
Horn orientation				13.28	0.00
Obliquely upward	24(10.4)	5(2.2)	29(6.3)		
Back ward	206(89.6)	225(97.8)	431(93.7)		
Ear orientation				8.988	0.003
Semi-pendulous	130(56.5)	161(70)	291(63.3)		
Carried horizontal	100(43.5)	69(30)	169(36.7)		
Profile Back				5.047	0.025
Straight	113(49.1)	137(59.6)	250(54.3)		

Slope upward	117(50.9)	93(40.4)	210(45.7)		
Profile Head				4.4	0.036
Straight	167(72.6)	146(63.5)	313(68)		
Concave	63(27.4)	84(36.5)	147(32)		
Profile Rump				12.085	0.0001
Flat	15(6.5)	39(17)	54(11.7)		
Slopping	215(93.5)	191(83)	406(88.3)		
Wattle				4.7	0.03
Present	45(19.6)	28(12.2)	73(15.9)		
Absent	185(80.4)	202(87.7)	387(84.1)		
Bread				9.7	0.003
Present	50(21.7)	26(11.7)	76(16.5)		
Absent	180(78.3)	204(88.7)	384(83.5)		

X^2=chi-square, N=Number

Table 1: Qualitative characterization of Goat

Live Body Weight and Linear Body Measurements

Least Squares Means (LSM) for fixed effects of sex, age group and location on body weight and other linear body measurements of goat population in the study area are indicated in Table 2. Except ear length and horn length all the quantitative dependent variables were significantly (P< 0.05) affected by sex of the animal. The higher body weight in bucks than does noted in present study could be due to hormonal differences and different growth rates of the two sexes. In this study, males have higher body weight and other linear body measurements (P<0.05) than their females' counterpart. Location, sex and age differences were apparent for various body measurements. The finding was in agreement with the repot of Alefe (2014) [2].

Overall mean of matured goat (≥ 3PPI) heart girth, height at withers and body weight were 65.74±0.2cm, 62.43±0.2cm and 28.3±0.13kg, respectively. The value of the results were comparable with that reported by Mahilet (2012) [16] who reported that the average heart girth, height at withers and body weight were 69.32cm, 61.91cm and 24.48 kg, respectively for Hararghe highland goats and Alubel (2015) [3] who recorded value of 70.2 cm, 65.31cm and 27.52kg, for Abergelle goats and Lower than 74.90 cm, 71.02 cm and 33.95 kg for Central highland goats for average heart girth, height at withers and body weight, respectively.

Location effect: Live body weight (LBW) and all the linear body measurements were significantly affected by location except ear length. The body weight of goats in Tole and Becho woreda 27.32±0.133 kg and 26.35±0.156 kg respectively (2). This might be due to the effect of the management difference between the districts. Moreover, the farming system is dependent on extensive grazing without supplementation, the size and productivity of the grazing land can be taken as the sole component of the environmental factors affecting livestock productivity Yaecob et al. (2015) [24].

Sex effect: Live body weight (LBW) and all the linear body measurements were significantly affected by sex groups. All the body measurements in male goats were consistently higher than females for all variables. This might be due to hormonal effect, that is, release of androgen (which is known to have growth and weight - stimulating effects) in male animals after the testes are well developed (Frandson and Elmer, 1981). The sex related differences might be partly a function of the sex differential hormonal effect growth (Semakula et al., 2010).

Age effect: Live body weight and all LBMs were significantly affected by age group except Ear length and Horn length. Body weight and all body measurements were increased as the age increased from the youngest to the older age group. Body weight, heart girth, body length, height at wither, rump height, rump length and rump width increased as age increased from 1PPI to ≥3 PPI. The size and shape of the animal increases until the animal reach its maturity and the effect of age on body weight and other body measurements were also observed in different goat breeds of Ethiopia Yoseph (2007).

Sex by age group: The interaction between sex and age group was not significantly affected by body weight and LBMs. The value of body weight for female goat in age group 1PPI, 2PPI and 3PPI were 26.071±0.305kg, 27.185± 0.2kg and 29.63±0.24kg, respectively and the values for males in the same age groups were 24.75±0.103Kg, 25.93±0.10Kg, and 28.864±0.136Kg, respectively. Higher body weight of males than that of females at all ages is attributed to aggressive behavior of males during feeding and sucking and male sex hormone, which has an anabolic effect. In all age groups and measurements, male goats performed greater than female goats. This finding is in agreement with that of Grum, (2010) and Mahilet, (2012) who reported on short eared Somali goats and Hararghe Highland goats, where values for male goats were found greater than their female counter parts in all age group and all measurements.

Effect	N_O	Variables							
		BW (kg)	HG (cm)	HW (cm)	RH (cm)	HL (cm)	EL (cm)	SC (cm))	BL (cm)
Overall	460	26.8±0.15	63.1±0.19	59.4±0.2	61±0.29	11.2±0.15	13.6±0.92	24.7±0.18	56.5±0.19
CV (%)		3.77	2.153	2.91	2.63	20.91	10.38	2.28	2.28
R^2		0.802	0.788	0.708	0.707	0.033	0.007	0.712	0.738
Location		<0.0001	<0.0001	0.0262	0.0009	0.0001	0.4207	0.0022	<.0001
Tole	230	26.4±0.16	62.4± 0.2	59.6±0.26	61.3±0.23	10.8±0.19	13.6±0.08	24.4±0.15	55.9±0.18
Becho	230	27.3±0.13	63.8±0.17	59.3±0.14	61.2±0.15	11.7±0.1	13.5±0.1	24.9±0.21	57.1±0.14
Sex		<0.0001	<0.0001	<0.0001	<0.0001	0.7557	0.8416		<0.0001
Male	60	27.7±0.23	64.4± 0.29	60.5±0.34	62.5±0.29	11.1±0.34	13.5±0.18	24.7±0.13	57.4±0.25
Female	400	26.7±0.11	62.9±0.15	59.3±0.16	61.1±0.15	11.3±0.12	13.6±0.07		56.3±0.13
Age		<.0001	<.0001	<.0001	<.0001	0.8877	0.4207	<.0001	<.0001
1PPI	136	24.9±0.10[a]	60.5±0.14[a]	56.7±0.12[a]	58 ±0.12[a]	11.2±0.8	13.7±0.37	23.6±0.1[a]	54.4±0.14[a]
2PPI	150	26.2 ± 0.1[b]	62.4±0.15[b]	58.4±0.12[b]	60.3±0.14[b]	11.2±0.22	13.4±0.12	24.4±0.1[b]	55.8±0.13[b]
≥3PPI	112	28.3±0.13[c]	65.74±0.2[c]	62.43±0.2[c]	64.1±0.18[c]	11.3±0.22	13.7±0.13	25.8±0.2[c]	58.7±0.15[c]
Sex*Age		NS	NS	NS	NS	NS	NS	NS	NS
M*1ppI	14	26.1±0.31	62.3±0.5	56.9±0.64	59.1±0.8	11.2±0.83	13.7±0.37	23.6±0.13	53.5±0.5
M*2ppI	27	27.2± 0.2	63.8±0.25	59.8±0.24	62.1±0.3	11.1±0.47	13.3±0.27	24.4±0.09	56.9±0.24
M*≥3ppI	19	29.6±0.24	66.6±0.33	64.3±0.54	64.7±0.4	10.9±0.58	13.7±0.33	25.8±0.18	59.4±0.29
F*1ppI	122	24.7±0.10	60.3±0.14	56.6±0.13	60.7±0.12	11.3±0.19	13.6±0.13		54.2±0.15
F*2ppI	123	25.9±0.10	62±0.16	58.1±0.12	61.9±0.14	11.2±0.24	13.4±0.13		55.6±0.14
F*≥3ppI	155	28.9±0.14	65.6±0.18	62.3±0.19	63.9±0.18	11.3±0.24	13.7±0.14		58.6±0.15

BW=Body weight, Kg=kilogram, HG=Heart girth, cm=centimeter, HW=Height at withers, RH=Rump height, HL=Horn length=Ear Length, SC=Scrotum circumference, BL=Body length, CV=Coeffient of variance, R^2=R-square, F=Female=Male, 1PPI=one pair permanent incisor, 2PPI=Two pair permanent incisor, 3PPI=Three pair permanent incisor, MS=least square mean, SE=Standard error, NS=Not significant at P=0.05

Table 2: Least squares means and standard errors of live body weight (kg) and linear body measurements (cm)

Correlation and Regression Analysis of Indigenous Goat

Multivariate analysis was conducted using quantitative variables for adult females and males separately. Among the multivariate analysis multiple correlations and multiple linear regression analysis were employed.

Multiple Correlation Analysis Between Body Weight and LBMs

The Pearson correlation coefficients between body weight and LBMs for female and male goats are presented in Table 3. The strong correlation coefficients recorded between body weight and linear body measurements, suggests that either of these LBMs variables or their combination could provide a good estimate for predicting body weight of indigenous goat found in both districts.

Based on the present analysis, positive correlation ($p<0.05$) between live body weight and LBMs (i.e., HG, HW, RH, and SC for male) were observed in both sampled female and male goats, indicating that LBMs increased as body weight of goat increased. Variables such as HG, HW, RH, HL, ELand BL, displayed low to high positive correlations and significant ($p<0.05$) with live body weight in female (r =0.005-0.971) goats. In male goats' variables such as HG, HW, RH, HL, EL SC and BL displayed low to high positive correlations and significant ($p<0.05$) with live body weight (r = 0.089 -0.955).

	BW	HG	HW	RH	HL	EL	SC	BL
BW	1	0.96**	0.87**	0.85**	0.09^{ns}	0.16^{ns}	0.75**	0.95**
HG	0.97**	1	0.82**	0.80**	0.08^{ns}	0.16^{ns}	0.73**	0.94**
HW	0.92**	0.89**	1	0.93**	-0.08	0.16^{ns}	0.59**	0.78**
RH	0.92**	0.89**	0.96**	1	-0.08	0.21^{ns}	0.62**	0.75
HL	0.01	0.03	-0.03^{ns}	-0.03	1	-0.18	0.09^{ns}	0.19
EL	0.02	0.04	0.04^{ns}	0.01^{ns}	-0.03^{ns}	1	0.10^{ns}	0.19
SC							1	0.74
BL	0.97**	0.95**	0.90**	0.90**	0.00	0.01^{ns}		1

BW=Body weight, Kg=kilogram, HG=Heart girth, cm=centimeter, HW=Height at withers, RH=Rump height, HL=Horn length=Ear Length, SC=Scrotum circumference, BL=Body length

Table 3: Pair wise correlation among body weight and different linear body measurements (above diagonal=Male and below=Female)

Multiple Linear Regression Analysis Between Body Weight and LBMs

Multiple linear regression equations were developed for predicting live body weight (LBW) from other LBMs. In order to predict live body weight from LBMs multiple regressions procedure was carried out within both sexes based on independent variables which had positive correlation with body weight. There is often a great need for livestock herds' men to know how much their animal's weigh. Reasonable skill in estimating weight is, therefore, necessary for the stockman as it will frequently be necessary to know weights when a weigh bridge is not readily available or its use is not practically feasible (Singh and Mishra, 2004). In this study, regression equation was developed for estimation of live body weight using 8 LBMs (HG, HW, BL, PW, HL, EL, SC and SL) in males and 6 LBMs (HG, HW, BL, PW, HL and EL) in females (Table 3).

The small sample size of male goat in this study may decrease the accuracy of the result if separate age groups are used. Thus, instead of using separate equation for different age groups, it seems logical to pool age groups for the prediction of live body weight which could be based on regression equation y = -20.8+0.75x for male goats and y = - 20.73+0.754x for female goats, where y and x are live body weight and heart girth, respectively. The better association of body weight with heart girth was possibly due to relatively larger contribution of heart girth to body weight which consists of bones, muscles and viscera [23].

The best fitted variables were selected using higher value of adjusted R^2 and smaller value of C(P), AIC, R MSE and SBC. For male goats heart girth among the variables (RH, and BL) was the best fitted variable for prediction of body weight. For female goats heart girth among the variables (HW, RH and BL) was again the best fitted variables for prediction of body weight.

The overall regression model fit for male and female were highly significant based on the F-test in the ANOVA model. The adjusted R^2estimates were high, male (0.954) and female (0.971) indicating that no redundant predictor existed in the fitted regression model.

Model		Parameter									
Male	I	β0	β1	β2	β3	R^2	AR^2	C(P)	AIC	RME	SBC
HG	-20.80	0.75				0.91	0.91	59. 6	-75	0.52	-70.84
HG+BL	-22.80	0.42	0.41			0.94	0.94	18.6	-100.9	0.42	-94.62
HG+RH+BL	-24.90	0.28	0.18	0.41		0.96	0.95	4.23	-114.3	0.37	-105.9
Female											
HG	-20.73	0.75				0.94	0.94	37.1	-480.45	0.55	-472.5
HG+BL	-22.67	0.41	0.42			0.96	0.96	97.0	-657.21	0.44	-645.2
HG+RH+BL	-21.93	0.37	0.14	0.30		0.97	0.97	5.53	-739.71	0.4	-723.7
HG+RH+HW+BL	-22.15	0.37	0.11	0.05	0.29	0.97	0.97	3.03	-742.30	0.39	-722.3

I=intercept, HG=Heart girth, HW=Height at withers, RH=Rump height, BL=Body length, R^2=Square, A R^2= adjusted R-square, C (P)=Mallows' statistic, AIC= Akaikei's information criterion, RMSE= Root mean square, SBC=Schwarz's Bayesian criterion

Table 4: Multiple Linear Regression body weight with different linear body measurements

Conclusion

Generally, the overall observed body color type plain which followed patchy and spotted. The mostly dominant body hair type colors in study area were white, brown and white and black. The majority of hair type goats in the study area was Smooth. All goats selected for field measurements were had horn. Except ear length and horn length all the quantitative dependent variables were significantly ($P< 0.05$) affected by sex of the animal. Live body weight (LBW) and all the linear body measurements were significantly affected by location except ear length and horn length. Based on the present analysis, positive correlation ($p<0.05$) between live body weight and LBMs (i.e., HG, HW, RH, and SC for male) were observed in both sampled female and male goats, indicating that LBMs increased as body weight of goat increased. The result of the multiple regression analysis showed that heart girth combined with body length could predict body weight in male and female of sampled population of local goat with the equation $y = 20.8+0.75x$ for males and $y = 20.73+0.754x$ for females**.** The Most observed body color type was plain in the study area so its need investigation because of farmers needs plain color and the body weight of animal was affected by age group, and sex of animal therefore its better if feeding animal classifying according to their age group and sex group.

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