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Morphological Characterization of Indigenous Sheep Populations in North Shoa Zone, Central Ethiopia

[1,2]Gadisa Fikadu and [1]Solomon Shiferaw

[1]Ambo University, College of Agriculture and Veterinary Sciences, Ethiopia
[2]Derra District Livestock and Fishery Resource Development Office, Ethiopia

Abstract: Morphological measurements taken from 272 adult sheep were used to physically characterize indigenous sheep population in Derra district of North Shoa Zone, Central Ethiopia. Purposive and simple random sampling was employed to select the study Kebeles and all the sheep for quantitative measurements. Majority of the indigenous sheep population among the three agro ecologies had plain (46%) coat color pattern followed by patchy (31.6%). Brown and grey color to identifying high and midland sheep while in lowland white color was dominant. Majority of male sheep in the study areas had horn and most of female had no horn. Indigenous sheep population in all agro ecologies had mainly characteristics of short fat tailed type. The overall means of body weight, body length, wither height, chest girth, chest depth, pelvic width, ear length, horn length, tail length, rump length and scrotal circumference of Derra sheep 26.91±0.25(kg), 58.64±0.21, 61.69±0.25, 69.81±0.27, 26.29±0.13, 17.17±0.26, 9.15±0.13, 12.31±0.91, 22.92±0.34, 16.92±0.12 and 24.63±10.93 (cm), respectively. Most quantitative traits indicated significant difference by agro ecology, with higher values recorded for highland as compared to lowland sheep. Lowland sheep had shortest ear and tail length and widest scrotal circumferences for male sheep, revealing of adaptation to their environment. Sex and age classes of sheep also had significant variation on the most traits except ear length and scrotal circumference. Chest girth was the most vital variables for estimation of live body weight in sheep. It was to conclude that highland sheep is slightly larger in linear body measurements as compared to lowland and midland sheep. Further molecular level characterization of sheep population in the study area would necessary to validate the current phenotypic results particularly on possible genetic variation among these populations.

Key words: Body Measurements · Characterization · Derra · North Shoa Zone · Sheep

INTRODUCTION

Ethiopia's sheep population estimated about 39.89 million sheep, is found widely distributed across the diverse agro-ecological zones of the country of which 99.56% are indigenous types [1]. The majority of the sheep are found in the highlands, while one-fourth of them are reared in the lowlands [2]. Sheep play an important role in the smallholders' farming systems, for instance, they provide tangible (cash, milk, meat, fiber and manure) and intangible benefits (prestige, saving, insurance, cultural and ceremonial purposes) [3]. Oromai Regional State has 9.75 million sheep [1]. According to Norh Oromia Zone Livestock resource development office annual report North Shoa Zone has 945, 409 heads; among this Derra distric has 62, 820 indigenous sheep respectively [4].

Ethiopia has a diverse sheep population of around 14 sheep types in four main groups such as highland long fat-tailed, sub-alpine short fat-tailed, lowland fat-ramped/tailed and lowland thin-tailed [5]. They were grouped together based on their geographic distribution and tail phenotypes [6, 7]. However, the local sheep breeds with very low productivity dominate smallholder production system, which are mainly confounded by lack of effective long-term sheep genetic

Corresponding Author: Gadisa Fikadu, Ambo University, College of Agriculture and Veterinary Sciences, Ethiopia, Derra District Livestock and Fishery Resource Development Office, Ethiopia.

improvement, multiplication and effective delivery systems, environmental as well as socio-economic factors [8].

Efforts to improve the productivity of the local sheep through improving management and husbandry interventions, implementing breed improvement through selection and crossbreeding for terminal cross breed is important. Nowadays with existing awareness on impact of climate change, due emphasize on production improvement is advised to take advantage of the locally adapted breeds [9]. Morphological characterization involves the description and documentation of the physical traits of a breed [10] and it is very important for developing a breeding strategy in a particular production system [11-13].

Studies indicated that majority of sheep breeds in Ethiopia were characterized and some of them are re-characterized in more current studies, including Arsi sheep [14], Simien sheep [15], Highland sheep [16], Short fat tailed sheep [17, 19], Washera sheep [20], Afar sheep [19, 21]. In addition to these studies, some effort was done in the Oromia region on Bale sheep [22] and North Shoa Zone on Wuchale and Debra Libanos sheep [23]. However, the efforts made to characterize the Ethiopian indigenous sheep genetic resources as mentioned above, they have not yet been comprehensive in covering all regions of the country in general and the Oromia region, particular in Dera district. Even though the district has rich in sheep resource, information on morphological characteristics of existing sheep population under smallholder management system is limited. Thus, there is a need for continued characterization of phenotypic traits in the study area. Therefore, the current study was conducted to achieve the gaps and phenotypically characterize the indigenous sheep population of Derra district, North Shoa Zone, Central Ethiopia.

MATERIALS AND METHODS

The Study Areas: The study was conducted in Dera district, which is located in the Northern Shoa Zone of Oromia National Regional State. It is located in 38°20' to 38°52' E longitude and 10°03' N to 10°24'N with altitude ranging from 700 to 2575 m.a.s.l (Figure 1). The maximum and minimum annual temperature is 25°C and 18°C, respectively whereas the average annual rainfall varies from 800 to 1000 mm. The total livestock population in Dera district is estimated at 468, 050 heads, out of which 202, 610 are cattle, 62, 820 sheep, 169, 864 goats, 30, 773 equines and chicken is estimated to be 26, 376.

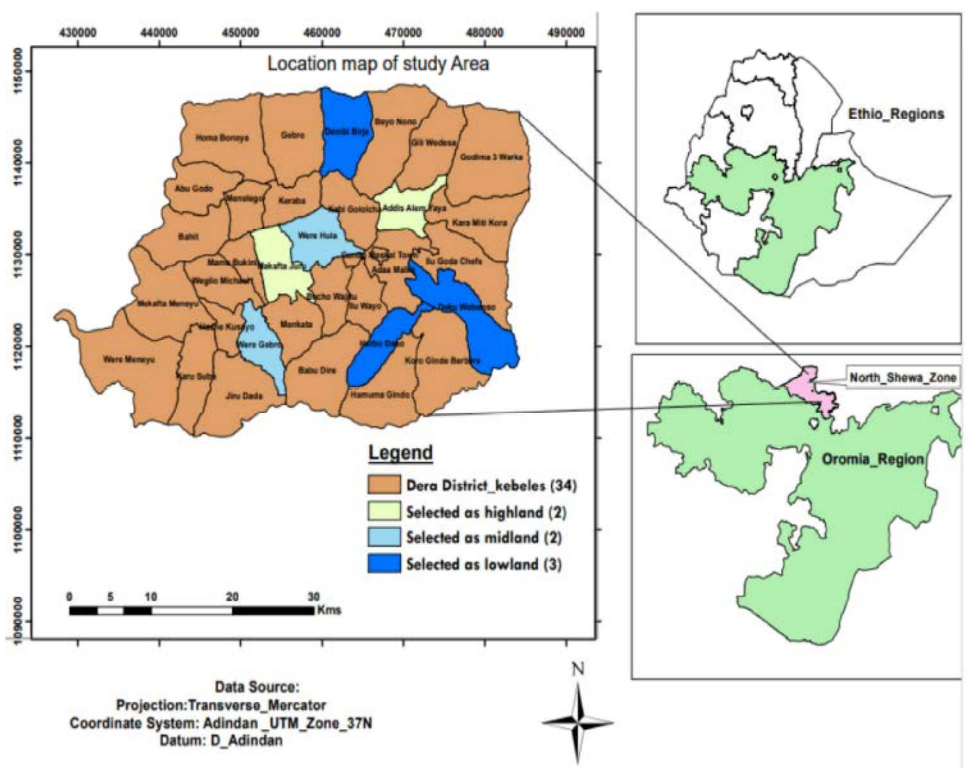

Fig. 1:

Sampling Techniques and Sample Size Determination: Derra district was selected purposively based on the availability of sheep population. All Kebeles in the district were stratified into highland, midland and lowland. Based on this, two Kebeles from highland (Makafta Jiru and Adis Alem Yaya), two Kebeles from midland (Ware Gabro and Ware Hula) and three Kebeles from lowland (Dembi Birje, Dengnu Wabeso and Harbo Daso) were selected purposively based on sheep potential and accessibility of the area. A total of seven *Kebeles* were selected for this study.

Qualitative and quantitative trait measurements should be taken only from a representative set of adult animals (as judged by dentition): about 100-300 females and 10-30 males according to their accepted standard description format as outlined in FOA [24]. Based on this, qualitative description and body measurements 272 adult sheep (245 females and 27 male) were taken from sheep herds of 136 household. Accordingly, 94 adult sheep from highland (85 female and 9 male), 92 sheep from midland (83 female and 9 male) and 86 sheep from lowland (77 female and 9 male) were selected randomly for both qualitative and quantitative body measurement. Each experimental adult animal were classified by sex and dentition. Pregnant females (ewes) were excluded in sampling because of pregnancy have influence on body parameters. All age group sheep were classified into three age groups (1 PPI, 2 PPI and 3 PPI).

Data Source and Method of Data Collection: In the current study, qualitative traits and Quantitative measurements data were collected based on sex and age groups and recorded on the format adopted from the standard description list developed by FAO [24]. Visual observations of qualitative traits like coat color pattern, coat color type, head profile, back profile, ear orientation, tail type, horn, wattle and ruff were observed and recorded. Each morphologically measured animal was identified by agro ecology, sex and age group.

Quantitative measurements traits like Body weight (BW), Body Length (BL), Wither Height (WH), Chest Girth (CG), Chest Depth (CD), Pelvic width (PW) Ear Length (EL), Horn length (HL), Tail Length (TL), Rump length (RL) and Scrotum circumference (SC) were measured using flexible measuring tape whereas body weight (BW) were measured using suspended spring balance having 50kg capacity with 0.2kg precision. Quantitative trait measurements were taken by restraining and holding the animals in a steady condition. Adult sheep was classified into three age groups; 1 PPI, 2 PPI and 3PPI to represent age of 1-1½ years, 1½-2years and 2½-3years, respectively.

Data Management and Analysis: The collected data was coded and entered into Microsoft EXCEL. The qualitative data from individual observation were analyzed by frequency, percentage and descriptive statistics using statistical analysis system (SAS version 9.1.3 [25] for the district.

The General Linear Model (GLM) procedure of SAS was employed to analyze quantitative variables to determine effects of class variables (agro ecology, sex and age) using the LSD test when comparison was undertaken for sample populations to show significance difference between least square means were separated. The effects of class variables were expressed as Least Square Means (LSM) ± SE. Agro ecology, sex and age were fitted as fixed factors.

The model employed for analyses of body weight and other quantitative measurements scrotum circumference was:

$$Y_{ijk} = \mu_i + A_i + S_j + D_k + (AS)_{ij} + e_{ijk}$$

where:

- Y_{ijk} = the observed k (record of body weight and linear body measurements) in the ith age group, j[th] Sex and kth agro ecology;
- μ_i = Overall mean;
- A_i = the effect of ith age group (i=1 PPI, 2 PPI and 3 PPI);
- S_j = the effect of jth Sex (j= male and female);
- D_k = the effect of kth agro ecology (highland, midland and lowland)
- $(AS)_{ij}$ = the effect of interaction of i of age group with j of sex
- e_{ijk} = random residual error

Model to analyze the scrotum circumference was:

$$Y_{ik} = \mu_i + A_i + D_k + e_{ik}$$

where:

- Y_{ik} = the observed k (scrotum circumference) in the ith age group and kth agro ecology;
- μ_i = Overall mean;
- A_i = the effect of ith age group (i=1 PPI, 2 PPI and 3 PPI);
- D_k = the effect of kth agro ecology (highland, midland and lowland)
- e_{ik} = random residual error

Pearson correlation coefficient analysis between body weight and other linear body measurements was employed using PROC CORR of SAS. Pearson's correlation coefficient was computed for each of sex classes. Stepwise regression was employed using PROC REG of SAS to regressed body weight on body measurements. Best fitting models were selected based on higher coefficient of determination (R^2) and R^2 change. Models were used for the estimation of body weight from linear body measurements.

For male:

$Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + e_j$

where:

Y_j = the response variable (body weight)

α = the intercept

X1, X2, X3, X4, X5, X6, X7, X8, X9 and *X10* are the explanatory variables body length, wither height, chest girth, chest depth, pelvic width, ear length, horn length, tail length, rump length, scrotal circumference and, respectively.

$\beta_1, \beta_2 \ldots \beta_9$ is regression coefficient of the variables *X1, X2… X 10*

ej = the residual random error

For female:

$\alpha_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + e_j$

where:

Yj = the dependent variable (body weight)

α = the intercept

X1, X2, X3, X4, X5, X6., X7, X8 and *X9* are the independent variables; body length, wither height, chest girth, chest depth, pelvic width, ear length, horn length, tail length, rump length, respectively.

$\beta_1, \beta_2 \ldots \beta_8$ is regression coefficient of the variable *X1, X2… X9*

ej = the residual random error.

RESULTS

Qualitative Traits of the Sample Population: The major qualitative traits of sample sheep population are presented in Table 1. The result revealed that all observed qualitative traits were significantly associated ($P<0.05$) with the three agro ecology. Majority of the indigenous sheep population can be characterized plain coat color pattern followed by patchy. Brown and grey coat colors were the main dominant observed in high and midland agro ecologies while white color was dominant in lowland indigenous sheep (Table 1).

Most of the sheep sampled have Straight head profile (58.5%); semi-pendulous ear orientation (47.8%) and straight back profile (43.8%). The current result also indicated that most of the sheep sampled have absence of horns; wattle and ruff among the three agro ecologies. Majority of sampled sheep population also had short fat tailed (59.93%) followed by long fat (40.07%) tail type (Table 1). More of the sheep in the study area had plain coat pattern, brown, grey and white coat color, straight head and back profile, semi-pendulous ear orientation and short and long fat tail type.

Body Weight and Linear Measurement: The overall least squares means and standard errors for the effect of agro ecology, sex and age group on the body weight and other linear body measurements are presented in Tables 2. Average least squares means and standard errors of body weight, body length, wither height, chest girth, chest depth, pelvic width, ear length, horn length, tail length, rump length and scrotal circumference of Derra sheep 26.91±0.25 (kg), 58.64±0.21, 61.69±0.25, 69.81±0.27, 26.29±0.13, 17.17±0.26, 9.15±0.13, 12.31±0.91, 22.92±0.34, 16.92±0.12 and 24.63±10.93 (cm), respectively. Most of quantitative traits were significantly affected by agro ecology, sex and age differences.

Agro Ecology Effect: Effect of agro ecology on more of quantitative measurements was body length, chest girth, chest depth, ear length, tail length and scrotal circumferences, with the highest value recorded for highland sheep population. However, midland sheep have similar measurement traits with in lowland sheep population except tail length and scrotal circumference at significant level. Lowland sheep had widest scrotal circumference, shortest tail and ear length.

Sex Effect: Majority of the quantitative traits (wither height, chest depth, pelvic width, horn length, tail length and rump length) were affected by sex of sheep indicating higher value for males. However, body weight, body length, chest girth, ear length and scrotal circumference of the study sheep were not affected ($p>0.05$) by sex (Table 2).

Table 1: Description of qualitative traits in the study areas

		Agro ecologies				
Trait	Attribute	Highland N (%)	Midland N (%)	Lowland N (%)	Over all N (%)	χ^2
Coat color pattern	Plain	37(43.5)	38(41.3	44(51.2)	125(46)	
	Patchy	28(32.9)	35(38.0)	23(26.8)	86(31.6)	<0.0001
	Spotted	20(23.5)	19(20.7)	19(22.1)	61(22.4)	
Coat color	White	8(9.41)	9(9.78)	26(30.2)	43(15.8	
	Black	7(8.24)	8(8.70)	1(1.16)	16(5.9)	
	Brown	15(17.7)	13(14.1)	6(6.98)	34(12.5)	
	Red	11(12.9)	9(9.78)	12(13.9)	34(12.5)	<0.0001
	Grey	14(16.5)	17(18.5)	18(20.9)	53(19.5)	
	Light red	4(4.71)	13(14.1)	7(8.14)	24(8.8)	
	Dark brown	3(3.53)	3(3.26)	n/a	6(2.2)	
	white and red with white dominant	8(9.41)	8(8.70)	10(11.6)	27(9.9)	
	Black and with white dominant	8(9.41)	6(6.52)	n/a	15(5.5)	
	Red and brown with red dominant	7(8.24)	6(6.52)	6(6.89)	20(7.4)	
Head profile	Straight	49(57.7)	55(59.9)	48(55.8)	159(58.5)	
	Concave	19(22, 45)	20(21.7)	18(20.9)	59(21.7)	<0.0001
	Convex	17(20.0)	17(18.5)	20(23.3)	54(19.9)	
Horn presence	Presence	19(20.2)	27(29.4)	16(18.6)	62(22.8)	<0.0001
	Absent	75(79.8)	65(70.7)	70(81.4)	210(77.2)	
Horn orientation	lateral(sideways),	7(36.8)	12(42.9)	5(31.3)	24(38.1)	
	obliquely upward	n/a	3(14.3)	6(37.5)	10(15.9)	0.0099
	back ward	12(63.2)	12(42.9)	5(31.3)	29(46)	
Ear orientation	Erect	1(1, 06)	2(2.17)	1(1.16)	4(1.5)	
	Pendulous	17(18.1)	11(11.9)	5(5.81)	33(21.1)	<0.0001
	semi-pendulous	47(50)	41(44.6)	42(48.8)	130(47.8)	
	carried horizontally	29(30.9)	38(41.3)	38(44.2)	105(38.6)	
Back profile	Straight	41(43.6)	41(44.6)	37(43.0)	119(43.8)	
	slopes up toward the rump	23(24.5)	24(26.1)	28(32.6)	75(27.6)	0.0013
	slopes down the from withers	30(31.9)	27(29.4)	21(24.4)	78(28.7)	
Tail type	long thin	n/a	n/a	n/a	n/a	
	short thin	n/a	n/a	n/a	n/a	
	long fat,	47(50)	39(42.39)	23(26.74)	109(40.07)	0.0011
	short fat	47(50)	53(57.6)	63(73.26)	163(59.93)	
Wattle	Present	8(8.51)	13(14.1)	9(10.5)	30(11)	<0.0001
	Absent	86(91.5)	79(85.9)	77(89.5)	242(89)	
Ruff	Present	6(6.68)	8(8.70)	7(8.14)	21(7.7)	<0.0001
	Absent	88(93.6)	84(91.3)	79(91.9)	251(92.3)	

N = number of observations, % percentage, n/a= absence of numbers

Age Effect: Age classes for most linear body measurements and body weight were found to be significant affected (P<0.05) except ear length, tail length and scrotal circumferences. The value of most traits (body weight, body length, wither height, chest girth, chest depth, pelvic width and horn length) had increased in dentition class one to three ages (Table 2). Whereas, this was not true in some measurement traits (ear length, tail length and scrotal circumference).

The scrotal circumference of adult Derra sheep was 24.6±0.05 cm. Body weight of males in age group 1PPI and age group 2PPI were 23.64±0.59 and 32.06±0.86, respectively.

Correlation Between Body Weight and Body Measurements: The relationship between body weight and linear body measurements for male and female sample sheep population was presented in Table 3.

Table 2: Least squares means (LSM) ± standard error (SE) for the main effect of agro-ecology, sex and age and sex by age interaction on the live body weight (Kg) and linear body measurements (cm) of sheep

Level	N	BW SM±SE	BL SM±SE	WH SM±SE	CG SM±SE	CD SM±SE	PW SM±SE
overall	272	26.91±3.19	58.62±2.69	61.69±3.06	69.82±3.65	26.27±1.75	17..17±4.13
R^2		0.43	0.36	0.45	0.36	0.32	0.09
CV%		11.85	4.60	4.96	5.23	6.64	24.03
Agro-ecology		NS	*	NS	*	*	NS
Highland	94	27.69±0.43[a]	59.39±0.35[a]	61.69±0.39[a]	70.89±0.43[a]	26.81±0.22[a]	17.09±0.18[a]
Midland	92	26.49±0.41[a]	58.09±0.33[b]	61.43±0.39[a]	69.28±0.46[b]	25.97±0.19[b]	16.93±0.19[a]
Lowland	86	26.49±0.47[a]	58.39±0.38[b]	60.79±0.40[a]	69.24±0.50[b]	26.03±0.25[b]	16.78±0.18[a]
Sex		NS	NS	*	NS	*	*
Female	245	26.85±0.3[a]	58.64±0.2[a]	61.0±0.2[b]	69.82±0.3[a]	26.08±0.1[b]	17.02±0.1[a]
Male	27	27.38±1.1[a]	58.39±0.97[a]	64.17±0.67[a]	69.54±0.98[a]	28.13±0.41[a]	16.2±0.30[b]
Age		*	*	*	*	*	*
1PPI	76	23.53±0.38 [a]	56.28±0.33[a]	58.87±0.37[a]	66.68±0.47[a]	25.29±0.21[a]	15.47±0.17[a]
2PPI	91	26.85± 0.39[b]	58.41±0.32[b]	60.91±0.37[b]	69.5±0.44[b]	26.18±0.22[b]	16.86±0.16[b]
3PPI	105	29.39±0.32 [c]	60.49±0.26[c]	63.35±0.30[c]	72.36±0.33[c]	27.06±0.19[c]	18.67±0.62[c]
Sex by age		*	*	*	*	*	*
F1PPI	61	23.50±0.47[d]	56.42±0.45[c]	58.16±0.76[e]	66.57±0.54[c]	24.74±0.22[d]	15.51±0.26[b]
F2PPI	79	26.06±0.43[c]	57.91±0.37[b]	60.11±0.41[d]	68.89±0.57[b]	25.77±0.25[c]	16.79±0.21[ab]
F3PPI	105	29.39±0.33[b]	60.49±0.25[a]	64.42±0.31[b]	72.37±0.36[a]	27.06±0.17[b]	18.67±0.14[a]
Male 1PPI	15	23.64±0.96[d]	55.70±0.75[c]	61.77±0.96[c]	67.13±0.89[bc]	27.53±0.41[b]	15.3±0.35[b]
Male 2PPI	12	32.06±1.09[a]	61.75±1.11[a]	66.21±0.53[a]	73.50±1.08[a]	28.88±0.72[a]	17.33±0.37[ab]

[a, b, c, d] means on the same column with different superscripts within the specified dentition group are significantly different ($P<0.05$); Ns = Non- significant ($P>0.05$); BW = Body weight; BL = Body Length; WH = Wither height; CG = Chest Girth; CD = Chest Depth ; PW=Pelvic Width ; 1 PPI = 1 Pair of Permanent Incisors; 2PPI = 2 Pairs of Permanent Incisors;3PPI = 3Pair of Permanent; NA = Not applicable

Table 2: (Continued)

Level	N	EL SM±SE	HL SM±SE	TL SM±SE	RL SM±SE	N	SC SM±SE
Overall	272	9.15±2.19	12.57±5.05	22.93±5.17	16.92±1.66		24.63±2.04
R^2		0.028	0.53	0.15	0.30		0.49
CV%		23.61	40.18	22.55	9.81		8.28
Agro-ecology		*	NS	*	NS	NA	*
Highland	94	9.51±0.23[a]	13.65±1.80[a]	24.11±0.56[a]	16.89±0.20[a]	9	22.67±0.82[b]
Midland	92	9.12±0.20[ab]	10.73±0.65[a]	23.54±0.58[a]	16.97±0.19[a]	9	24.44±0.53b
Lowland	86	8.81±0.26[b]	14.33±2.44[a]	20.98±0.56[b]	16.66±0.21[a]	9	26.78±0.78[a]
Sex		NS	*	*	*		NS
Female	245	9.21±0.1a	9.67±0.32[b]	22.37±0.34[b]	16.6±0.1[b]	NA	NA
Male	27	8.65±0.5[a]	17.72±1.9[a]	27.87±1.1[a]	18.87±0.41[a]	27	24.6±0.5
Age		NS	*	NS	*		NS
1PPI	76	9.14±0.26[a]	11.17±1.19[ab]	22.88±0.71[a]	16.07±0.19[a]	15	23.93±0.59[a]
2PPI	91	9.16±0.24a	14.92±1.72[a]	23.25±0.59[a]	17.13±0.24[a]	12	25.5±0.86[a]
3PPI	105	9.13±0.21[a]	10.17±0.44[b]	22.69±0.49[a]	17.36±0.16[b]	NA	NA
Sex by age		NS	*	NS	*		
F1PPI	61	9.18±0.29[a]	8.64±0.75[c]	21.74±0.83b	15.63±0.26[d]	-	-
F2PPI	79	9.31±0.29[a]	10.00±0.56[bc]	22.48±0.71[b]	16.59±0.24[c]	-	-
F3PPI	105	9.13±0.18[a]	10.17±0.40[bc]	22.69±0.43[b]	17.36±0.15[bc]	-	-
Male 1PPI	15	9.0±0.67[a]	13.50±2.01[b]	27.50±1.69[a]	17.83±0.35[b]	15	23.93±0.59[a]
Male 2PPI	12	8.21±0.78[a]	22.80±3.06[a]	28.33±1.29[a]	20.17±0.64[a]	12	25.50±0.86[a]

[a, b, c, d] means on the same column with different superscripts within the specified dentition group are significantly different ($P<0.05$); Ns = Non- significant ($P>0.05$); EL = Ear Length; HL= Horn Length; TL = Tail Length; RL= Rump length; SC = Scrotal Circumference; 1 PPI = 1 Pair of Permanent Incisors; 2PPI = 2 Pairs of Permanent Incisors; 3PPI = 3Pair of Permanent NA=Not applicable

Table 3: Correlation coefficients of quantitative traits males (above the diagonal) and females (below the diagonal) in Derra sheep population

	BW	BL	WH	CG	CD	PW	EL	HL	TL	RL	SC
BW		0.88^{*}	0.87^{*}	0.90^{*}	0.65^{*}	0.72^{*}	-0.28^{ns}	0.64^{*}	-0.03^{ns}	0.74^{**}	0.34^{ns}
BL	0.88^{*}		0.81^{*}	0.87^{*}	0.47^{*}	0.64^{*}	-0.23^{ns}	0.57^{*}	-0.07^{ns}	0.63^{*}	0.20^{ns}
WH	0.93^{*}	0.85^{*}		0.77^{**}	0.48^{*}	0.61^{*}	-0.06^{ns}	0.56^{*}	0.12^{ns}	0.63^{*}	0.28^{ns}
CG	0.94^{*}	0.79^{*}	0.85^{*}		0.62^{*}	0.69^{*}	-0.42^{*}	0.54^{*}	-0.14^{ns}	$0.69*^{*}$	0.36^{ns}
CD	0.84^{*}	0.72^{*}	0.74^{*}	0.79^{*}		0.27^{ns}	-0.45*	0.41^{ns}	-0.35^{ns}	0.41*	0.34^{ns}
PW	0.37^{*}	0.35^{*}	0.34^{*}	0.34^{*}	0.25^{*}		-0.34^{ns}	0.52^{*}	0.14^{ns}	0.59^{*}	0.56^{*}
EL	-0.01^{ns}	-0.06^{ns}	-0.02^{ns}	-0.03^{ns}	-0.002^{ns}	-0.03^{ns}		-0.12^{ns}	0.16^{ns}	-0.32^{ns}	-0.59^{*}
HL	0.22^{ns}	0.12^{ns}	0.22^{ns}	0.20^{ns}	0.24^{ns}	0.31^{ns}	-0.04^{ns}		-0.01^{ns}	0.59^{*}	0.33^{ns}
TL	0.28^{*}	0.21^{*}	0.29^{*}	0.27^{*}	0.29^{*}	-0.001^{ns}	0.18^{*}	0.20^{ns}		0.12^{ns}	0.21^{ns}
RL	0.65^{*}	0.53^{*}	0.61^{*}	0.63^{*}	0.62^{*}	0.22^{*}	-0.05^{ns}	0.25^{ns}	0.15^{*}		00.39^{*}

NS= Non-significant (P<0.05); * significant at 0.05 level; BW= Body Weight; BL=Body Length; CG= Chest Girth; WH= Wither height; CD= Chest Depth; PW = Pelvic Width; EL= Ear Length; TL= Tail Length; RL= Rump Length; SC = Scrotal circumference

Majority of the parameters considered had positive and strong correlation with live body weight. In male's, chest girth (r=0.90), body length (r=0.88), wither height (r=0.87), rump length (r=0.74) pelvic width (r=0.72), chest depth (0.65), horn length(r=0.64), Scrotal circumference (0.56) were positive and strong association found between body weight and other linear body measurements.

In females also wither height (r=0.93), chest girth (r=0.94), body length (r=0.88), chest depth(r=0.84), rump length (r=0.65), among the body measurements, chest girth was the most strongly correlated trait with body weight (r=0.90 for males; r=0.94 for females). The result shows that chest girth is the vital variable for estimating live weight than other linear measurements. Ear length had lower and negative correlation with body weight and other linear body measurements. Scrotum circumference (SC) had positive and strong correlation with body weight at most other linear body measurement with correlation coefficient of 0.56 for males.

Prediction of Body Weight from Different Linear Body Measurements: Regression analysis of live body weight on different body linear measurements for females and males in the study areas is presented in Table 4. The result of stepwise multiple regressions were used to predict body weight from linear measurements which had positive correlation with body weight. The best fitting models were selected based on higher coefficient of determination (R2) values. Chest girth, height at wither, body length, chest depth and rump length were the best fitted model for female sheep, whereas chest girth, body length, wither height, pelvic width and horn length were the best fitted model for male sheep.

Except 1 PPI of male, in all sex and age category of Derra sheep chest girth was consistently selected and entered into the model in step one procedure of stepwise regression due to its larger contribution to the model than other variables. The coefficient of determination (R^2) represents the proportion of the total variability explained by the model. Chest girth was the first variable to explain more variation than other variables in both males (97%) and females (98%) of Derra sheep. Chest girth was more consistent in forecasting body weight than other linear body measurements. Hence, in the sampled population, lives body weight at various growth stages could be fairly estimated from chest girth measurements.

The stepwise linear regression equations were developed to predicting body weight from other linear body measurements. Multiple regressions was incorporated for pooled age group within each sex by entering all body measurements except CD, EL, TL, RL and SC for male and by excluding PW, EL, TL and SC for females for selection of explanatory variables. The overall equation of the pooled age group using(CG+HW+BL+ CD+ RL) as important variable used for the prediction of body weight for female sheep and (CG +BL+WH +HL) used for prediction of body weight for male sheep in the study area. The prediction of body weight could be based on the following regression equation was:

For female sheep

$$Y = -40.55+0.41CG+0.31WH+0.24BL+0.28CD+(-0.12)RL$$

for females

where Y= response variable (body weight) and chest girth, wither height, body length, chest depth and rump length are independent variables.

For male sheep

$$Y = -49.77+0.50\,CG+0.31BL+0.36WH+0.06HL$$

for males.

where Y= response variable (body weight) and chest girth, body length, wither height and horn length are independent variables.

Table 4: Regression models for estimating body weight of female and male sheep population in the study districts from some linear body measurements

Dentition	Equations	Intercept	β1	β2	β3	β4	β5	β6	R^2	R^2 Change
Female										
1PPI	CG	-26.74	0.75						0.89	0.00
	CG+BL	-32.07	0.59	0.28					0.96	0.07
2PPI	CG	-24.67	0.74						0.86	0.00
	CG+HW	-30.71	0.45	0.43					0.96	0.10
	CG +WH + BL	-38.03	0.34	0.38	0.29				0.98	0.02
	CG+WH+BL+CD	-37.73	0.32	0.25	0.30	0.34			0.99	0.01
3PPI	CG	-32.42	0.86						0.97	0.00
	CG+BL	-40.13	0.75	0.26					0.98	0.01
	CG + BL+RL	-40.72	0.72	0.26	0.16				0.98	0.01
	CG+BL+RL+HL	-37.54	0.69	0.25	0.20	-0.16			0.99	0.01
1- 3PPI	CG	-33.45	0.86						0.92	0.00
	CG+WH	-36.54	0.51	0.46					0.97	0.05
	CG+WH+BL	-40.64	0.45	0.36	0.24				0.98	0.01
	CG+WH+BL+CD	-40.29	0.41	0.29	0.25	0.24			0.987	0.005
	CG+WH+BL+CD+RL	-40.55	0.41	0.31	0.24	0.28	-0.12		0.990	0.003
Male										
1PPI	BL	-42.99	1.20						0.93	0.00
	BL+CG	-44.21	0.84	0.32					0.97	0.04
	BL+CG+PW	-46.72	0.78	0.32	0.38				0.98	0.01
	BL+CG+PW+WH	-50.82	0.59	0.29	0.31	0.27			0.99	0.01
2PPI	CG	-48.10	1.09						0.97	0.00
1-2PPI	CG	-43.21	1.01						0.91	0.00
	CG+BL	-45.09	0.62	0.49					0.96	0.05
	CG+BL +WH	-53.78	0.52	0.43	0.39				0.97	0.01
	CG +BL+WH +HL	-49.77	0.50	0.31	0.36	0.06			0.98	0.01

Note: CG =chest girth, BL= body length, WH= wither height, CD= chest depth, PW= pelvic width, RL= rump length, HL= horn length

DISCUSSION

Qualitative Traits: In both sexes, the main dominant coat color patterns of the sheep were plain and patch with the same proportions of appearance. The study results are in good line with the finding of Abera *et al*. [26] for the sheep population found in east Gojam zone as well as Hailu *et al.* [27] for Tahtay maichew sheep population. Similarly, Coat colors can vary among the different agro ecology. The most of the high and midland indigenous sheep from the recent study have brown and grey. Indigenous sheep populations sampled from the lowland area show dominantly white colors which is in line with the report of Getachew *et al*. [28] for the lowland Afar sheep. Among the qualitative traits coat color and presence of horn are used as a criteria to select individual sheep for breeding purpose [23].

The majority of the sampled sheep have straight head profile, semi-pendulous ear orientation and straight back profile. The results are in agreement with the finding of Demeke *et al*. [29] in Meket and Giday sheep types. Majority of sampled sheep population had short fat tailed (50.93%) followed by long fat (40.07%) tail type. According to the Gebreyowhens and Tesfay [16], the Highland sheep of Tigray is characterized as short fat tailed. Another studies indicated by Edea *et al*. [30] for Bonga sheep and Getachew *et al.* [31] for Horro and Menz sheep had characteristic long fat tail.

Body Weight and Linear Measurement: Majority of the studied quantitative traits were affected by agro ecological difference, which might be due to the difference in age of sheep, management levels and agro ecological zone in which the flocks were kept. Most of the highland sheep have higher values for body length, chest girth, chest depth, ear and length as compared to lowland sheep, which might aid them to adapt their environment. This finding is contrary the results of Hailu *et al.* [27], who reported lowland sheep have higher value for body measurement traits than highland sheep in Tahta machew district. Hailemariam *et al.* [32] and Nugise *et al*. [33] reported that agro ecology was the highest contribution factor to the in linear measurement and body weight of the sheep might due to the non -genetic factor (like feed quality and quantity, environmental factor, management levels).

Most of linear body measurement traits show significant different between sexes. The traits were larger for males than females, which might qualified to enhanced skeletal bone development and muscle mass in male due to testosterone hormone secretions [34]. These results are in agreement to the previous studying with Gebreyowhens and Tesfay [16] and Hailu *et al.* [27] who reported that males were greater than the females in most linear quantitative traits in sheep. The current study showed that no significant differences were observed among body weight of males and females sheep. The result is in line with the finding of Melaku *et al*. [15] for Simien sheep ewes and rams. Similar to this study the differences in most linear body measurements between sexes with rams being dominant over ewes [27, 35]. However, differences due to sex were not attributed in Tigray Highland sheep populations [18].

The overall body weight of male (27.38±1.10 kg) and female (26.85±0.30 kg) sheep in the study area was higher than the report of Abera et al. [26] who reported that the body weight of indigenous rams (26.09±0.47 kg) and ewes (22.46±0.31) found in south Wollo while the result is lower than the body weight of males (32.85±0.23 kg) and females (27.95±0.12) in Meket and Gidan District, North Wollo Zone [29]. Additionally, the body weight of males and females presented in the study area were higher than those reported for Tigray highland sheep and Simien sheep [15, 16], other quantitative traits such as height at withers, body length, chest girth, tail length and ear length were similar among those indigenous sheep populations.

The current results showed that body weight and most linear body measurements of the sheep population differences with age. The trend in most quantitative measurements increased with increase in dentition class one to three years. This result is in agreement with the reports of Asefa *et al*. [22] for Bale sheep and Hailu *et al*. [27] for Tahtay Machew distric sheep population who reported that the most body mesuamennts increased towards the optimum age of three years. Similar finding is also reported by Yoseph [36] who reported that the size and shape of the animal increases until the animal reaches its optimum growth point or until maturity.

The scrotal circumference of adult sampled sheep population (25.5±0.86 cm) is greater than matured Menz (24.5±0.58cm) sheep and less than matured Afar (27.5±0.67cm) sheep [37]. Edea [38] also reported that animals at older age group had larger scrotal circumference than animals at younger age groups. The result showed that this parameter is a sex dependent character and it is affected by the age of the male sheep. Body weight of males in age group 1PPI (23.64±0.96) and age group 2PPI (32.06±1.09) in the current study is higher than body weight of Menz males (22.9 ± 0.39kg) and 24.9 ± 0.67 in the same age group [37].

Both in males and females chest girth was the most strongly correlated trait with body weight (r=0.90 for males; r=0.94 for females). The result shows that chest girth was the highest association variable for predicting live weight than other measurements. This result is in agreement with other results [23, 39]. Ear length had lower and negative correlation with body weight and other linear body measurements. This result is in line with the report of Asefa *et al*. [22] for Bale zone sheep who reported negative correlation coefficients of ear length with body weight and other linear body measurements. Scrotum circumferences (SC) have positive and strong correlation with body weight at most other linear body measurement with correlation coefficient of 0.56 for males. The strong correlation of SC with body weight is in agreement with previous reports of Holla sheep breed [40].

CONCLUSIONS

Majority of the indigenous sheep had plain coat pattern, brown, grey and white coat color, straight head and back profile, semi-pendulous ear orientation and short fat tail type. The current study indicated that most of different linear body measurements were significantly affected by agro ecology with higher values recorded in highland as compared to lowland and midland sheep. Sex and age classes of for most linear body measurements were found to be significant ($P<0.05$) except ear length and scrotal circumferences. Most of the quantitative measurements are higher in males than females. The trend in most of the quantitative traits increased with increase in dentition class one to three ages. Positive and strongly significant ($p<0.05$) correlations were observed between body weight and most of the linear body measurements. The result of the stepwise regression analysis showed that chest girth was the highest association variable for estimating body weight of sheep. The present phenotypic information could enable to conserve and improve the indigenous sheep population in the study area. It is recommended that molecular level characterization of sheep population in the study area would necessary to validate the current phenotypic results particularly on evaluating the genetic potential.

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