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Original Article

On-Farm Phenotypic Characterization of Indigenous Sheep in Simada and Lay Gayint Districts, South Gonder Zone Of Amhara Region, Ethiopia

Sintayehu Sisay Mekonen

Animal science department, Bonga university, Bonga, Ethiopia

ABSTRACT

The study was carried out in Simada and Lay- Gayint districts of South Gonder Zone. The objectives were to describe and phenotypically characterize indigenous sheep populations in the study area. The body measurements were taken from 400 (280 females, 120 males) sheep. The majority of coat colour pattern of Simada sheep was plain (57%), with the most frequently observed coat color type being light red. Similarly, 67% of the Lay-Gayint sheep had plain coat color pattern. Majority of Simada and Lay Gayint sheep has short fat tailed and the tail was cylindrical with curved tip at the end. Average estimated body weight, heart girth, wither height and body length for Simada adult male sheep were 27.45±0.18kg, 77.95±0.28 cm, 66.83±0.30cm, and 58.63±0.15cm, respectively. While that for female sheep of the same district was 24.59±0.13kg, 74.60±0.18 cm, 65.64±0.22 cm and 57.47±0.17cm. Age of sheep had significant ($p<0.01$) effect on body weight and many of the linear body measurements. In conclusion, the present morphometric information could aid future decision on the management, conservation and improvement of the indigenous sheep genetic resources and provide preliminary information for further research, either genotypic or molecular level characterization of sheep, which would be undertaken to investigate characteristic of the sheep type and estimate its genetic potential.

Keywords: Sheep breed, phenotype characterization, Lay Gayint, Simada

Corresponding Author: Sintayehu Sisay Mekonen <sintiesisay12@gmail.com >

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INTRODUCTION

Ethiopia is home for diverse indigenous sheep populations, being the largest in Africa, parallel to its diverse ecology, production systems and ethnic communities. The estimated livestock population of Ethiopia is about 70 million cattle, 42.9 million sheep, 52.5 million goats, 0.39 million mules, 10.8 million donkeys, 2.15 million horse, 8.1 million camels, and 57 million poultry (CSA, 2021). The Amhara National Regional State has above ten 10 million heads of sheep (CSA, 2021). Sheep have special features like efficient utilization of marginal and small plot of land, short generation length, high reproductive rate, low risk of investment and more production per unit of investment as compared with cattle (Gizaw S. *et al*., 2008).

Characterization of farm animal genetic resources (e.g., sheep, goat, cattle) is essential in managing the resource for optimum benefit. Farm animal genetic resources are organized into 'breeds' that describe productive and adaptive characteristics of identified groups of animals (Gizaw S. *et al*., 2008).

Phenotypic characterization of animal genetic resources (AnGR) for food and agriculture is the practice of systematically documenting the observed characteristics, geographical distribution, production environments and uses of these resources. The information provided by characterization studies is essential for planning the management of AnGR at local, national, regional and global levels. The Global Plan of Action for Animal Genetic Resources recognizes that "A good understanding of breed characteristics is necessary to guide decision-making in livestock development and breeding programs". The Global Plan of Action's Strategic Priority Area is devoted to "Characterization, Inventory and Monitoring of Trends and Associated Risks" (FAO, 2011).

Despite characterizing and properly documenting the small ruminant genetic resource is crucial for further conservation and managements of animal genetic resource. information on phenotypic traits of this sheep type is limited. Hence, detailed characterization study of Simada and Lay Gayint sheep is required. Therefore, this study was set with the objective to describe and phenotypically characterize indigenous sheep populations in the study area

MATERIALS AND METHODES

Description of the Study Area

The study was conducted in Simada and Lay Gayint districts of South Gonder Zone, Amhara National Regional State.

Simada district

The administrative town of the district is located about 105 km southeast of the zonal capital Debre Tabor and 205 and 770 kms away from the regional capital Bahir Dar and,from the capital city of Ethiopia, Addis Ababa. Agro-ecologically, the district is classified as 48% lowland, 41% midland and 11% high land. The livestock population of the district is composed of 142,258 cattle, 97,399 goats, 107,586 sheep, 22,703 equine, 86,944 poultry and 14,031 beehives. Its land use pattern is 89,480ha cultivated land, 283,282ha forest land, 68,311.42ha grazing land and 397,886ha others (Simada district agricultural office report, 2016).

Lay Gayint district

Lay Gayint district is located 75 km from Debre Tabor, 175 km from Bahir Dar and and 739 km from Addis Ababa. There are 29 rural Kebele and 3 urban kebeles in Lay Gayint district. The production system in this area is characterized by a mixed crop-livestock system..

The district has a human population of 208,244, of which 105,713 are males and 102,536 are females. The total number of rural households of the woreda is 39,908 among which 31,515 are men and 8,393 are women headed. It falls under four agro-ecological zones, 39.4% highland, 45.4% midland, 7.6% lowland and 7.6% frosty.

Sampling procedure

The districts were purposively selected based on their high sheep population and road accessibility. Selections of the kebeles in the districts were done using multi-stage purposive sampling technique. Ten Kebeles in each study district were selected purposively based on their suitability for sheep production, road access, non-adjacent kebeles to one another and willingness of the farmers to participate in the study. A total of 280 female (14 females from each kebele) and 120 male (6 from each kebele) sheep were selected for body linear measurements. About 1-3 unrelated sheep were taken from each household. Explanatory and confirmatory survey was done before the main survey to know the presence and absence of traditional classification of sheep, distribution and concentration of local sheep types in the kebeles.

Morphological traits and Linear body measurements

The standard breed descriptor list for sheep developed by FAO (2012) was closely followed in selecting morphological variables. Qualitative traits like: coat color pattern, coat color type, hair type, head profile, ears, wattle, horn and tail were observed and recorded. Quantitative traits measurements like Heart girth (HG), Body length (BL), Height at wither (HW), Rump width (RW), Ear length (EL), Horn length (HL), Tail length (TL), Tail width (TW), Rump length (RL) and Scrotum circumference (SC) were measured from adult (matured) sheep using flexible measuring tape on level ground while weight was measure using suspended spring balance having 50 kg capacity with 0.2 kg precision. Each experimental animal was identified by sex and district. Sheep was classified into four age groups; 1PPI (one pair of permanent incisor), 2PPI (two pair of permanent incisor) 3PPI (three pair of permanent incisor and 4PPI (four pair of permanent incisor). Linear body measurements were done by restraining and holding the animals in a stable condition.

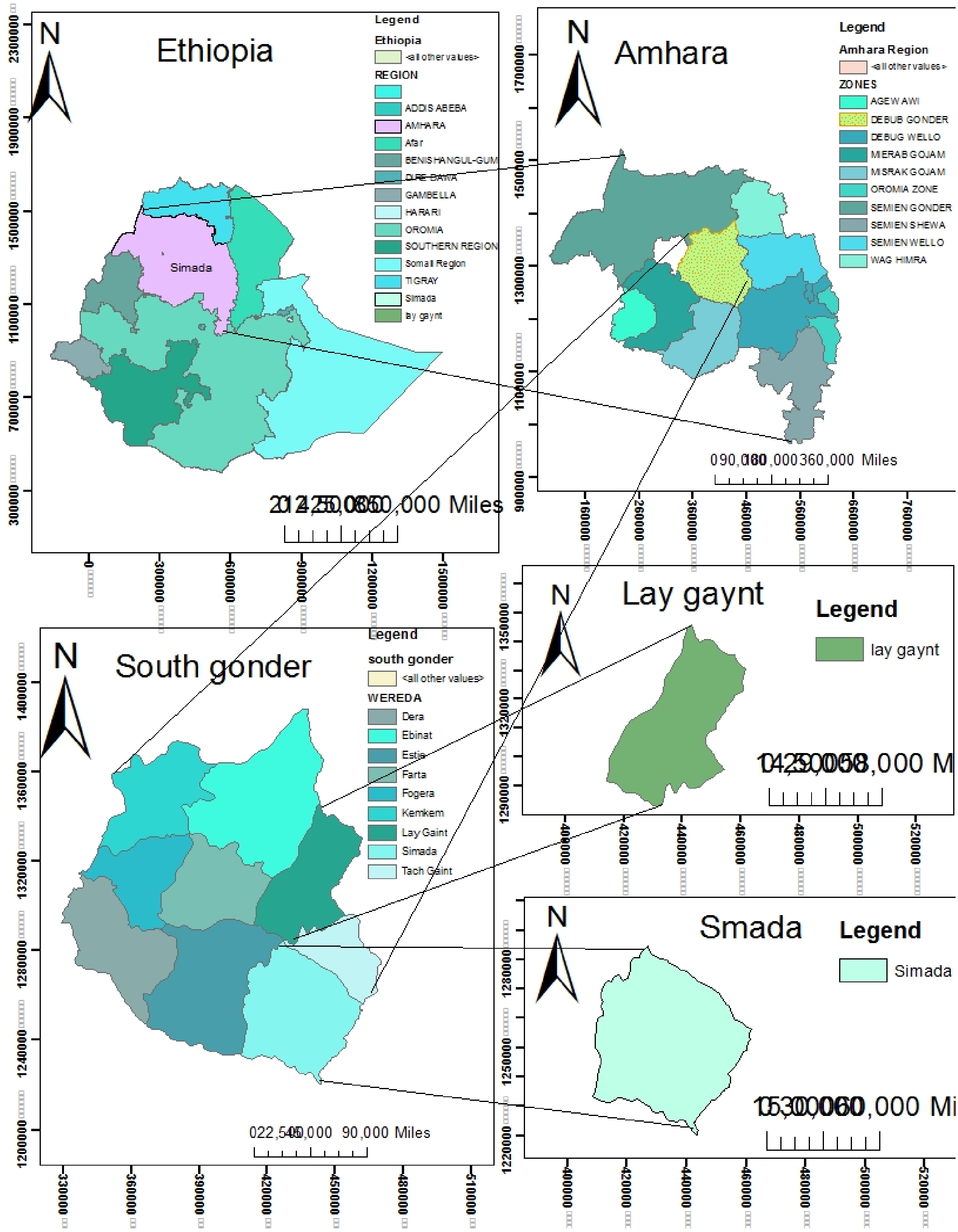

Figure 1: Maps of the study areas

Data analyses

Quantitative and qualitative data were entered into Microsoft Office Excel, 2010 and analyzed using Statistical Analysis System Version 9.2 (SAS, 2008). Basic statistics (mean, standard deviation, frequency and percentage) were undertaken for qualitative and quantitative traits. A General Linear Model (GLM) procedure of SAS was used to analyze data from quantitative data of adult sheep. For morphological characterization of adult sheep, the data was analyzed fitting linear body measurements as independent variables and sheep population as fixed factor. The magnitudes of quantitative variables were expressed as Least Square Means (±SE).

Model used for the least - squares analysis in females and males was:

$Yijk = \mu + Bi + Dj + (B \times D)ij + eijk$

Where: Yijk= Observed body weight or linear measurements

μ = Overall mean

Bi = the fixed effect of i^{th} district (i = Lay Gayint, Simada)

Dj = the fixed effect of j^{th} dentition classes (j = 1PP, 2PPI, 3PPI, 4PPI)

(B x D)ij = Dentition by district interaction effect

Eijk = random error

Univariate and multivariate analysis

General linear model procedures (PROC GLM) of SAS were employed for the analysis quantitative variables. Mean comparisons were undertaken for quantitative variables in each district populations. For qualitative measurement descriptive statistics have been used. The quantitative variables from female and male animals were separately subjected to discriminant analysis (PROC DISCRIM of SAS) and canonical discriminant analysis (CAN DISC) programme to ascertain the existence of population level phenotypic differences among the sample sheep populations in the study area.

Correlation analysis was done between body weight and other linear body measurements for each population. This was done separately for the two sexes including Scrotum Circumference (SC) for males. The stepwise REG procedure of SAS (2008) was used to determine the relative importance of live-animal body measurements in a model designed to predict body weight. Small Alkaike's Information Criteria (AIC), Conceptual predictive criterion (Cp) and Error mean square (MSE) value and higher adjusted coefficient of determination (R^2) are included in regression equation. The small Cp indicates precision and small variance in estimating the population regression coefficients while the coefficient of determination (R^2) represents the proportion of the total variability explained by the model. Error mean square (MSE) usually decreased when new variables are added to the model but addition of unnecessary variable to the model can increase the MSE.

The following model was used to regress body weight from linear body measurements for male:

$Yj = \alpha + \beta_1X_1 + \beta_2X_2 + . . . + \beta nXn + \varepsilon j$

Where: Yj = the dependent variable; body weight

α = the regression intercept

X1, X2 . . . Xn are the explanatory traits (BC, BL, HW, CG, CW, RL, PW, HL, EL and SC)

β1, β2, . . . βn are partial regression coefficients of the traits

εj= the residual random error

The following model was used to regress body weight from linear body measurements for female.

$Yj = \alpha + \beta_1X_1 + \beta_2X_2 + . . . + \beta_nX_n + \varepsilon j$

Where: Yj = the dependent variable; body weight

α = the regression intercept

X_1, X_2. . . X_n are the explanatory traits (BC, BL, HW, CG, CW, RL, PW, HL, and EL)

β_1, β_2, . . . βn are partial regression coefficients of the traits

εj= the residual random error

Canonical discriminant analysis

Canonical discriminant analysis is a dimension-reduction technique related to principal component analysis and canonical correlation. Given a classification variable and several interval variables, canonical discriminant analysis derives *canonical variables* (linear combinations of the interval variables) that summarize between-class variation in much the same way that principal components summarize total variation. The analysis was implemented by calling the DISCRIM procedure with the CANONICAL option in SAS 9.2, 2008.

Results and Discussions

Morphological Characters of Simada Sheep

The morphological characters of Simada sheep are presented (Table 1). All the sheep studied are exclusively short fat tailed (100%) where the dominant tail shape is cylindrical with curved tip at the end (93.0%).The reaming sheep tail shape were cylindrical straight (7.0%). Majority (94.0%) of sheep had coarse wool coat hair type whereas sheep with hair coat hair type accounted for 6.0%. Coat colour pattern of Simada sheep was plain (57.0%), patchy (33.5 %) and spotty (9.5%). Coat colour type of plain light red (31.5%), plain white (28.5%), and white with light red patch (7%) were observed for Simada sheep.

Table 1: Morphological characters of Simada sheep

		Male		Female		Total	
Variable	Trait	N	%	N	%	N	%
Coat color pattern	Plain	35	58.3	79	56.4	114	57.0
	Spotted	7	11.7	12	8.6	19	9.5
	Patchy	18	30.0	49	35.0	67	33.5
	Total	60	100.0	140	100.0	200	100.0
Coat color	Black	5	8.3	12	8.6	17	8.5
	White	17	28.3	40	28.6	57	28.5
	Light red	20	33.3	43	30.7	63	31.5
	Dark red	0	0.00	4	2.9	4	2.0
	Balch and white	7	11.7	11	7.9	18	9.0
	Light red and white	11	18.3	30	21.4	41	20.5
	Total	60	100.0	140	100.0	200	100.0
Hair type	Hair	4	6.7	8	5.7	12	6.0
	coarse wool	56	93.3	132	94.3	188	94.0
	Total	60	100.0	140	100.0	200	100.0
Horn	Present	57	95.0	0	0.00	57	28.5
	Absent	3	5.0	140	100.0	143	71.5
	Total	60	100.0	140	100.0	200	100.0
Horn shape	Spiral	45	78.9	0	0.00	45	78.9
	Straight	0	0.00	0	0.00	0	0.00
	Curved	12	21.1	0	0.00	12	21.1
	Total	57	100.0	0	0.00	57	100.0
Horn orientation	Lateral	12	21.1	0	0.00	12	21.1
	back ward	45	78.9	0	0.00	45	78.9
	Total	57	100.0	0	0.00	57	100.0
Head profile	Straight	38	63.3	119	85.0	157	78.5
	Concave	0	0.00	0	0.00	0	0.00
	Convex	22	36.7	21	15.0	43	21.5
	Total	60	100.0	140	100.0	200	100.0
Wattle	Present	0	0.00	37	26.4	37	18.5
	Absent	60	100.0	103	73.6	163	81.5
	Total	60	100.0	140	100.0	200	100.0
Tail shape	cylindrical straight	2	3.3	12	8.6	14	7.0
	cylindrical turned up at end	58	96.7	128	91.4	186	93.0
	Total	60	100.0	140	100.0	200	100.0
Tail type	Short fat	60	100.0	140	100.0	200	100.0
Ear Orientation	Pendulous	60	100.0	140	100.0	200	100.0

The head profile of most of the sample populations of males and females were straight (78.5%) followed by convex (21.5%) which is mainly observed in males. About 26.4% of the female had wattle while all of the males had no wattle. Pendulous ear forms observed in all (100%) the sample sheep population in simada district.
All (100%) of the ewes were polled whereas most (95.0%) of the rams were horned. Out of the horned rams, 78.9% had spiral horn shape and the remaining 21.1% had curved horn. Out of the total rams having spiral and curved shape, almost half (78.9%) of the ram had back ward oriented and the remaining 21.1% had laterally oriented horns. The horn shape and orientation obtained in this study are in agreement with the report for Menz sheep (Tesfaye, 2008).

Morphological Characters of Lay Gayint Sheep

The physical body characteristics for Lay Gayint sheep obtained in the present study are presented in (Table 2). Most (67.0%; 61.7 for males and 69.3% for females) of the Lay Gayint sheep had plain coat color pattern followed by patchy (23.5%) and spotted(9.5%). There were different coat color types in Lay Gayint sheep populations to which white coat color was relatively frequent (34.5%; 30.0% for males and 36.4% for females) in both males and females and light red (dangle) (28.0%; 28.3% for males and 27.9% for females) was the next dominate coat color for both sexes. Black, dark red, the mixtures of black and white and light red and white were accounted for 14.5%, 8.0%, 5.0% and 10.0%, respectively.
Lay Gayint Sheep is short fat tailed (100%) and the tail was cylindrical turned up at end (92.5%). Almost all (90.0%) of Lay Gayint sheep had coarse wool/hair and semi-pendulous ear form (100%). To this end, similar result was reported by Sisay (2002) for central highland sheep and Solomon (2008) for Tikur sheep. The proportions of sheep with straight, convex and concave head profile were 64.5%, 32.0% and 3.5%, respectively. On average, the morphological characteristics obtained in this study agree with the report of (Bimrew *et al*., 2011) for the farta sheep.
Horn and wattle are sex dependent characteristic in Lay Gayint sheep. In the present study, horn was present in 96.7% male but absent in female Lay Gayint sample sheep population. Most common horn orientation observed in the sample male population in the district were backwards orientation (75.9 %) where as the dominant horn shape (60.3%) were curved one. The remaining 37.9% and 1.7% had horn shape of spiral and straight for the same district. Rams had no wattle while 2.1% of the ewes were with wattle. The current finding on horn of sheep in Lay Gayint is consistent with report by Sisay (2002) and Solomon (2008).

Table. 2 Morphological characters of Lay Gayint sheep

		Male		Female		Total	
Variable	Trait	N	%	N	%	N	%
Coat color pattern	Plain	37	61.7	97	69.3	134	67.0
	Spotted	8	13.3	11	7.9	19	9.5
	Patchy	15	25.0	32	22.9	47	23.5
	Total	60	100.0	140	100.0	200	100.0
Coat color	Black	11	18.3	18	12.9	29	14.5
	White	18	30.0	51	36.4	69	34.5
	Light red	17	28.3	39	27.9	56	28.0
	Dark red	4	6.7	12	8.6	16	8.0
	Balch and white	2	3.3	8	5.7	10	5.0
	Light red and white	8	13.3	12	8.6	20	10.0
	Total	60	100.0	140	100.0	200	100.0
Hair type	Hair	9	15.0	11	7.9	20	10.0
	coarse wool	51	85.0	129	92.1	180	90.0
	Total	60	100.0	140	100.0	200	100.0
Horn	Present	58	96.7	0	0.00	58	29.0
	Absent	2	3.3	140	100	142	71.0
	Total	60	100.0	140	100.0	200	100.0
Horn shape	Spiral	22	37.9	0	0.00	22	37.9
	Straight	1	1.7	0	0.00	1	1.7
	Curved	35	60.3	0	0.00	35	60.3
	Total	58	100.0	0	0.00	58	100.0
Horn orientation	Lateral	14	24.1	0	0.00	14	24.1
	back ward	44	75.9	0	0.00	44	75.9
	Total	58	100.0	0	0.00	58	100.0
Head profile	Straight	37	61.7	92	65.7	129	64.5
	Concave	2	3.3	5	3.6	7	3.5
	Convex	21	35.0	43	30.7	64	32.0
	Total	60	100.0	140	100.0	200	100.0
Wattle	Present	0	0.00	3	2.1	3	1.5
	Absent	60	100.0	137	97.9	197	98.5
	Total	60	100.0	140	100.0	200	100.0
Tail shape	cylindrical straight	0	0.00	16	11.4	16	8.0
	cylindrical turned up at end	60	100.0	124	88.6	184	92.0
	Total	60	100.0	140	100.0	200	100.0
Tail type	Short fat	60	100.0	140	100.0	200	100.0
Ear Orientation	semi-pendulous	60	100.0	140	100.0	200	100.0

Body Weight and Linear body measurements

Live body weight (Kg) and body measurements of female sheep in the study area are shown in Table 3. Districts were not significantly ($P > 0.05$) different in most of the body measurements in female sheep except ear length, rump length and tail width which is higher in Lay Gayint than Simada district whereas, Simada sheep had significantly ($P < 0.05$) higher values for rump width. Body weight and linear measurements of male sheep in the study district are indicated in Table 3 Results for body weight and linear measurements of male sheep revealed that Lay Gayint males had significantly ($P < 0.01$) larger height at wither, body length, rump length and tail width than Simada males. Simada male on the other hand had higher value for heart girth, scrotal circumferences and rump width than Lay Gayint male. Such differences might be due to slight management and environmental differences between the two districts. With similay to this study The difference in the linear body measurement and the body weight within the same sex with different agro ecology was also reported by (Fsahatsion H. *et al;* 2018)

The overall body weight value for ewes (24.45±1.52kg) and for rams (26.60±1.22 kg) reported in the present study was higher than the result of Afar ewes (21.2±0.16) and rams (24.3±0.50kg) which is reported by Tesfay (2008). While, it was lower than the value reported by (Abera *et al.* 2016) for ewe (28.3 kg) and ram (30.8 kg) for Gozamen, Sinan and Hulet eju districts in East Gojam. Body weight of rams (26.60±1.22 kg) is lower than that reported by Bimrew *et al* (2011) for Farta sheep (28.0±0.51) of the same breed and Sisay (2002) for central highland sheep (29.4 kg). Similarly the weight of ewes (24.45±1.52 kg) in this study is lower than the value (27.65±0.21kg) reported for Horro ewes (Zewdu, 2008) and (29.68 kg) reported for Dawro and Konta ewes (Amelmal, 2011).

Age Effect- In this study age classes in female sheep significantly affected body weight and most of the body measurements. Rump length, tail width and tail length in Simada and only tail length in Lay Gayint district were not affected (P>0.05) by age group. Likewise, in males age classes or groups significantly (P<0.01) affected body weight, heart girth; wither height, body length and scrotal circumference, tail length, rump length and tail width.

Body measurements such as bodyweight, heart girth, height at wither and body length were kept increased as the age increased from the age group1(youngest) to age group 4 (oldest) and reached their maximum value in the oldest age (4pp) of the sheep as indicated in Figures 1and 2. This implies that these variables might be best explaining the growth pattern of the animals. Larger variation was observed between animal in age group 2 and 3. This was attributed to the fact that animals at these life phase shows fast growth rate compared to at the later ages. Hence this may be the appropriate age to get maximum output from our input. Whereas lower variation observed between animals in age group 3 and 4 and most probably because the matured body weight of the animal was almost fully attained. This is in agreement with the report (Hailu A. *et al*; 2020) reported that values of some traits (body weight, chest depth, shoulder point width, rump width, testis circumference, body length, heart girth, and height at withers) gradually increased towards the optimum age of three years and then decreased towards the oldest age.

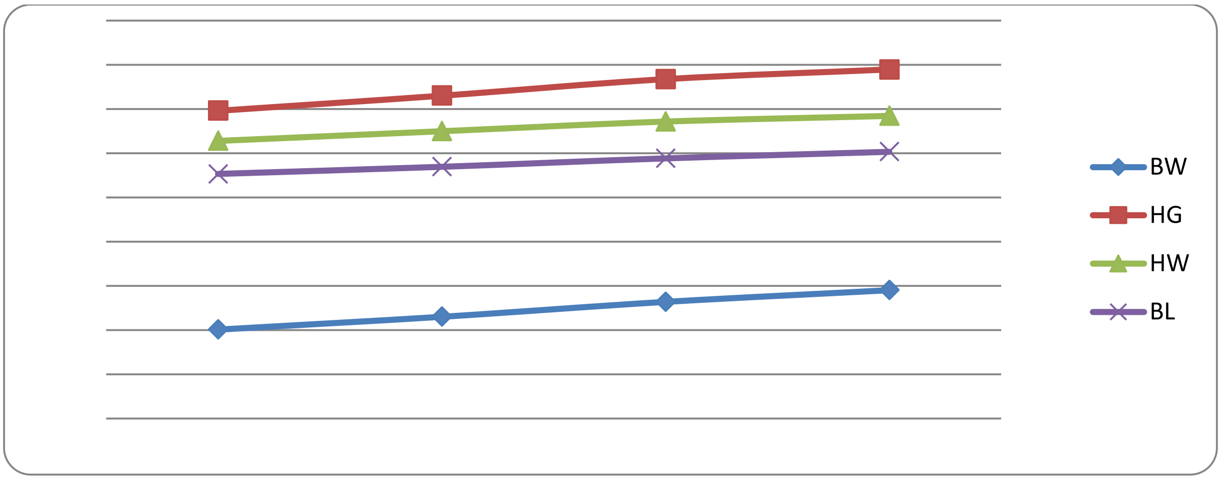

Figure 2: Effect of age on body weight, heart girth, height at withers and body length female sheep

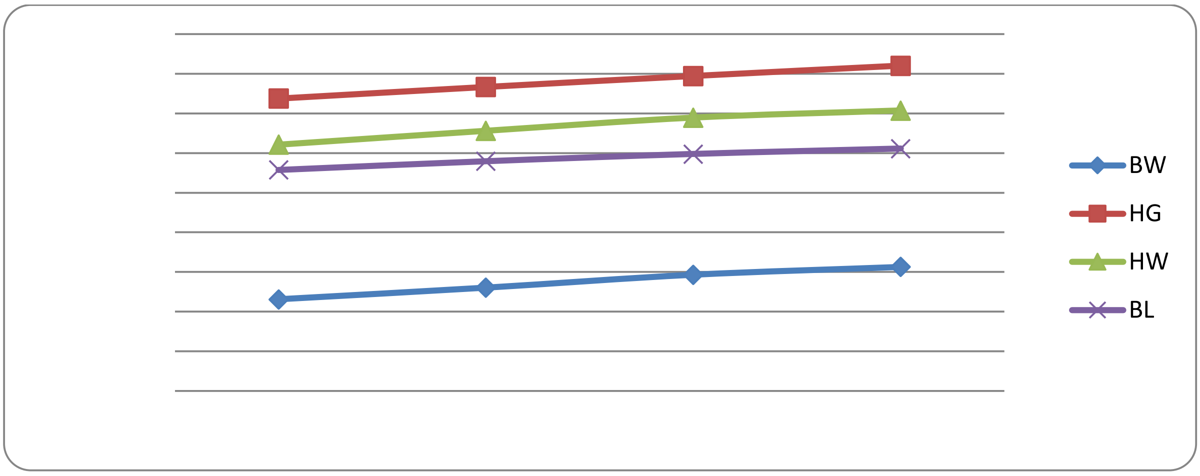

Figure 3: Effect of age on body weight, heart girth, height at withers and body length male sheep

Animals in age groups 3 and 4 had higher values than those between 1 and 2 age categories. This shows that younger animals (in dentition one and two) were still growing compared to animals at advanced age. Yet the older animals (> 3 pairs of permanent incisors) had higher values than the middle age animals (2- 3 pairs of permanent incisors) in most of the parameters considered. This scenario is however not surprising since the size and shape of the animal is expected to increase as the animal is growing with age.

Table 3: Least squares means (LSM) ± standard error (SE) for the main effect of district and dentition and district by dentition interaction on the live body weight (Kg) and body measurements in female Simada and Lay Gayint Sheep

Effect and level	N	BW	HG	HW	BL	EL
Over all		24.45±1.52	74.38±2.04	65.82±2.51	57.74± 1.92	10.38±1.33
District						
Simada	140	24.59±0.13	74.60±0.18	65.64± 0.22	57.47± 0.17	10.19±0.12^{a}
Lay gayint	140	24.69±0.13	74.55±0.17	66.10± 0.21	58.23± 0.16	10.60±0.11^{b}
Dentation class						
1PPI	62	20.12±0.19^{a}	69.61±0.25^{a}	62.82±0.31^{a}	55.30±0.24^{a}	9.64±0.16^{a}
2PPI	89	23.02±0.16^{b}	73.01±0.22^{b}	65.01±0.27^{b}	56.92±0.21^{b}	10.06±0.14^{ac}
3PPI	68	26.39±0.19^{c}	76.75±0.25^{c}	67.19±0.30^{c}	58.84±0.23^{c}	10.51±0.16^{c}
4PPI	61	29.03±0.20^{d}	78.93±0.27^{d}	68.47±0.33^{d}	60.34±0.25^{d}	11.37±0.17^{d}
Dent by district						
1PPI, Simada	29	20.00±0.25^{a}	69.20±0.34^{a}	63.02±0.42^{a}	55.05±0.32^{a}	9.62±0.22^{a}
2PPI, Simada	50	22.71±0.21^{b}	72.92±0.28^{b}	64.71±0.34^{b}	56.30±0.27^{ad}	9.96±0.18^{a}
3PPI, Simada	38	26.26±0.27^{c}	76.77±0.37^{c}	67.10±0.46^{c}	58.40±0.35^{bc}	10.00±0.24^{a}
4PPI, Simada	23	29.39±0.31^{d}	79.52±0.42^{d}	67.73±0.52^{ce}	60.13±0.40^{e}	11.17±0.28^{bc}
1PPI, Lay Gayint	33	20.24±0.28^{a}	70.03±0.38^{a}	62.62±0.46^{a}	55.55±0.35^{a}	9.65±0.24^{a}
2PPI, Lay Gayint	39	23.34±0.25^{b}	73.11±0.34^{b}	65.31±0.42^{bc}	57.54±0.32^{bd}	10.17±0.22^{ac}
3PPI, Lay Gayint	30	26.52±0.24^{c}	76.73±0.33^{c}	67.28±0.40^{c}	59.28±0.31^{ce}	11.02±0.22^{b}
4PPI, Lay Gayint	38	28.68±0.24^{d}	78.34±0.33^{d}	69.21±0.40^{e}	60.55±0.31^{e}	11.57±0.22^{b}

^{a,b,c,d,} means on the same column with different superscripts within the specified dentition group are significantly different (P<0.05); BW = Body weight; HG = Heart Girth; HW = height at wither; BL = Body Length; EL = Ear Length; 1PPI= 1 Pair of Permanent Incisors; 2 PPI = 2Pairs of Permanent Incisors; 4PPI = 4 pair of permanent incisors

Continued from table 3: Least squares means (LSM) ± standard error (SE) for the main effect of district and dentition and district by dentition interaction on the live body weight (Kg)and body measurements in female Simada and Lay Gayint Sheep

		LSM± SE			
Effect and level	**N**	**RW**	**RL**	**TW**	**TL**
Over all	280	17.69±0.78	18.18±1.02	12.50±2.02	18.68±1.73
District					
Simada	140	17.88±0.07[a]	17.88±0.09[a]	11.53±0.18[a]	18.34±0.15
Lay Gayint	140	17.51±0.07[b]	18.49±0.09[b]	13.50±0.17[b]	18.93±0.15
Dentation class					
1PPI	62	16.89±0.09[a]	17.52±0.13[a]	11.89±0.25[a]	18.40±0.21
2PPI	89	17.57±0.08[b]	18.10±0.11[b]	12.21±0.22[ba]	18.33±0.19
3PPI	68	18.03±0.09[c]	18.38±0.12[bc]	13.11±0.24[c]	18.82±0.21
4PPI	61	18.29±0.10[c]	18.69±0.13[c]	12.85±0.26[bc]	19.00±0.23
Dent by district					
1PPI, Simada	29	17.37±0.13[a]	17.40±0.17[a]	11.14±0.34[ab]	18.91±0.29
2PPI, Simada	50	17.63±0.10[a]	17.75±0.14[a]	11.03±0.27[a]	18.15±0.24
3PPI, Simada	38	18.23±0.14[b]	18.16±0.18[ab]	12.23±0.36[b]	18.36±0.31
4PPI, Simada	23	18.30±0.16[b]	18.13±0.21[ab]	11.73±0.42[ab]	17.95±0.36
1PPI, Lay Gayint	33	16.41±0.14[c]	17.65±0.18[a]	12.65±0.37[bc]	17.89±0.32
2PPI, Lay Gayint	39	17.51±0.13[a]	18.45±0.17[b]	13.40±0.34[cb]	18.51±0.29
3PPI, Lay Gayint	30	17.84±0.13[ab]	18.6±0.16[bc]	14.00±0.32[c]	19.28±0.28
4PPI, Lay Gayint	38	18.28±0.13[b]	19.26±0.16[c]	13.97±0.32[c]	20.05±0.28[a]

[a,b,c,d,] means on the same column with different superscripts within the specified dentition group are significantly different (P<0.05); RW = rump width; RL = rump Length; TE = tail width; TL= tail length;1PPI= 1 Pair of Permanent Incisors; 2 PPI = 2Pairs of Permanent Incisors; 4PPI = 4 pair of permanent incisors

Table 4: Least squares means (LSM) ± standard error (SE) for the main effect of district and dentition and district by dentition interaction on the live body weight (Kg)and body measurements in male Simada and Lay Gayint Sheep

		LSM± SE				
Effect and level	**N**	**BW**	**HG**	**HW**	**BL**	**EL**
Over all	120	26.60±1.22	76.66±1.96	66.81±2.10	58.65±1.08	9.05±1.15
District						
Simada	60	27.45±0.18	77.95±0.28[a]	66.83±0.30[a]	58.63±0.15[a]	8.87±0.16
Lay Gayint	60	27.75±0.18	77.18±0.28[b]	68.32±0.30[b]	60.07±0.15[b]	9.35±0.16
Dentation class						
1PPI	43	22.88±0.24[a]	72.96±0.40[a]	62.75±0.43[a]	56.11±0.22[a]	8.92±0.23
2PPI	39	25.96±0.17[b]	76.33±0.27[b]	66.87±0.29[b]	58.18±0.15[b]	8.91±0.16
3PPI	21	29.27±0.27[c]	78.98±0.43[c]	68.84±0.46[c]	60.65±0.23[c]	9.06±0.25
4PPI	17	32.29±0.30[d]	82.00±0.48[d]	71.85±0.51[d]	62.47±0.26[d]	9.56±0.28
Dent by district						
1PPI, Simada	20	23.12±0.43[a]	73.75±0.69[a]	62.12±0.74[a]	55.75±0.38[a]	8.50±0.40
2PPI, Simada	18	26.06±0.22[b]	76.66±0.35[b]	65.60±0.38[b]	57.93±0.19[b]	8.40±0.21
3PPI, Simada	12	29.33±0.35[c]	79.41±0.56[cd]	68.91±0.60[c]	59.75±0.31[c]	8.91±0.33
4PPI, Simada	10	31.30±0.38[d]	82.00±0.62[c]	70.70±0.66[cd]	61.10±0.34[cd]	9.70±0.36
1PPI, Lay Gayint	23	22.65±0.25[a]	72.17±0.40[a]	63.39±0.43[a]	56.47±0.22a	9.34±0.24
2PPI, Lay Gayint	21	25.85±0.26[b]	76.00±0.42[ab]	68.14±0.45[cd]	58.42±0.23[b]	9.42±0.25
3PPI, Lay Gayint	9	29.22±0.40[c]	78.55±0.65[cb]	68.77±0.70[cd]	61.55±0.36[d]	9.22±0.38
4PPI, Lay Gayint	7	33.28±0.46[d]	80.00±0.74[d]	73.00±0.79[d]	63.85±0.41[e]	9.42±0.43

[a,b,c,d,] means on the same column with different superscripts within the specified dentition group are significantly different ($P<0.05$); BW = Body weight; HG = Heart Girth; HW = height at wither; BL = Body Length; EL = Ear Length; 1PPI= 1 Pair of Permanent Incisors; 2 PPI = 2Pairs of Permanent Incisors; 4PPI = 4 pair of permanent incisors

(***Continued from table 4***)

Least squares means (LSM) ± standard error (SE) for the main effect of district and dentition and district by dentition interaction on the live body weight (Kg)and body measurements in male Simada and Lay Gayint Sheep

		LSM± SE					
Effect and level	**N**	**SC**	**HL**	**RW**	**RL**	**TW**	**TL**
Overall	120	24.22±1.85	20.86±3.47	17.32± 0.62	18.63±1.17	16.41±1.52	21.15±1.66
District							
Simada	60	$25.36{\pm}0.27^{a}$	21.83±0.50	$17.84{\pm}0.09^{a}$	$18.50{\pm}0.17^{a}$	$16.23{\pm}0.23^{a}$	21.88±0.24
Lay gayint	60	$24.45{\pm}0.27^{b}$	20.89±0.51	$17.15{\pm}0.09^{b}$	$19.28{\pm}0.17^{b}$	$17.50{\pm}0.24^{b}$	21.38±0.24
Dentation class							
1PPI	43	$22.36{\pm}0.38^{a}$	$19.22{\pm}0.71^{a}$	$16.83{\pm}0.12^{a}$	$17.61{\pm}0.24^{a}$	$15.85{\pm}0.31^{a}$	$19.97{\pm}0.34^{a}$
2PPI	39	$23.70{\pm}0.26^{b}$	$20.06{\pm}0.49^{a}$	$17.30{\pm}0.08^{a}$	$18.73{\pm}0.16^{b}$	$16.25{\pm}0.21^{ac}$	$20.55{\pm}0.23^{a}$
3PPI	21	$26.68{\pm}0.41^{c}$	$22.90{\pm}076^{b}$	$17.77{\pm}0.13^{b}$	$19.20{\pm}0.25^{bc}$	$17.06{\pm}0.33^{bc}$	$23.04{\pm}0.36^{c}$
4PPI	17	$26.90{\pm}0.46^{c}$	$23.27{\pm}1.85^{b}$	$18.07{\pm}0.15^{b}$	$20.03{\pm}0.29^{c}$	$17.61{\pm}0.37^{b}$	$22.97{\pm}0.41^{c}$
Dent by district							
1PPI, Simada	20	$23.00{\pm}0.66^{ab}$	$18.87{\pm}0.22^{a}$	$17.50{\pm}0.27^{ab}$	$17.75{\pm}0.41^{a}$	$15.50{\pm}0.53^{a}$	$20.25{\pm}0.58^{ac}$
2PPI, Simada	18	$23.73{\pm}0.34^{bd}$	$19.46{\pm}0.63^{a}$	$17.56{\pm}0.10^{b}$	$18.36{\pm}0.21^{ac}$	$15.23{\pm}0.27^{a}$	$20.43{\pm}0.30^{a}$
3PPI, Simada	12	$27.25{\pm}0.53^{c}$	$24.58{\pm}1.00^{b}$	$18.00{\pm}0.15^{ab}$	$18.42{\pm}0.33^{ab}$	$16.25{\pm}0.43^{ac}$	$23.75{\pm}0.48^{b}$
4PPI, Simada	10	$27.10{\pm}0.59^{c}$	$24.40{\pm}1.09^{bc}$	$18.30{\pm}0.27^{a}$	$19.50{\pm}0.37^{bc}$	$16.80{\pm}0.58^{ac}$	$23.10{\pm}0.52^{b}$
1PPI, Lay Gayint	23	$21.34{\pm}0.38^{a}$	$19.56{\pm}0.72^{a}$	$16.17{\pm}0.12^{c}$	$17.47{\pm}0.24^{a}$	$16.21{\pm}0.31^{ab}$	$19.69{\pm}0.34^{a}$
2PPI, Lay Gayint	21	$23.66{\pm}0.40^{b}$	$20.66{\pm}0.75^{ac}$	$17.04{\pm}0.13^{ab}$	$19.07{\pm}0.25^{ab}$	$17.28{\pm}0.33^{bc}$	$20.66{\pm}0.36^{a}$
3PPI, Lay Gayint	9	$26.11{\pm}0.62^{cd}$	$21.22{\pm}1.15^{ab}$	$17.55{\pm}0.17^{ab}$	$20.00{\pm}0.39^{cb}$	$17.88{\pm}0.50^{c}$	$22.33{\pm}0.55^{cb}$
4PPI, Lay Gayint	7	$26.71{\pm}0.70^{c}$	$22.14{\pm}1.31^{ab}$	$17.85{\pm}0.31^{ab}$	$20.57{\pm}0.44^{cb}$	$18.42{\pm}0.57^{c}$	$22.85{\pm}0.62^{cb}$

[a,b,c,d,] means on the same column with different superscripts within the specified dentition group are significantly different (P<0.05); SC = scrotum circumference; HL = horn length; RW = rump width; RL = rump Length; TE = tail width; TL= tail length;1PPI= 1 Pair of Permanent Incisors; 2 PPI = 2Pairs of Permanent Incisors; 4PPI = 4 pair of permanent incisors

Table 5:Correlation coefficients among body weight and LBMs female (N=280) and males (N=120) of Simada and Lay Gayint sheep

	BW	HG	HW	BL	EL	RW	RL	TW	TL	HL	SC
BW	1	0.91**	0.65**	0.74**	0.39**	0.47**	0.43**	0.29**	0.16*	-	
HG	0.92**	1	0.61**	0.57**	0.36**	0.48**	0.40**	0.24**	0.11	-	
HW	0.83**	0.92**	1	0.50**	0.56**	0.49**	0.39**	0.23**	0.19*	-	
BL	0.77**	0.72**	0.67**	1	0.34**	0.43**	0.47**	0.35**	0.18*	-	
EL	0.84**	0.83**	0.68**	0.73**	1	0.33**	0.28**	0.11	0.11*	-	
RW	0.11	0.04	0.01	0.17*	0.11	1	0.40**	0.17*	0.24*	-	
RL	0.59**	0.59**	0.63**	0.47**	0.41**	0.04	1	0.26**	0.21*	-	
TW	0.51**	0.49**	0.47**	0.59**	0.53**	0.21*	0.44**	1	0.37**	-	
TL	0.28*	0.31*	0.25*	0.43**	0.40**	0.25*	0.06	0.34*	1	-	
HL	0.58**	0.55**	0.52**	0.43**	0.46**	0.25*	0.43**	0.28*	0.30*	1	
SC	0.40**	0.37**	0.42**	0.48**	0.29*	0.02	0.27*	0.40**	0.29*	0.38**	1

BW =Body weight; HG= Heart girth; HW=Height at withers; BL=Body length; EL=Ear length; RW=Rump width; RL= Rump length; TW= Tail width; TL=Tail length; HL=Horn length SC= Scrotal circumference; **Correlation is significant at p <0.01; Values above the diagonal are for females and below the diagonal are for males

Table 6: Multiple linear regression analysis of live body weight on different LBMs for female and male sheep

Model	**I (β_0)**	**β_1**	**β_2**	**β_3**	**β_4**	**β_5**	**β_6**	**β_7**	**β_8**	**R^2**	**Adj. R^2**	**C(P)**	**AIC**	**Root MSE**	**SBC**
Male															
HG	-38.37	.84								.85	.85	131.37	62.12	1.28	67.69
HG+BL	**-51.70**	**.60**	**.54**							**.93**	**.93**	**1.48**	**-27.29**	**.88**	**-18.92**
HG+BL+RL	-51.87	.61	.56	-.09						.93	.93	1.68	-27.17	.87	-16.02
HG+ BL+ RW +RL	-52.87	.58	.57	.16	-.11					.93	.93	1.84	-27.13	.87	-13.19
HG +BL+ RW+ RL+ TL	-52.39	.58	.56	.14	-.10	.05				.93	.93	2.64	-26.42	.87	-9.70
HG+ BL+ HL+ RW +RL+ TL	-52.54	.58	.55	-.02	.13	-.09	.06			.93	.93	3.91	-25.21	.87	-5.70
HG+ HW+ BL+ HL +RW+ RL+ TL	-52.49	.58	.03	.53	-.02	.12	-.10	.06		.93	.93	5.28	-23.90	.87	-1.60
HG+ HW+ BL+ HL+ EL+ RW+ RL+ TL	-52.23	.57	.03	.53	-.02	-.03	.12	-.09	.06	.93	.93	7.10	-22.11	.87	2.97
Female															
HG	-36.78	.82								.83	.83	238.01	208.9	1.44	216.2
HG+BL	-49.20	.65	.43							.90	.90	10.60	45.43	1.07	56.34
HG+HW+BL	-50.68	.62	.07	.41						.91	.91	3.95	38.79	1.06	53.33
HG+HW+BL+ RW	**-49.96**	**.62**	**.08**	**.42**	**-.14**					**.91**	**.91**	**2.92**	**37.70**	**1.06**	**55.87**
HG+HW+BL+ RW+RL	-49.79	.62	.08	.43	-.12	-.06				.91	.91	3.90	38.65	1.06	60.46
HG+HW+BL+RW+RL+TL	-50.00	.63	.08	.43	-.13	-.07	.03			.91	.91	5.11	39.84	1.06	65.28
HG+HW+BL+RW+RL+TW+TL	-50.11	.63	.08	.43	-.13	-.07	-.01	.03		.91	.91	7.00	41.72	1.06	70.80
HG+HW+BL+EL+ RW+RL+TW+TL	-50.14	.63	.08	.43	-.00	-.13	-.06	-.01	.03	.91	.91	9.00	43.72	1.06	76.43

Correlation between body weight and linear body measurements

Pearson correlation matrix that indicates the association between live weight and other body measurements in sampled sheep are shown in Table 5 Strong positive correlation (*P*<0.01) between body weight, heart girth, height at wither, body length, ear length, rump width, rump length, tail width and tail length were observed in sampled female sheep.

Similarly, correlation matrix of the male sample population also confirmed that a strong positive correlation (*P*<0.01) between body weight, heart girth, height at wither, body length, ear length, rump length, tail width, tail length, horn length and scrotum circumference. The strong correlation of SC with body weight is in agreement with the result observed on Gamogofa ram (Fsahatsion H.*et al;* 2018). Yoseph (2007) described that SC was significantly influenced by breed and age and SC is an important trait that is closely associated with the testicular growth and sperm production capacity of domestic animals. The higher SC measurements indicate their higher testicular mass and larger sperm production (Fernandez *et al.,* 2004). Scrotal circumference is the most heritable components of fertility that should be included for evaluation of breeding soundness (Yoseph, 2007).

The high association between body weight and body measurements suggest that either of these variables or their combinations could provide a good estimate for predicting body weight of Simada and Lay Gayint sheep or would imply that these linear measurements can be used as indirect selection criteria to improve live weight (Solomon, 2008). Among the body measurements heart girth was the most related trait to body weight (female r=0.91 and male r=0.92).

The strong positive correlation (*P*< 0.01) between the dependent variable body weight and the independent variable heart girth to predict the body weight observed in this study is in agreement with the report of Amelmal(2011) for Dawro and Konta sheep and (Wossenie,2012) for Hararghe highland sheep.

Prediction of body weight from LBM

Table 6 shows that the number of variables entered in each step to predict the best fitted variable to estimate body weight. Multiple regression equations were developed for predicting body weight from linear body measurements. Heart girth, height at Wither, Body length, ear length , Rump length, Rump width, Tail width, Tail length, for Simada and Lay Gayint female sheep population. The male body weight also estimated using the above measurements, horn length and scrotal circumference**.**

Stepwise multiple regressions were used to predict body weight from linear measurements which had positive correlation with body weight. Variables that best fitted the model were selected using C(p) statistic, Alkaike's Information Criteria (AIC), Schwarz Bayesian Criteria (SBC), R^2 (R-square) and MSE (Mean square of error). For predication of body weight heart girth was consistently selected and entered into the model because of its higher coefficient of determination (R^2) value and its larger contribution to the model than other variables.

In most cases heart girth was found to be the most important in accounting sizeable proportion of the changes in the body weight. This result was consistent with various studies in the indigenous sheep populations in Ethiopia, Tassew (2012) for Habru and Gubalafto sheep in north Wollo zone of the Amhara region and (Mohammed N.*et al;* 2017) for Wegide, Borena and Legambo sheep in South Wollo Zone. The better association of body weight with chest girth was possibly due to relatively larger contribution to body weight of chest girth which consists of bones, muscles and viscera (Thiruvenkadan, 2005).

Parameter estimates in multiple linear regression model showed that higher R^2 adjusted was observed when more than one body dimensions were used in the multiple regression equation. The addition of other measurements to chest girth would result in significant improvements in accuracy of prediction even though the extra gain was little. This suggests that body weight could be more accurately predicted by combinations of two or more measurements than chest girth alone in Simada and Lay Gayint sheep types.

Two variables with significant contribution to the prediction model which included heart girth and body length were fitted first and second where they accounted for 93 % of the total variability of the male sheep. Four variables(Heart girth, Height at wither, Body length and Rump width) were found to have significant association with body weight for the female with R^2 value of 91%.The prediction of body weight from linear measurements could be based on the following regression equation:

$Y= -51.70+0.60x_1+0.54x_2$ for males Where y=Body weight x_1=Heart girth and x_2=Body length

$Y= -49.96+0.62x_1+0.08x_2+0.42x_3-0.14x_4$for female Where x_1=Body weight, x_2= height at wither, x_3= Body length and x_4= rump width

Multivariate Analysis

Discriminant analysis

The performance of a discriminant function can be evaluated by estimating error rates (Probabilities of misclassification). Values on the diagonal of the classification table reflect the correct classification of individuals into groups based on their scores on the discriminant dimensions.

In case of female sample sheep population, the overall average error count estimate was 21.79% for all observations (Table 7) from both districts, which means that 78.21% of the samples were correctly classified. Discriminant analysis showed that relatively large number of female from Simada sheep (25%) was misclassified as Lay Gayint sheep and about 18.57 % of female sheep individuals were misclassified as

Simada sheep from Lay Gayint districts showing the level of genetic exchange that has taken place between the two sheep overtime.

Table 7: Percent classified into each district (hit rate) for female sample population using discriminant analysis

District	1	2	Total
1	75.00 (105)	25(35)	100.00(140)
2	18.57 (26)	81.43 (114)	100.00(140)
	46.79 (131)	53.21(149)	100.00(280)
Rate	0.2500	0.1857	0.2179
Prior	0.5	0.5	

1=Simada, 2=Lay Gayint

The error count estimate for male populations (7.5) was even very low as compared to female sample populations (Table 8). This implied that 90.0% of the samples were correctly classified. As the result showed from discriminant analysis 10% of males populations were classified into Simada populations from Lay Gayint. But small numbers of male Simada sheep individuals (5%) were misclassified as Lay Gayint sheep.

Similar to this study misclassification of large number of female Habru sheep (13.8%) as Gublafto But small numbers of male Habru sheep individuals (5%) as Gubalafto sheep in North Wollo Zone of the Amhara Region was reported by Tassew (2012).

Majority of male and female individuals in the sample sheep population were correctly classified into their source population which means that 75 % of Simada female sheep and 81.43% of Lay Gayint female sheep individuals were correctly classified in their source population. Similarly, about 95% of Simada male sheep and 90% of Lay Gayint male sheep individuals were correctly classified in their source population. In contrast to this study, according to Wossenie (2012) only few individuals were classified into their source population (41.9% for Metta, 33.3% for Gorogutu, and 36.9% for Deder) for females and also only few individuals were classified into their source population (43.9% Metta, 30.3%, Gorogutu and Deder, 24.6%) for males. This shows the two populations mix up together due to various reasons and their heterogeneity were decreased.

Table 8: Percent classified into each district (hite rate) for male sample population using discriminant analysis

District	1	2	Total
1	95.00 (57)	5.00 (3)	100.00(60)
2	10.00 (6)	90.00 (54)	100.00(60)
Total	52.50 (63)	47.50 (57)	100.00(120)
Rate	0.0500	0.1000	0.0750
Prior	0.5000	0.5000	

1=Simada, 2=Lay Gayint

Canonical discriminant analysis

Canonical analyses showed Mahalanobis distance of the morphological traits between Simada and Lay Gayint sheep. More differentiation was observed between male populations of the two districts than female population. Similar result was observed in percent classification of the two districts sheep populations (Table 9)

Table 9: Squared mahalanobis' distance between district or sample populations for male and female population

District	Male		Female	
	1	2	1	2
1	***		***	
2	6.36832	***	2.49570	***

1= Simada 2= Lay Gayint

CONCLUSION

This study was conducted to describe physical characteristics of sheep in Simada and Lay Gayint sheep in south Gonder Zone. The phenotypic variation in quantitative dependent variables such as height at wither, body length, rump length, tail width heart girth, scrotal circumferences and rump width in male were significantly different ($P<0.01$) for districts. And this variation may due to genetic or environmental difference so further genetic analysis should be done to conserve indigenous Animal genetics resource and will also enable to plan sustainable breeding program in order to breed improvement and increase productivity of sheep production.

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