G.J.A.S.R
GLOBAL JOURNAL OF ANIMAL SCIENTIFIC RESEARCH
Journal homepage: www.gjasr.com
Print ISSN:2345-4377 Online ISSN:2345-4385

Original Article

Characterization of Indigenous Sheep Breed Based on Morphological Traits

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ABSTRACT

This study aimed to generate organized information on physical characteristics and prediction of live weight using linear body measurements of indigenous sheep breeds in three districts of Kellem Wolega Zone (Sedi Chanka, Dale Sedi, and Hawa Gelan). The main frequently observed coat color pattern of both sex sheep was plain 63.3%, 72.1%, and 86.9% and the main frequently observed coat color type was brown 51.5%, 53.6%, and 55.4% Dale Sedi, Sedi Chanka, and Hawa Gelan districts, respectively. Straight head profiles 85.9%, 93.6%, and 94.6% were mainly observed for sheep in Dale Sedi, Sedi Chanka, and Hawa Gelan districts, respectively. All the sampled female and male sheep had no horns. The most ear form of sheep observed was semi-pendulous 85.1%, 76.7%, and 65.9% for Dale Sedi, Sedi Chanka, and Hawa Gelan districts sheep populations, respectively. The majority of sampled sheep population in Dale Sedi (52.1%) possesses cylindrical and twisted at the end, whereas Sedi Chanka (79.5%) and Hawa Gelan (74.6%) possess a cylindrical and straight tail shape. The majority of the sheep population in the studied districts had no wattle 96.2

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Cite this Article: Ebro, M.Y., Yusuf, A., and Kebede, K. (2023). Characterization of Indigenous Sheep Breed Based on Morphological Traits. *Global Journal of Animal Scientific Research,* 11(2), 46-61.
Retrieved from http://www.gjasr.com/index.php/GJASR/article/view/167
Article History: Received: 2023.02.26 Accepted: 2023.03.31

followed by the presence of wattle 3.8%. The highest correlation between chest girth and body weight both for male and female sheep indicates that chest girth is the best variable for predicting live weight than other measurements. The overall mean of body weight, chest girth, body length, pelvic width, wither height, ear length, tail length, tail circumference, and scrotal circumference was 28.74 kg, 70.9 cm, 68.78 cm, 63.21 cm, 15.25 cm, 11.29 cm, 26.13cm, 18.92 cm, and 22.63 cm, respectively. The highest correlation between chest girth and body weight both for male and female sheep indicates that chest girth is the best variable for predicting live weight than other measurements. Consequently, this finding was put baseline for consideration of the physical characteristics of sheep and helped as a base for designing a sustainable breeding program and selection schemes in the study area.

Keywords: Breed, Morphological characterization, Native sheep, West Wollega Zone

INTRODUCTION

Ethiopia's vast sheep population, expected at about 30.70 million heads (Amelmel, 2011) is highly adaptable to a broad range of environments (Tsedeke, 2007), owned by smallholder farmers as an essential part of the livestock sub-sector (Workneh, 2000)

, and farmers keep small ruminants for trade and meat consumption in a household where gross income is determined by the size of the flock number elevated by the owners (Gemeda *et al*, 2007). Genetic improvement is one way to increase the productivity of the sheep resource in the country. The essential procedure for genetic improvement of livestock comprises documentation of the breeds or strains of livestock and the type of environment in which they are kept, description of the breed characteristics, their adaptation as well as production potentials in those environments (Workneh *et al*., 2004). For the planning of a community-based breeding strategy as well as setting a useful sheep development program, the genetic and phenotypic value and production system of that particular breed is requisite. Still, information available on Ethiopian sheep types is not only scarce but incomplete to on-station managed flocks with great importance on body weight measurement (Workneh *et al*., 2004).

On farms, characterization can serve as the basis for the sustainable improvement and conservation of indigenous animal genetic resources and has established increasing attention in determining the variation between and within pure breeds (Rege, 2003). On farm, evaluation has some benefits over on-station evaluation. By on-farm evaluation, it is possible to perform characterization with the least cost, it will create better communication with farmers, and above all, it also creates chances to see their performance under their natural inhabitant (Solomon, 2007). The absence of adequate information on the characteristics of the animal would be hard to know the animals and their capacities, and accordingly leads to miss decision and genetic erosion through cross-breeding, replacement, and dilution. In Ethiopia, there are unlike studies carried out to characterize the indigenous sheep breeds managed in their native production system. However, characterization has not been done so far particularly for indigenous sheep found in Kellem Wollega Zone, Ethiopia under their traditional management system. Due to this, information is scanty to show the physical characteristics of the existing sheep breed in the Kellem Wollega Zone. Therefore, more comprehensive evidence specific to on-farm phenotypic characterization of indigenous sheep breeds in the native environment should be made available. Accordingly, in this study, on-farm phenotypic characterization was carried out to describe the sheep population in Kellem Wollega Zone. Therefore, the objective of this study was tried to physically characterize the indigenous sheep breed in the Kellem Wollega zone, Ethiopia.

MATERIAL AND METHODS

Description of the Study Areas

The study was conducted in three districts (Sedi Chanka, Dale Sedi, and Hawa Gelan) of Kellem Wollega Zone of Oromia National Regional State. Kellem Wollega Zone, which is one of the 18 zones in Oromia, is found in the western part of the region. The capital town of the zone is Dambi Dollo. It is located at a distance of 652 km away from Addis Ababa. It is bordered by West Wollega in the north and east, Gambella National Regional State in the south, and Illubabor in the west. The agro-climatic zone of the Kellem Wollega is classified as lowland (38.4%), midland (47.7%), and highland (13.9%) with altitudinal ranges from 500 to 3335 m.a.s.l. The annual temperature varies between 12°C to 36°C. The Zone has a total of 280 kebeles. Of the total kebeles, 255 belong to rural kebeles and 25 to urban kebeles. The total livestock population was 569399 cattle, 230242 sheep, 119528 goats, 11198 horses, 6479 mules, 6214 donkeys, 956959 poultry, and 180319 beehives, respectively (KWZLAFO, 2017).

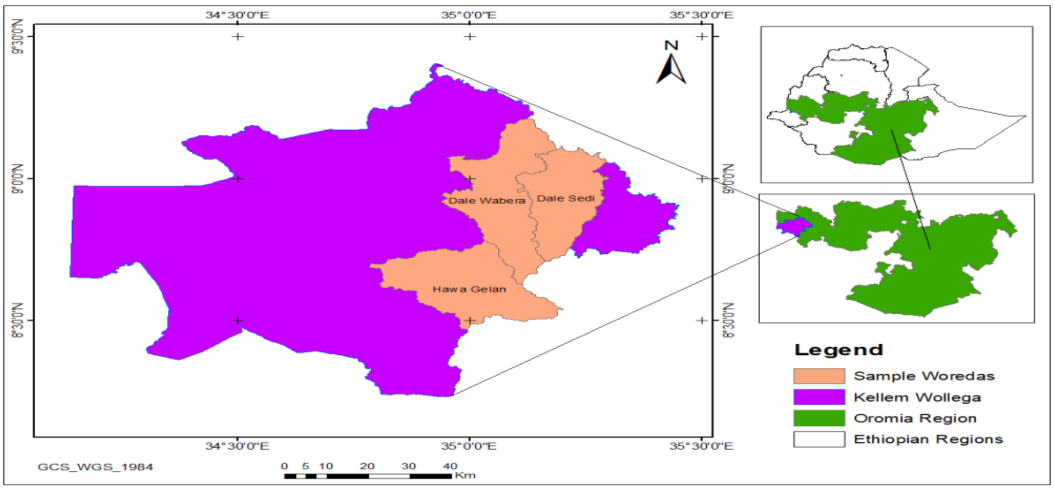

Figure1: Map of the study area

Sampling Methods

The sampling technique employed for this study was a purposive sampling system, which was based on the perspective of sheep production in the zone. Kellem Wollega has 11 districts from which three districts mainly Sedi Chanka, Dale Sedi, and Hawa Gelan were selected purposively based on the spreading of the sheep population. An examination tour was made in advance together with the local staff of the office of agriculture they are habituated to the range of agroecological conditions, road accessibility, and the current farming systems and sheep population in the study area. Meetings were held with local farmers and every occasion was taken for a wayside informal discussion. Discussions were also detained with zonal and district agricultural experts as well as development agents to gather information about the distribution of Kellem Wollega sheep in the selected three districts. Three rural kebeles which represent different agroecology were selected purposively based on the potential and spreading of sheep from each of the three districts. Secondary information on the distribution, number, and type of sheep was obtained from agricultural offices of the respective district before the actual fieldwork.

Data Collection Methods

In every sampling unit, farmers were informed about the objective of the study before the origination of the data collection and random open-ended discussion was inside. Data were collected by employing field observations and measurements as well as secondary sources.

Quantitative Trait Data Collection

Fast field surveys procedure (Stewart, 1983) in which sample flock owners are observed only once were employed to record quantitative and qualitative data for description of sheep types. During a single visit to the sampling site qualitative and quantitative measurements were made on 1170 matured sheep of both sex (390 from each district and 130 from every kebeles) based on FAO guidelines specified that 100 to 300 mature females and about 30 mature males per population are required for phenotypic characterization indicated and the standard breed descriptor list for the sheep developed by (FAO, 2012) was closely followed to record both qualitative observation and quantitative measurements. Quantitative traits like body weight, heart girth, height at withers, height at the rump, body length, ear length, scrotal circumference, horn length, rump length, and tail length were measured using tailors measuring tape while body weight was measured using suspended spring balance having 50 kg capacity with 0.2 kg precision. Measurements were from animals having one pair of permanent incisors and above by assuming that this is the age at which the local sheep start to attain sexual maturity. Measurements were also taken in the morning to avoid the effect of feeding and watering on the animal's size and conformation. Pregnant and diseased animals were excluded from the sample to avoid bias because that can produce an effect on parameters like thoracic measurements. Ages of the animals were estimated from dentition class following the procedure described by Wilson and Durkin (Wilson and Durkin, 1984) Adult sheep were classified into four age groups; 1 PPI, 2 PPI, 3PPand 4PPI to represent the age of 15.5 to 22 months, 22.5 to 27 months, 28 to 38 months and above 39 months, respectively.

Qualitative Trait Data Collection

The standard breed descriptor list developed for sheep (FAO, 2012) was closely followed in selecting morphological variables. Data for a qualitative variable like sex, age, body hair coat color pattern, body hair coat color, fiber type, hair length, horn presence, horn orientation, facial (head) profile, horn shape, tail type, tail shape, rump profile, back profile, ear orientation, and ruff were observed. Every animal was identified by its sex, dentition, and sampling site. A dentition record was taken to guess the age of the animal. The age of the animal was estimated from the dentition class following the procedure described by Wilson and Durkin (1984). Adult sheep were classified into four age groups; 1 PPI, 2 PPI, 3 PPI, and 4 PPI to represent the age of 15.5 to 22 months, 22 to 28 months, 28 to 38 months, and above 39 months.

Data Management and Analysis

The data collected from each study site was checked for any errors and corrected during the study period, coded, and entered into the computer for more analysis.

Qualitative And Quantitative Data Analysis

Morphological (qualitative) and linear body measurement (quantitative) data were recorded on the computer using Microsoft EXCEL 2007 software. Before data analysis, Descriptive statistics like mean and percentage were calculated to recap and describe qualitative data. Quantitative characters (body weight and linear body measurements) were analyzed using the Generalized Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 2003), and also proc univariate, descriptive statistics and mean separation were considered. For mature sheep, sex, age group, and location of the experimental sheep were fitted as fixed independent variables while body weight and linear body measurements except for scrotum circumference and horn length were fit as dependent variables. Scrotum circumference and horn length were analyzed by fitting age group agroecology and location as a fixed factor. Test of significance among different variables was employed based on chi-square test using Proc FREQ of statistical analysis system (SAS, 2003). Tukey-Kramer tests were used to evaluate the difference among the compared groups.

The model employed for analyses of adult (mature) body weight and other linear body measurements except for scrotum circumference and horn length was:

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

Where: Y_{ijk} = the observed (body weight or linear body measurements except scrotum circumference and horn length) in the i^{th} age group, j^{th} sex, k^{th} district, μ= overall mean A_i = the effect of i^{th} age group (i = 1, 2 and ≥ 3), S_j = the effect of j^{th} sex (j= male and female), D_k = the effect of k^{th} district (k= Sedi Chanka, Dale Sedi, and Hawa Gelan), $(As)_{ij}$ = the effect of the interaction of i of age group and j of sex, e_{ijk} = random residual error.

The model to analyze the scrotum circumference and horn length was: $Y_{ik} = \mu + A_i + D_k + e_{ik}$

Where: Y_{ij} = the observed j (scrotum circumference or horn length) in the i^{th} age group and k^{th} district, μ= overall mean, A_i = the effect of i^{th} age group (i = 1, 2 and ≥ 3), D_k = the effect of k^{th} district (k= Sedi Chanka, Dale Sedi, and Hawa Gelan), e_{ik}= random residual error, However, only significant interaction among fixed effect were discussed and stated.

Correlation and Regression Analysis

Pair-wise correlation analysis among different quantitative variables was employed using PROC CORR of SAS. For adult male sheep body weight and other body measurements including heart girth (HG), height at withers (HW), body length (BL), pelvic width (PW), ear length (EL), scrotal circumference (SC), and horn length (HL), tail length (TL) and tail circumference (TC) were considered, whereas scrotum circumference (SC) and horn length (HL) were avoided for the analysis of adult female sheep. A pairwise correlation was computed for each the sex classes.

Stepwise regression was employed using PROC REG of SAS to regress body weight on body measurements. Best fitting models were selected based on their coefficient of determination (R2) and smaller mean square error, the Mallows C parameters C (p), Alkaike's Information Criteria (AIC), and Schwarz Bayesian Criteria (SC). The following models were used for the analysis of multiple linear regressions.

For male:

$yj = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \ldots\ldots\ldots + \beta 9X9 + ej$

Where:

yj = the response variable (body weight)

α= the intercept and $X1, X2 \ldots\ldots\ldots X8$ is the explanatory variables (heart girth (HG), height at Withers (HW), body length (BL), pelvic width (PW), ear length (EL), scrotal circumference (SC), horn length (HL), tail length (TL) and tail circumference (TC), $\beta 1$ ..., $\beta 9$ are regression coefficients of the variables $X1.., X9$, ej = random error.

For female:

$Yj = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \ldots\ldots\ldots \beta 7X7 + ej$; - where:-

Yj = the dependent variable body weight

α= the intercept and X1*...X7* are independent variables (body length, height at wither, heart girth, pelvic width, ear length, tail length, and tail circumference), β*1*... β7 are regression coefficients of the variable *X1.., X7,* ej = random error.

RESULT AND DISCUSSION

Qualitative Traits

The results showed (table 1) that all observed morphological characters were significantly associated (P<0.05) with districts except the presence of horn, horn orientation, and presence of wattle (P>0.05). The highest frequently observed coat color patterns of both sex sheep were plain 74.1% plain, 19.9% patchy, and 6% spotty. The most predominantly observed coat color types in study districts were brown (53.5%), red (14.7%), and white (8%). The majority of sampled female and male sheep had no horn 99.2%. The most ear form of sheep observed was semi-pendulous 85.1%, 76.7%, and 65.9% for Dale Sedi, Sedi Chanka, and Hawa Gelan districts sheep populations, respectively. The majority of sampled sheep population in Dale Sedi (52.1%) possesses cylindrical and twisted at the end, whereas in Sedi Chanka (79.5%) and Hawa Gelan (74.6%) possess a cylindrical and straight tail shape. The majority of the sheep population in the studied districts had no wattle 96.2 followed by the presence of wattle 3.8%.

Morphometric Measurements

In this existing study body weight and most of the linear body, measurements were significantly affected by the district (P<0.05) except live body weight and body length (P>0.05). The outcomes of this study exposed that chest girth measurement was higher for Sedi Chanka than Hawa Gela and Dale Sedi districts, but the height at wither measurements was higher for Dale Sedi than Sedi Chanka and Hawa Gelan districts. The present result of live body weight of sheep in the studied districts is higher than (Zewdu, 2008) report; the body weight of Horro sheep was 27.65 ± 0.21. The correspondence in body weight between sheep of different districts could be described by there being no difference in the management system in the study area. The sex of animals had a significant effect (P<0.05) on the linear body measurements and most of the live body weight whereas ear length was not affected by sex. Highest body weight, body length, chest girth, height at withers, and tail length and tail circumference were recorded for male sheep than female sheep. The probable reason might be related to the usual difference between sexes and hormonal actions, which directs to differential growth rates. The body weight of rams (29.63±0.21kg) and ewes (28.84±0.10) in the current study was somewhat greater than those reported for central highland sheep with 29.4 kg and 24.6 kg (Sisay, 2002), and Menz rams and ewes, with 22 kg and 19.3 kg, respectively (Tesfaye, 2008). The weight of ewes (28.84kg) obtained from this study was lower than the value (29.68 kg) reported for

Dawro and Konta ewes (Amelmel, 2011) but slightly higher than the value for Horro ewe (27.65kg; (Zewdu, 2008) and Haragehe highland sheep (26.5 kg; (Wossenie, 2012). Correspondingly, bodyweight of rams (29.63±0.21kg) is much higher than what was reported for Menz (22.0±0.22kg) and Afar (24.3±0.50kg) rams (Tesfaye, 2008). In the current study, body weight and all recorded linear body measurements were significantly (P<0.05) affected by the age group of animals. All measured traits show an increment with age of animal. As reported earlier, the size and shape of the animal increase until the animal reaches its optimum growth point or until maturity (Yoseph, 2007). Body weight, body length (BL), heart girth (HG), height at wither (HW), and scrotal circumference (SC) kept increasing as the age increased from the dentition group 1(youngest) to dentition group 3 (oldest) as presented in Table 2. Body weight 26.85±0.14, 29.24±0.21 and 31.62±0.25, chest girth 69.61±0.26, 71.56±0.39 and 73.53±0.47 were recorded for 1PPI, 2PPI, and ≥3PPI age of the group of animals, respectively. Similarly, Nurlign *et al*., (2017) reported that body weight and all linear body measurements were significantly influenced by age group, and body weight and other linear body measurements were increase with the age of animals, (Yosef *et al*., 2017) reported body weight of indigenous sheep (both sexes) showed an increment with an increase in age of the animals. Age-by-sex interaction had a significant effect (p<0.05) on body weight and most linear measurements. But the interaction effect (p>0.05) was not observed in some linear measurements (CG, PW, and EL) implying that these parameters were not affected by the sex-age interaction effect in this particular study. Likewise, the interaction of sex and age group was significant (p<0.05) for all quantitative traits except for ear length for both Habru and Gubalafto sheep (Tassew, 2012). The value of live body weight for male and female sheep was increased as dentition class increased from age group 1PPI to 3PPI. The value of body weight for male sheep in age groups 1PPI, 2PPI, and 3PPI were 26.89 kg, 29.38 kg, and 32.68 kg, respectively and the values for females in the same age groups were 26.87 kg, 29.11 kg, and 30.55 kg, respectively. In all age groups and measurements, male sheep performed greater than female sheep.

Table1: Description of qualitative traits in the study areas

Traits	District (N %)									Overall	
	Dale Sedi			Sedi Chanka			Hawa Gelan				X2
	M	F	T	M	F	T	M	F	T		
Coat color pattern											60.1*
Plain	50 (55.6)	197 (65.7)	247(63.3)	58(64.4)	223(74.3	281(72.1)	72(80)	267(89)	339(86.9)	867(74.1)	
Patchy	31 (34.4)	83(27.7)	114(29.2)	27(30)	52(17.3)	79(20.3)	13(14.4)	27(9)	40(10.3)	233 (19.9)	
Spotted	9(10)	20 (6.7)	29(7.4)	5(5.6)	25(8.3)	30(7.7)	5(5.6)	6(2)	11(2.8)	70 (6)	
Coat color type											20.37*
White	9(10)	33(11)	42(10.8)	6(6.7)	12(4)	18(4.6)	13(14.4)	21(7)	34(8.7)	94(8)	
Brown	45(50)	156(52)	201(51.5)	43(47.8)	166(55.3	209(53.6)	36(40)	180(60)	216(55.4)	626(53.5)	
Black	1(1.1)	15(5)	16(4.1)	5(5.6)	22(7.3)	27(6.9)	7(7.8)	10(3.3)	17(4.4)	60(5.1)	
Red	17(18.9)	38(12.7)	55(14.1)	28(31.1)	34(11.3)	62(15.9)	20(22.2)	35(11.7)	55(14.1)	172(14.7)	
Grey	2(2.2)	9(3)	11(2.8)	-	15(5)	15(3.8)	1(1.1)	15(5)	16(4.1)	42(3.6)	
Bla+whit	6(6.7)	15(5)	21(5.4)	3(3.3)	22(7.3)	25(6.4)	4(4.4)	12(4)	16(4.1)	62(5.3)	
Red+whi	7(7.8)	28(9.3)	35(9)	5(5.6)	20(6.7)	25(6.4)	6(6.7)	25(8.3)	31(7.9)	91(7.8)	
Red+whi+bla	3(3.3)	6(2)	9(2.3)	-	9((3)	9(2.3)	3(3.3)	2(0.7)	5(1.3)	23(2)	
Head profile											22.45*
Straight	70(77.8)	265(88.3)	335(85.9)	82(91.1)	283(94.3	365(93.6)	79(87.8)	290(96.7)	369(94.6)	1069(91.4)	
Slightly convex	20(22.2)	3	55(14.1)	8(8.9)	17(5.7)	25(6.4)	11(12.2)	10(3.3)	21(5.4)	101(8.6)	
Ear form											39.61*
Semi-pendu Long	67(74.4)	265(88.3)	332(85.1)	61(67.8)	238(79.3)	299(76.7)	57(63.3)	200(66.7)	257 (65.9)	888(75.9)	
Carried Horizon Tally	23(25.6)	35(11.7)	58(14.9)	29(32.2)	62(20.7)	91(23.3)	33(36.7)	100(33.3)	133(34.1)	282(24.1)	
Tail shape											102.25
Cylindrical + Straight	40(44.4)	147(49)	187(47.9)	60(66.7)	250(83.3)	310(79.5)	50(55.6)	241(80.3)	291(74.6)	788(67.4)	
Cylindrical + twisted at end	50(55.6)	153(51)	203(52.1)	30(33.3)	50(16.7)	80(20.5)	40(44.4)	59(19.7)	99(25.4)	382(32.6	
Horn											0.69ns
Present	3(3.3)	-	3(0.8)	4(4.4)	-	4(1)	2(2.2)	-	2(0.5)	9(0.8)	
Absent	87(96.7)	300(100)	387(99.2)	86(95.6)	300(100)	386(99)	88(97.8)	300(100)	388(99.5)	1161(99.2)	
Horn shape											1.41ns
Curved	-	-	-	1(25)	-	1(25)	-	-	-	1(11.1)	
Spiral	3(100)	-	3(100)	3(75)	-	3(75)	2(100)	-	2(100)	8(88.9)	
Straight	-	-	-	-	-	-	-	-	-		
Horn orientation											
Backward	-	-	-	-	-	-	-	-	-	-	
Lateral	3(100)	-	3(100)	4(100)	-	4(100)	2(100)	-	2(100)	9(100)	
Forward	-	-	-	-	-	-	-	-	-	-	
Wattle											2.64 ns
Present	1(1.1)	9(3)	10(2.6)	3(3.3)	14(4.7)	17(4.4)	6(6.7)	12(4)	18(4.6)	45(3.8)	
Absent	89(98.9)	291(97)	380(97.4)	87(96.7)	286(95.3)	373(95.6)	84(93.3)	288(96)	372(95.4)	1125(96.2)	

M= male; F= female; T=total; N= Number of sheep exhibiting a particular qualitative character, X2 =Pearson-chi-square of significance.

Table 2: Least squares means (LSM) ± standard error (SE) for the main effect of district and dentition and sex by dentition interaction on the live body weight (Kg) and body measurements (cm) of sheep.

Levels	N	BW	CG	BL	HW	PW	EL	TL	TC		SC
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	N	LSM±SE
Overall	1170	28.74±0.10	70.9±0.17	68.78±0.21	63.21±0.12	15.25±0.06	11.29±0.04	26.13±0.15	18.92±0.14	270	22.63±0.24
R^2	1170	0.28	0.10	0.05	0.12	0.09	0.18	0.07	0.11		0.19
CV%	1170	9.98	7.68	10.41	6.36	11.94	12.05	18.64	23.95		15.51
District	*	NS	*	NS	*	*	*	*	*	*	*
Sedi Chanka	390	29.18±0.17^{a}	72.5±0.32^{a}	70.17±0.42^{a}	64.65±0.24^{a}	15.56±0.11^{a}	11.46±0.08^{ac}	27.24±0.29^{a}	20.57±0.27^{a}	90	22.5±0.41^{a}
Hawa Gelan	390	29.48±0.16^{a}	71.19±031^{b}	69.18±0.41^{a}	63.9±0.23^{bc}	14.69±0.10^{b}	11.16±0.08^{b}	26.09±0.28^{b}	19.65±0.26^{b}	90	24.02±0.39^{b}
Dale Sedi	390	29.05±0.17^{a}	71.01±0.32^{cb}	69.14±0.42^{a}	64.97±0.23^{c}	15.89±0.11^{c}	11.3±0.08^{cb}	26.48±0.28^{b}	18.69±0.26^{c}	90	24.18±0.40^{b}
Sex		*	*	*	*	*	NS	*	*		Na
Male	270	29.63±0.21	72.54±0.40	70.1±0.52	65.44±0.29	15.56±0.13	11.23±0.1	27.4±0.36	20.94±0.33		
Female	900	28.84±0.10	70.59±0.19	68.89±0.24	62.91±0.14	15.20±0.06	11.39±0.05	25.81±0.17	18.33±0.15		
Age		*	*	*	*	*	*	*	*		
1PPI	485	26.85±0.14^{a}	69.61±0.26^{a}	66.95±0.34^{a}	62.09±0.19^{a}	14.98±0.09^{a}	10.61±0.06^{a}	25.34±0.23^{a}	18.64±0.22^{a}	170	21.55±0.27^{a}
2PPI	293	29.24±0.21^{b}	71.56±0.39^{b}	70.04±0.51^{bc}	64.55±0.29^{b}	15.41±0.13^{bc}	11.46±0.10^{b}	26.61±0.35^{b}	19.55±0.32^{b}	62	24.07±0.45^{b}
≥3PPI	392	31.62±0.25^{c}	73.53±0.47^{c}	71.51±0.61^{c}	65.88±0.34^{c}	15.75±0.16^{c}	11.85±0.12^{c}	27.87±0.42^{c}	20.72±039^{b}	38	25.07±0.57^{b}
Sex by age		*	NS	*	*	NS	NS	*	*		Na
Male. 1PPI	170	26.89±0.22a	70.45±0.42^{a}	66.59±0.55^{a}	62.76±0.31^{a}	15.15±0.14^{abde}	10.67±0.1^{a}	25.84±0.37^{a}	19.77±0.35^{a}		
Male, 2PPI	62	29.38±0.36^{b}	72.85±0.69^{b}	70.62±0.91^{bcd}	65.83±0.51^{b}	15.58±0.23b^{ce}	11.29±0.17^{bc}	28.20±0.62^{b}	21.54±0.58^{b}		
Male, ≥3PPI	38	32.68±0.47^{c}	74.32±0.89^{b}	73.1±0.98^{c}	67.72±0.65^{c}	15.94±0.3^{c}	11.72±0.22^{cd}	28.16±0.79^{b}	21.52±0.74^{b}		
Female,1PPI	315	26.87±0.16^{a}	68.77±0.31^{c}	67.31±0.40^{a}	61.41±0.23^{d}	14.81±0.1^{d}	10.54±0.08^{a}	24.84±0.27^{c}	17.50±0.26^{c}		
Female,2PPI	231	29.11±0.19^{b}	70.27±0.36^{a}	69.45±0.47^{d}	63.27±0.27^{a}	15.24±0.12^{e}	11.64±0.09^{ec}	25.01±0.3^{2ac}	17.57±0.3^{c}		
Female,≥3PPI	354	30.55±0.15^{d}	72.74±0.29^{b}	69.92±0.38^{d}	64.04±0.21^{e}	15.56±0.10^{cf}	11.98±0.07^{d}	27.58±0.26^{b}	19.92±0.24^{a}		

Means with different superscripts within the same column and class are statistically different (at least P<0.05). Ns = non significant; Na = not applicable. * Sig nificant at 0.05; BW=Body weight, BL= Body length, CG=Chest girth, HW= Height at whither; EL= Ear length; PW=Pelvic width; TL=Tail length TC=Tail circumstance; SC= Scrotum circumstance; 1PPI = 1 pair of permanent incisor, 2PPI = 2 pair of permanent incisor and ≥ 3 PPI = 3 or more pairs of permanent incisors.

Correlation of Body Weight and Linear Body Measurements

Moderate to strong correlations were observed between body weight and linear body measurements for both male and female of indigenous sheep considered in the study area. The quantitative traits in both male and female indigenous sheep populations, body weight was indicated that highly correlated with chest girth and body length 0.81 and 0.77 in the male indigenous sheep population, respectively, and also chest girth and body length 0.71 and 0.66 in female of indigenous sheep population, respectively. However, moderate correlations were observed between wither height, pelvic width, ear length, tail length, tail circumference, and scrotal circumference 0.58, 0.59, 0.18, 0.13, 0.32, and 0.20 for the male sheep population, respectively, and wither height, pelvic width, tail length, tail circumference 0.36, 0.46 0.15 and 0.20 for female sheep population, respectively.

Table 3: Correlation coefficients among body measurements and weight of females and males of indigenous sheep in the study area (values above the diagonal are for males and below the diagonal are for females) (N= 270 male; N= 900 females).

Traits	BW	CG	BL	HW	PW	EL	TL	TC	SC
BW		0.81*	0.77*	0.58*	0.59*	0.18*	0.13*	0.32*	0.20*
CG	0.71*		0.84*	0.59*	0.58*	0.04^{NS}	0.16*	0.41**	0.25*
BL	0.66*	0.55*		0.47*	0.51*	-0.04^{NS}	0.07^{NS}	0.35*	0.15*
HW	0.36**	0.47*	0.21*		0.32*	0.26*	0.21*	0.29*	0.27*
PW	0.46*	0.49*	0.41*	0.29*		0.14**	0.14*	0.31*	0.07^{NS}
EL	0.02^{NS}	0.13*	-0.06^{NS}	0.24*	0.18*		0.11^{NS}	-0.11^{NS}	0.13*
TL	0.15*	0.19*	0.14*	0.16*	0.14*	0.08*		0.33	0.24*
TC	0.20*	0.20*	0.16*	0.17*	0.23*	0.05^{NS}	0.28*		0.27*

*=P<0.05; BW=Body weight, BL= Body length, CG=Chest girth, HW= Height at whither; EL= Ear l ength; PW=Pelvic width; TL=Tail length TC=Tail circumstance; SC= Scrotum circumstance; NS = non-significant.

Multiple regression analysis

Multiple linear regression equations were developed for predicting live body weight (LBW) from other linear body measurements (LBMs) for *Sedi Chanka, Dale Sedi,* and *Hawa Gelan* sheep populations. Stepwise regression was carried out for each sex and pooled age group by entering all the above traits at a time for males and by excluding scrotal circumference for females for selection of independent variables. In both sexes, (male and female) *Sedi Chanka, Dale Sedi,* and *Hawa Gelan* sheep, CG (chest girth) were consistently nominated and entered into the model in step one procedure of stepwise regression due to its larger contribution to the model than other variables. In the second step of stepwise regression two independent variables were selected to be in the model, at the third step three independent variables, and so on. Entering of significant (P<0.05) and best among the rest variables continued in consecutive steps until no other variable met the 0.05 significance level for entry into the model. Each stepwise selection of variables was employed after examining all variables to see if any should eliminate at that step. The number of variables entered in each step, parameter estimates, their contribution in terms of coefficient of determination (R2), C (*p*) statistic, R2 (adjusted R-square), MSE (Mean square of error), Schwarz Bayesian Criteria (SBC) and Alkaike's Information Criteria (AIC) are presented in Table 4, respectively.

The coefficient of determination (R2) 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 males (87%) and females (76%). The strong relationship between BW CG BL EL PW WH and TC for male sample population makes it possible to predict the body weight based on these four linear measurements but for field conditions simple measurement with a maximum of one or two variables is enough to predict the dependent variable. This is because the addition of more variables under field condition increases error, and besides, some variables are more affected by the animal posture compared to others, which makes it so difficult to measure such variables precisely. Similarly, strong relationship between BW CG BL WH PW and TC for female sampled population makes it thinkable to predict body weight based on these measurements. This suggests that combinations of two or more measurements could more accurately predict body weight than body length and chest girth alone. However, under farmers' conditions, body weight estimation using CG for males and females, respectively, alone would be preferable use to combinations with other measurements because of the difficulty of correct animal check during measurement. Besides, most the sheep producers are not aware of such measurements and it is time demanding. It was recognized that chest girth is among the variables that is least affected by the animal posture and easy to measure than other measurements like wither height and body length. Thus, under field conditions, live weight estimation using chest girth alone would be preferable. Parameter estimates in the multiple linear regression model showed that males had a higher R2 (0.87) value than females (0.76). This points out that those linear measurements could predict more accurately in males compared to females. The small sample size of males in this study may decrease the accuracy of the result if separate age groups are used. Thus, instead of using the separate equation for different age groups, it seems logical to pool age groups for the prediction of body weight for males and females. The best-fitted variables were selected using a higher value of the coefficient of determination R^2, adjusted $R^{2,}$ and smaller values of C(P), AIC, R MSE , and SBC. Regression models for predicting body weight of males and female's sheep types from some linear body measurements; Y=response variable (body weight) and x= explanatory variable (chest girth). For males and females; Y= -18.95+0.87x for males, Y=-21.18+0.76x for females.

Table 4: multiple linear regression analysis of live body weight on different LBMs for male and female sheep in studied area in all age groups

MODEL	I (β0)	Parameters β1	β2	β3	β4	β5	β6	R^2	R^2 Adj	C(P)	AIC	Root MSE	SBC
Male													
CG	-18.95	0.87						0.68	0.67	53.66	160.27	3.57	164.53
CG+ BL	-34.92	0.46	0.59					0.78	0.77	23.07	140.65	3.02	147.03
CG +BL+ EL	-44.65	0.37	0.51	0.33				0.79	0.78	19.37	137.94	2.93	146.45
CG+ BL+ EL +PW	-48.36	0.35	0.48	0.31	0.38			0.81	0.80	15.20	134.42	2.83	145.05
CG+ BL +EL +PW +WH	-47.39	0.36	0.51	0.32	0.41	-0.28		0.83	0.81	12.15	131.50	2.75	144.26
CG+BL+EL+PW+WH+ TC	-58.60	0.33	0.45	0.37	0.40	-0.36	1.07	0.84	0.82	9.47	128.56	2.66	143.45
Female													
CG	-21.18	0.76						0.58	0.58	105.4	842.00	3.73	847.52
CG +BL	-29.06	0.47	0.46					0.65	0.65	41.88	789.80	3.44	801.10
CG +BL +PW	-34.47	0.39	0.42	0.98				0.67	0.66	27.90	777.06	3.36	792.12
CG +BL+ WH+ PW	-40.77	0.35	0.39	0.22	0.84			0.68	0.67	19.01	768.62	3.31	787.44
CG +BL+ WH+ PW+ TC	-55.89	0.30	0.41	0.27	0.75	1.10		0.68	0.68	13.82	763.52	3.28	786.11

BW=Body weight, BL= Body length, CG=Chest girth, HW= Height at whither; EL= Ear length; PW=Pelvic width; TL=Tail length TC=Tail circumstance; SC= Scrotum circumstance; R^2=R- square; MSE= Mean square of error; A.R^2= adjusted R^2; C(p) =Mallows C parameters; AIC=Alkaike's Information Criteria; SBC =Schwarz Bayesian Criteria.

CONCLUSION

The study was accompanied in the Kellem Wollega zone of Oromia Regional State Ethiopia. The results indicated that all observed morphological characters were significantly associated ($P<0.05$) with districts except horn presence, horn shape, and presence of wattle. Most of the sheep in the study area had plain coat patterns brown coat color, straight head profiles, no wattles, and semi-pendulous (75.9%). There was a significant difference in body weight and all recorded linear body measurements ($P<0.05$) among the districts except body weight and body length in the study area might be no variation in body weight between sheep of the different districts could explained by there is no any difference of the management system. The sex of animals had a significant effect ($P<0.05$) on the linear body measurements and live body weight whereas ear length was not affected by sex, as detected by pair-wise comparisons for both sexes. Age-by-sex interaction had a significant effect ($p<0.05$) on body weight and most linear measurements. But the interaction effect ($p>0.05$) was not observed in some linear measurements (CG, PW, and EL) implying that these parameters were not affected by the sex-age interaction effect in this particular study. Chest girth was the first variable to explain more variation than other variables for body weight prediction. For any breed improvement program and to increase the productivity of indigenous sheep, characterization of the breed within their environment is the baseline. Then, this initial work could be used to support genetic analyses to determine variation between and within these small populations. Additional research is recommended to design a community-based breeding program as an important option for genetic improvement of the Kellem Wollega sheep population populations.

AUTHOR'S CONTRIBUTION

The authors equally contributed to the data collection, data analysis, andwrite-of the manuscript. The authors read and approved the final manuscript.

DECLARATION OF COMPETING INTEREST

The authors declared that there are no conflicts of interest concerning the research, authorship, and/or publication of this article.

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