On-Farm Phenotypic Characterization of Indigenous Sheep in West Shewa Zone, Oromia Regional State, Ethiopia

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ABSTRACT

The current study was conducted in Tokke Kutaye, Ambo and Dandi districts of West Shewa zone to investigate the phenotypic characteristics of indigenous sheep found in the areas as a step towards developing sustainable sheep breeding strategy. The districts were purposively selected based on their potential for indigenous sheep production and the long-standing issues of demarcating clear boundaries between Horro and the central highland sheep breeds. Field observation, measuring and recording of sheep physical and morphmetrical characters were employed to capture all relevant information. Body weight and linear measurements were taken on 690 adult sheep (200 females and 30 males from each district). Age was estimated from dentition. The Statistical Analysis System (SAS, 2008) software was used to analyze the qualitative and quantitative data. Plain coat color was the dominant color with 76.2%, 70.9% and 70.9 % in Tokke Kutaye Ambo and Dandi districts, respectively. Almost all of male sheep in Dandi and about half in Ambo districts were horned while the majority of male sheep were polled in Tokke Kutaye district. Pair wise comparison of the least squares means of body weight and linear body measurements were significantly affected by the district, sex and age (P<0.01). The recorded body mature weight was 28.4±0.24, 26.1±0.19 and 25.9±0.15kg for sheep in Tokke Kutaye, Ambo and Dandi, respectively. All linear body measurements considered in this study were significantly (p<0.01) higher for male. Chest girth had the highest correlation coefficient for both males (0.79) and females (0.73). Based on results obtained from both qualitative and quantitative traits, the geographical demarcation of Horro and the central high land sheep breeds is Ambo district. Further investigation is warranted to put clear demarcation between the two breeds through deepest phenotypic and molecular characterizations.

Keywords: Body weight, Indigenous sheep, Linear body measurements, Phenotype characterization

INTRODUCTION

Livestock, which is kept by more than 70% of the Ethiopian population, is an integral part of agriculture, accounting for about 45% to the total value of agricultural production and supporting the livelihoods of a large share of the population (FAO, 2019). Beyond providing foods and other goods and services to the population, the livestock sector is a major contributor to export earnings, mainly through the export of live cattle and small ruminants. According to FAO (2019), Ethiopian livestock contribute about 10% to total export earnings, of which 69% accounted for by live animal exports.

Small ruminants are one of the most preferred livestock species that make an important contribution to household food and economic security. They have great potential to contribute more to the livelihood of low-income farmers in low input and low output smallholder, and pastoral production systems (Kosgey and Okeyo, 2007; Tesfaye, 2008). For men and women in developing countries, small ruminants are important assets and sources of income where women are more likely to be owners of small ruminants while men tend to own large livestock (Hiwot et al., 2020). According to the authors, the preferences of women directly matches to the four food security dimensions: the accessibility of small ruminants to be sold or exchanged to fulfill immediate cash requirements, nutritional value to meet basic food needs through consumption of meat and milk, production availability with short reproductive cycles and high reproductive rates to ensure sufficient food resources for the family and resistance to extreme weather conditions which makes them a stable asset for the household.

The small ruminant industry in Ethiopia contributes substantially to the livelihood of the rural poor and the country at large but is faced with various challenges. At the national level, sheep and goat account for about 90% of meat and 92% of skin export trade value (Sisay, 2010). The population of sheep in Ethiopia is estimated to be 39.89 million, out of which about 70. 28% are females, and about 29.72% are males. From the total sheep population of the country, about 99.56% are indigenous breeds (CSA, 2020).

While most Ethiopian sheep are currently well characterized, sheep populations found in the central highlands of the country need further characterization. For instance, sheep breed/s available in the central highlands of the country including those available in west Shewa zone is/are generally named as central highland sheep mainly due to lack of proper characterization. Tokke Kutaye, Ambo and Dandi districts are some of the districts situated in western Shewa zone where characterization information on the available sheep breed/s is needed to design genetic improvement and other development strategies. In the indicated districts, phenotypic characterization like morphological information and breeding practices on the existing sheep breed/types in their respective production environments are not well studied or documented. In addition, there are controversial ideas about the sheep breed/s found in the indicated districts, particularly Ambo and Tokke Kutaye. Literature reports (eg. Galal, 1983) indicated that Horro sheep breed are distributed in some parts of western Shewa zone, but no one tells the exact demarcation of the Horro sheep breeds or in other words points where the Horro sheep breed and the central high land sheep breeds are delineated. Therefore, the current study was aimed to characterize the phenotypic feature of indigenous sheep populations found in the districts and determine the boundaries among the available sheep breeds/types, particularly between Horro and the central high land sheep breeds.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in three districts of West Shewa zone of Oromia region, Ethiopia. Map of the study areas is indicated in figure 1. The districts are: Tokke Kutaye, Ambo and Dandi. West Shewa Zone is one of the 18 zones in Oromia National Regional State. The altitude of the zone ranges from 1166 to 3238 meters above sea level (m.a.s.l). It receives a mean annual rainfall of about 900 mm (range 800 to 1000 mm) and annual temperature ranging from 15 to 29°C with an average annual temperature of 22°C (AARDB, 2016). West Shewa zone has mainly midland and highland topography and mixed crop-livestock production system is the main stay of livelihood of the community of the zone. The livestock sub-sector plays an important role in the livelihood of the rural people in terms of providing alternative income sources and also contributing to their food security. According to Agricultural and Rural Bureau of West Shewa zone (AARDB, 2016), the total livestock population of the zone are estimated at 3,764,183 head of cattle,1,138,236 head of sheep, 818,792 head of goat, 282,633 head of horse, 275,738 head of donkey, 42,188 head of mule and 1,634,423 head of chicken.

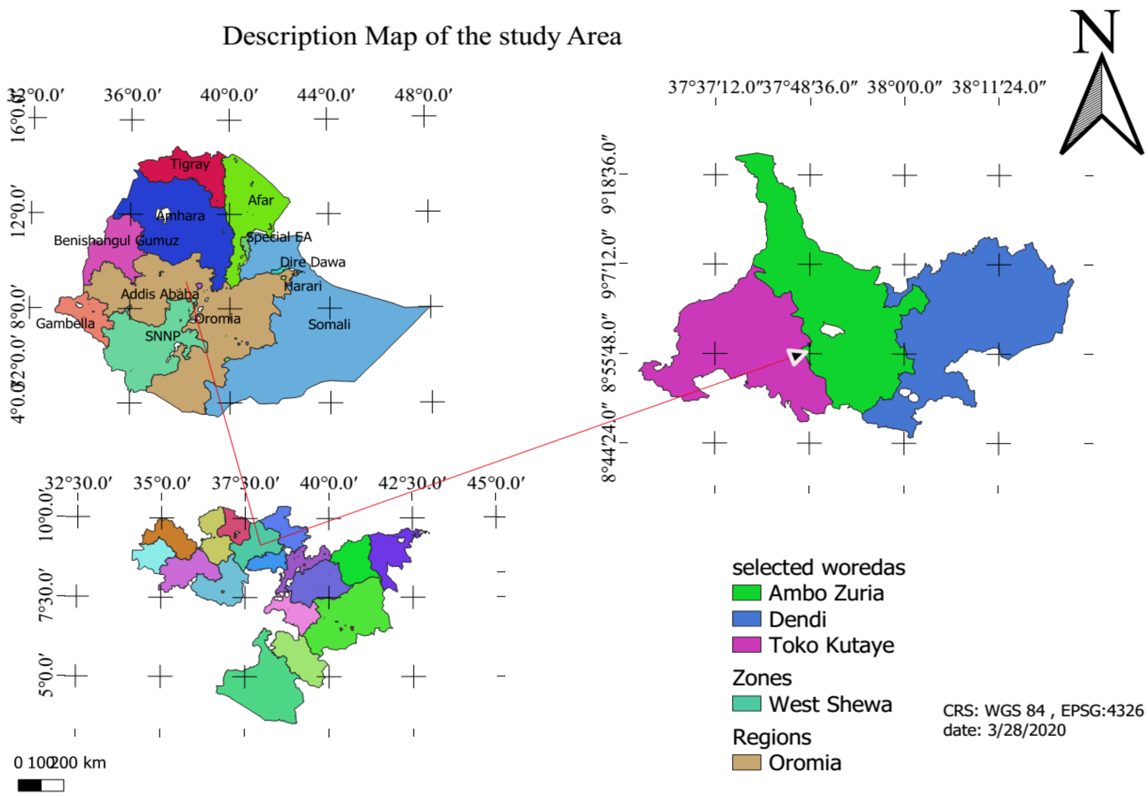

Figure 1. Map of the study area

Sampling and Data Collection Procedure

Sampling procedure

Tokke Kutaye, Ambo and Dandi districts were purposively selected based on their potential for indigenous sheep production and the long-time standing issues of demarcating clear boundaries between Horro sheep and the central highland sheep breeds. Furthermore, targeted peasant associations (PAs) were purposively selected from the three districts based on sheep population based on a rapid reconnaissance survey which was conducted in each district to know the distribution and concentration of indigenous sheep to establish sampling framework. Body weight and linear measurements were taken from a total of 690 adult sheep (600 female and 90 male) which were randomly selected within the selected districts based on (FAO. 2012).

Data collection method

Secondary data sources, observation and linear body measurements were used to capture necessary information during the current study.

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Morphological and linear body measurement

Qualitative traits such as coat color pattern, coat color type, hair type, head profile, ears, wattle, horn, ruff and tail types were observed and recorded. Leaner body measurements like heart girth (HG), body length (BL), wither height (WH), ear length (EL), head length (HeL), horn length (HL), tail length (TL), tail width (TW), rump length (RL), rump width (RW) and scrotum circumference (SC) were measured using flexible measuring tape while body weight (BW) was measured using suspended spring balance having 50kg capacity with 0.2kg precision. Experimental animals were identified by sex, districts and age group. Adult sheep were classified into three age groups: 1PPI (one pair of permanent incisors), 2PPI (two pair of permanent incisors and ≥3PPI (more than three pair of permanent incisors). Linear body measurements were taken by restraining and holding the animals in a stable condition. The standard breed descriptor list for sheep developed by FAO (2012) was closely followed in selecting morphological variables.

Data Management, Morphological and Body Measurement Data Analysis

Observations on morphological characters were analyzed for male and female sheep using frequency procedure while quantitative data such as body weight and linear body measurements were analyzed using the Generalized Linear Model (GLM) procedures of the Statistical Analysis System (SAS, 2008, version, 9.2). District, sex and age group were fitted as fixed independent variables while body weight and linear body measurements except scrotal circumference and horn length were fitted as dependent variables. Scrotal circumference was analyzed by fitting district and age group as fixed factor. When analysis of variance declares significance, least square means were separated using adjusted Tukey-Kramer test.

Except for scrotum circumference (SC), which was only considered for males, parameters such as body weight and other body measurements like heart girth (HG), body length (BL), wither height (WH), ear length (EL), horn length (HL), head length (HL), tail length (TL), rump length (RL), rump width (RW) and rump height (RH) were considered for both female and male sheep.

Model fitted to analyze adult body weight and other linear body measurements except the scrotal circumference and horn length was: $yijkl = \mu + Ai + Sj + Dk + (A*S)ij + eijkl$

Where: Yijkl= the observed l (body weight or LBMs) in the ith age group, jth sex and kth district; μ= overall mean; Ai = the effect of ith age group (i= 1, 2, ≥3) PPI; Sj= the effect of jth sex (j = female or male); Dk= the effect of Kth district; (A*S) ij = the effect of the interaction of i of age group with j of sex; and eijkl= random residual error

Model fitted to analyze the scrotum circumference and horn length was:

$$yikl = \mu + Ai + Dk + eikl$$

Where: Yikl= the observed l (SC) in the ith age group and kth district; μ = overall mean; Ai = the effect of ith age group (i= 1, 2, ≥3) PPI; Dk= the effect of kth district and eikl= random residual error

Pearson's correlation coefficients were used to estimate the correlation between body weight and all body measurements using the Statistical Analysis System (SAS, 2008, version, 9.2).. Furthermore, body weight was regressed on body measurements (HG, BL, WH, RW, RL, RH, TL, HL, EL and SC) using backward elimination stepwise multiple regression to determine the best fitted regression equations for the prediction of body weight from linear body measurements for adult animals. Best fitted models were selected based on higher coefficient of determination (R^2) and lower the Mallows (C) parameters C (p), Alkaike's Information Criteria (AIC) and Schwarz Bayesian Criteria (SBC) Values for simplicity of measurement under field condition. The following model was fitted for the multiple linear regression analysis within sex classes.

For females: $yij = a + \sum \beta ixj + eij$

Where: Yij= the dependent variable body weight; a = the intercept, β1, β2... βi are the partial regression coefficient considering each independent variables. X1, X2…Xj are independent variable like Heart girth, height at wither, body length, rump length, rump width, rump height, tail length, head length and ear length, respectively; and ei = the residual error

For males: $yij = a + \sum \beta ixj + eij$

Where: Yj = the dependent variable body weight; a = the intercept, β1, β2..., βi are the partial regression coefficient respecting for independent variables. X1, X2…Xj are independent variable like heart girth, height at wither, body length, rump length, rump width, rump height, tail length, head length, ear length and scrotal circumference, respectively; and ej = the residual error

RESULTS AND DISCUSSIONS

Phenotypic Characteristics of Sheep in the Study Areas

Characterization of qualitative traits

There was an increasing interest in the characterization of African small ruminant populations because of their major role in the maintenance of genetic resources as the basis of future improvement at both the production and the genetic levels (Nsoso *et al.*, 2004). Description of the physical characteristics of livestock breeds is very important for developing a breeding strategy in a particular production system (Taye *et al*., 2016). The current study areas are believed to be boundary areas for two sheep breeds, Horro and the Central Highland sheep breeds. That means characterization in here serves multiple purposes: to exactly locate the exact boundary of the two breeds and for genetic improvement and conservation intervention.

All traits except head profile, ruff and wattle were significantly different (P<0.05) among districts. The major qualitative traits such as coat color patterns, coat color type, hair type, head profile, ear form, horn, horn shape, horn orientation, wattle and ruff of physical traits of body parts as observed in an individual head of sheep at Tokke Kutaye, Ambo and Dandi districts are summarized in Table 1. The dominant coat color pattern in the study areas was plain with 76.2%, 70.9% and 70.9 % in Tokke Kutaye Ambo and Dandi districts, respectively. The rest of the sampled populations were patchy and spotted coat color pattern (Table 1). The most frequently observed color type in all study districts was brown followed by black and white for both sexes. Coat color of sheep breed in Tokke Kutaye was more uniform than it was in Ambo and Dandi districts. Because sheep breed in Tokke Kutaye share the Horro sheep breed morphological traits that have uniform coat color while sheep breed in Dandi district had mixed coat color due to share centeral high land sheep breed morphological trait. However, the coat color of sheep breed in Ambo districts was the mixtures of Horro and Centeral high land sheep breed coat color characters. This is consistent with the report of Zewdu et al. (2012) for Horro sheep breed where above 80.0% of the indicated sheep breed exhibited uniform brown coat color. In the current study, about 60%, 44.3% and 40.5% of sampled sheep color types were brown, 10.9%, 14.3% and 14.4% were black and 7.8%, 13% and 12.2% were white color type were dominantly observed among sheep population in Tokke Kutaye, Ambo and Dandi districts, respectively. As one moves from sole Horro ecotype area, in this case Tokke Kutaye, to Ambo and then Dandi coat color uniformity decreases.

About 90.4% of the sampled sheep population from Tokke Kutaye, 71.3% from Ambo and 76.5% from Dandi districts had coarse smooth hair followed by coarse and short (Table 1). The head profiles of about 62.6%, 64.3% and 73% and about 37%, 35.7% and 27.4% of the sampled sheep population were straight and concave in Tokke Kutaye, Ambo and Dandi, respectively. The result was in agreement with Mesfin *et al.* (2016) who reported that about 93.8% of local sheep did have straight head in Wolaita zone. In contrast to the current findings, about 87.0% of rams and ewes with concave head profile were reported from Gamogofa and Gurage Silite (Abera *et al*., 2013). The majority of indigenous sheep in the current study districts had long fat tail (79.6%) followed by long thin tail (20.4%). The proportions of sheep which had long fat tail and long thin tail were about 79.6% and 20.4% in Tokke Kutaye, 60.0% and 40% in Ambo, respectively. However, in Dandi district long thin tail was the most frequently observed tail type followed by long fat tail (Table 1). Their proportions for the long thin tailed and long fat tailed sheep were about 58.3% and 41.7%, respectively. Almost all sampled sheep population in Tokke Kutaye was hornless. Only, about 4.3% of sheep was horned in Tokke Kutaye. Nevertheless, about 49.1% and 72.6% of the sheep populations found in Ambo and Dandi districts were horned. Almost all rams in Dandi and around half of the rams in Ambo were horned. The higher percentage of sheep did have semi pendulous ear form 81.3%, 69.6% and 76.0% followed by horizontal ear form 18.7%, 30.4% and 23.9% in Tokke Kutaye Ambo and Dandi, respectively. Based on the above qualitative parameters, sheep populations in Tokke Kutaye are likely Horro breed but sheep breed in Dandi district was different from Horro sheep breed. The breed may be attributed to the central high land sheep breed while sheep breed in Ambo district was the admixture of the two breeds.

In the current study, ruff was mainly sex and age dependent. Females were totally devoid of ruff and it was more readily observed in adult males as compared to young growing males. With regard to ruff, similar findings were also reported Zewdu (2008) for Horro sheep. About 7%, 4.3% and 3.5% of sampled sheep population in the present study had ruff from Tokke Kutaye, Ambo and Dandi districts, respectively. Ruff was observed on adult ram (male) in all study districts and most of the sampled sheep population did not have wattle.

Table 1. Description of qualitative traits in study areas

		Districts								
Traits	Attributes	Toke kutaye			Ambo			Dandi		
		M	F	T	M	F	T	M	F	T
		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Coat color pattern	Plain	22(73.3)	153(76.1)	176(76.2)	24(80)	138(69.3)	163(70.9)	19(63.3)	144(72)	163(70.9)
	Patchy	3(10)	29(14.4)	32(13.9)	3(10)	27(13.6)	30(13.3)	7(23.3)	13(6.5)	20(8.7)
	Spotted	5(16.7)	18(9)	23(10)	3(10)	34(17.1)	37(16.2)	4(13.3)	43(21.5)	47(20.4)
Test	**X^2& p_value**								**11.75**	**0.019**
Color type	White	1(3.3)	17(8.5)	18(7.8)	4(13.3)	26(13)	30(13)	1(3.3)	27(13.5)	28(12.2)
	Black	0(0)	25(12.5)	25(10.9)	3(10)	30(15)	33(14.3)	1(3.3)	33(16.5)	34(14.4)
	Brown	22(73.3)	116(58)	138(60)	16(53.3)	86(43)	102(44.3)	20(66.7)	81(40.5)	101(43.9)
	Red	3(10)	14(7)	17(7.4)	3(10)	16(8)	19(8.3)	2(6.7)	12(6)	14(6.1)
	Grey	0(0)	0(0)	0(0)	0(0)	6(3)	6(2.6)	2(6.7)	4(2)	6(2.6)
	White and black	3(10)	9(4.5)	12(5.2)	3(10)	19(9.5)	22(9.6)	3(10)	23(11.5)	26(11.3)
	Red and white	1(3.3)	19(9.5)	20(8.7)	1(3.3)	17(8.5)	18(7.8)	1(3.3)	19(9.5)	20(8.7)
	Red, white and black	_	0(0)	0(0)	_	0(0)	0(0)	_	1(0.5)	1(0.4)
Test	**X^2 and p_value**								**27.77**	**0.021**
Hair type	Coarse and short	8(26.7)	14(7)	22(9.6)	11(36.7)	54(27)	65(28.3)	13(43.3)	40(20)	53(23)
	Coarse and smooth	22(73.7)	186(93)	208(90.4)	19(63.3)	145(72.5)	164(71.3)	17(56.7)	159(79.5)	176(76.5)
	Coarse and long	_	0(0)	0(0)	_	1(0.5)	1(0.4)	_	1(0.5)	1(0.4)
Test	**X^2 and p_value**								**27.76**	**<0.0001**
Head profile	Straight	18(60)	126(63)	144(62.6)	17(56.7)	131(65.5)	148(64.3)	21(70)	146(73)	167(72.6)
	Concave	12(40)	73(36.5)	85(37)	13(43.3)	69(34.5)	82(35.7)	9(30)	54(27)	63(27.4)
	Convex	_	1(0.5)	1(0.4)	_	0(0)	0(0)	_	0(0)	0(0)
Test	**X^2 and p_value**								**7.69**	**0.104**
Tail type	Long thin tailed	1(3.3)	46(23)	47(20.4)	2(6.7)	90(45)	92(40)	3(10)	131(65.5)	134(58.3)
	Long fat tailed	29(96.7)	154(77)	183(79.6)	28(93.3)	110(55)	138(60)	27(90)	69(34.5)	96(41.7)
Test	**X^2 and p_value**								**68.84**	**<0.0001**
Tail Form	Cylindrical and straight	18(60)	127(63.5)	145(63)	16(53.3)	123(61.3)	139(60.4)	11(36.7)	91(45.5)	102(44.3)
	Cylindrical and turned up at the end	4(13.3)	64(32)	68(29.6)	3(10)	21(10.5)	24(10.4)	6(20)	58(29)	64(27.8)
	Bi lobbed without appendage	8(26.7)	9(4.5)	17(7.4)	11(36.7)	56(28)	67(29.1)	13(43.3)	51(25.5)	64(27.8)
Test	**X^2 and p_value**								**63.08**	**<0.0001**

Table 1. (*Continued*)

Horn	Present	1(3.3)	9(4.5)	10(4.3)	17(56.7)	96(48)	113(49.1)	28(93.3)	139(69.5)	167(72.6)
	Absent	29(96.7)	191(95.5)	220(95.7)	13(43.3)	104(52)	117(50.8)	2(6.7)	61(30.5)	63(27.4)
Test	**X^2 and p_value**								**227.07**	**<0.0001**
Horn shape	Straight	0(0)	0(0)	0(0)	6(20)	30(15)	36(157)	1(3.3)	44(22)	45(19.6)
	Rudimentary	0(0)	2(1)	2(0.9)	4(13.3)	27(13.5)	31(13.5)	6(20)	59(29.5)	65(28.3)
	Spiral	1(3.3)	6(3)	7(3)	7(23.3)	30(15)	37(16.1)	21(70)	35(17.5)	56(24.3)
	Corkscrew	_	0(0)	0(0)	_	7(3.5)	7(3)	_	1(0.5)	1(0.4)
Test	**X^2 and p_value**								**245.74**	**<0.0001**
Horn orientation	Lateral	0(0)	0(0)	0(0)	4(13.3)	26(13)	30(13)	1(3.3)	54(27)	55(23.9)
	Oblique up ward	0(0)	0(0)	0(0)	3(10)	21(10.5)	24(10.4)	3(10)	18(9)	21(9.1)
	Back ward twisted	1(3.3)	8(4)	9(3.3)	10(33.3)	46(23)	56(24.3)	24(80)	67(33.5)	91(39.6)
Test	**X^2 and p_value**								**236.53**	**<0.0001**
Ear form	Semi pendulous	22(73.3)	165(82.5)	187(81.3)	23(76.7)	137(68.5)	160(69.6)	22(73.3)	153(76.5)	175(76.1)
	Horizontal	8(26.7)	35(17.5)	43(18.7)	7(23.3)	63(31.5)	70(30.4)	8(26.7)	47(23.5)	55(23.9)
Test	**X^2 and p_value**								**8.64**	**0.013**
Ruff	Present	16(53.3)	0(0)	16(7)	8(26.7)	2(1)	10(4.3)	8(26.7)	0(0)	8(3.5)
	Absent	14(46.)	200(100)	214(93)	22(73.3)	198(99)	220(95.7)	22(73.3)	200(100)	222(96.5)
Test	**X^2 and p_value**								**3.23**	**0.20**
Wattle	Present	1(3.3)	8(4)	9(3.9)	0(0)	14(7)	14(6.1)	1(3.3)	6(3)	7(3)
	Absent	29(96.7)	192(96)	221(96.1)	30(100)	186(93)	216(93.9)	29(96.7)	194(97)	223(97)
Test	**X^2 and p_value**								**2.72**	**0.26**

M= male; F= female; T=total; N= Number of sheep exhibiting a particular qualitative character (_) = Not existed

Live body weight and linear measurements

Information on body weight and physical linear measurements of specific sheep population at constant age has paramount importance in the selection of genetically superior animals for production and reproduction purposes (Mohammed *et al.*, 2017). Universally, body weight of sheep increases with age. The main source of variation in live body weight and linear body measurements were district/location, sex, age group and the interaction of both sex and age group. The least squares mean and standard errors for the effect of district, sex, age group and interaction of age group and sex on body weight and other body measurements are presented in Table 2

Districts/location effect

The least squares mean and standard errors for the effect of districts/location on body weight and other body measurements are presented in Table 2. In the current study, body weight and most of the linear body measurements (BL, HG, WH, EL, HL, RH and TL) were significantly affected ($p<0.01$) by district, except rump width and rump length which were not influenced ($p>0.05$) by district. Body weight and most of the linear body measurement were highest in Tokke Kutaye than they were in Ambo and Dandi districts. Average body weight obtained for Tokke Kutaye, Ambo and Dandi districts were 28.4±0.24 kg, 26.1±0.19 kg and 25.9±0.15kg, respectively. This indicate mean body weight obtained in Ambo district was lower than the mean body weight obtained from Tokke Kutaye, but higher than the mean body weight obtained from Dandi district. The mean live body weight obtained in Tokke Kutaye was in close agreement the 27.7±0.21kg mean body weight reported by Zewdu (2008) for Horro sheep. On the other hand, the mean live body weight obtained from sheep population of Dandi district was somewhat comparable with the 24.6 kg reported by Sisay (2002) for the Central highland sheep. As body weight increases other linear body measurements were also increased. The highest mean leaner body measurements such as HG, WH, BL, and RH were also recorded for sheep population found in Tokke Kutaye followed by those found in Ambo district and the least mean leaner body measurements were reported from Dandi district (Table 2). Amelmal Alemayehu (2011) and Abera *et al*. (2016) reported that most of the linear body measurements and live body weight were affected by district.

Sex effect

Sex of the sheep had significant ($p<0.01$) effect on BW, HG, BL, WH, RH EL, HL, RW, R L, except TL that was not affected ($P>0.05$) by sex of the sheep. Similar influence of sex was also reported by Taye *et al*. (2016) on body weight, heart girth, body length and height at rump. On the other hand, Haylom *et al*. (2014) reported that sex had no effect on body weight; heart girth, body length and height at wither in highland sheep found in Atsbi Wonberta. In the current study, live body weights obtained for male and female sheep were 29.0±0.41 and 24.6±0.12kg, respectively. A difference of 2 cm was observed in heart girth between male and female sheep in the current study. Heart girth values of 75±.57cm and 73±.20cm were obtained for male and female sheep, respectively.

Age effect

In current study, body weight and all linear body measurements of the sampled sheep were significantly ($P<0.01$) affected by age group (Table 2). Body weight and all linear body measurements were increased as the age increased from the youngest (1PPI) to the oldest (≥ 3 PPI). Live body weight of 24.0±0.17kg 26.8±0.15kg 29.6±0.18kg were recorded for age group 1PPI, 2PPI, ≥ 3PPI, respectively. The corresponding heart girth (HG) measurement recorded were 69.8±0.30cm, 74.4±0.23cm and 78.5±0.27cm for age groups 1PPI, 2ppI and ≥3PPI, respectively. Results obtained in the current study were in agreement with literature reports (Hizkel *et al.*, 2017; Mohammed *et al*., 2017).

Age by sex interaction effect

Age by sex interaction had significant effect (P<0.01) on body weight (BW) and rump width (RW). However, they have no significant effect (P>0.05) on all other linear body measurements included in the current study (Table 2). The result was contradicted with Abera *et al.* (2014) who reported that all linear body measurements and live body weight were significantly (P<0.05) influenced by the interaction effects of age and sex.

Table 2. Body weight and leaner body measurement

Level	N	BW	HG	BL	WH	EL	HL	RL	RW	RH	TL	SC
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	690	26.8±.27	74.2±.39	64.1±.34	67.6±.35	12.5±.08	20.3±.14	21.0±.15	20.1±.13	67.7±.31	34.8±.31	22.5±.43
R^2		0.70	0.45	0.36	0.42	0.57	0.59	0.29	0.35	0.32	0.23	0.54
CV%		6.89	5.16	5.44	4.98	7.28	5.83	7.97	6.17	5.23	10.31	10.1
District		**	**	**	**	**	**	Ns	Ns	**	**	*
Tokke Kutaye	230	28.4±.24^{a}	75.5±.35^{a}	65.3±.28^{a}	68.6±.29^{a}	12.8±.08^{a}	20.5±.12^{a}	21.0±.13	20.1±.11	68.5±.30^{a}	36.3±.25^{a}	23.0±.44^{a}
Ambo	230	26.1±.19^{b}	74.1±.34^{b}	63.4±.29^{b}	67.3±.29^{b}	12.3±.09^{b}	20.0±.12^{b}	20.9±.15	20.1±.10	67.4±.28^{b}	34.4±.27^{b}	22.8±.42^{a}
Dandi	230	25.9±.15^{b}	73.1±.30^{c}	63.5±.25^{b}	66.8±.27^{b}	12.4±.09^{b}	20.3±.12^{a}	20.8±.11	19.9±.09	67.3±.26^{b}	34.3±.27^{b}	21.4±.42^{b}
Sex		**	**	**	**	**	**	**	**	**	Ns	
Male	90	29.0±.41^{a}	75.4±.57^{a}	65.2±.50^{a}	68.7±.53^{a}	12.8±.15^{a}	20.6±.20^{a}	21.2±.22	20.3±.20^{a}	68.5±.50^{a}	35.1±.45	22.5±.43
Female	600	24.6±.12^{b}	73.0±.20^{b}	63.0±.17^{b}	66.5±.17^{b}	12.2±.06^{b}	19.9±.07^{b}	20.7±.08	19.8±.06^{b}	66.9±.17^{b}	34.5±.16	
Age		**	**	**	**	**	**	**	**	**	**	**
1PPI	183	24.0±.17^{a}	69.8±.30^{a}	60.7±.24^{a}	63.9±.28^{a}	11.2±.08^{a}	18.14±.08^{a}	19.5±.12^{a}	18.7±.09^{a}	64.6±.28^{a}	33.0±.27^{a}	19.4±.44^{a}
2PPI	279	26.8±.15^{b}	74.4±.23^{b}	64.0±.24^{b}	64.0±.22^{a}	12.5±.06^{a}	20.2±.07^{b}	20.8±.11^{a}	20.1±.07^{b}	68.0±.22^{b}	34.9±.23^{b}	23.8±.37^{b}
≥3PPI	228	29.6±.18^{c}	78.5±.27^{c}	67.5±.23^{c}	71.0±.19^{b}	13.7±.05^{b}	22.1±0.09^{c}	22.4±.09^{b}	21.4±.08^{c}	70.7±.23^{c}	37.1±.33^{c}	24.0±.47^{b}
Sex By Age		**	Ns	Ns	Ns	Ns	Ns	Ns	**	Ns	Ns	
Male*1PPI	27	25.9±.24^{a}	71.0±.71	61.5±.63	64.9±.86	11.5±.25	18.8±.24	19.8±.35	18.8±.29^{a}	65.4±.83	33.1±.91	
Male*2PPI	39	29.1±.58^{b}	75.2±.78	64.9±.63	68.9±.73	12.7±.15	20.4±.18	20.8±.29	20.2±.26^{a}	68.6±.74	35.2±.57	
Male*≥3PPI	24	32.2±.75^{c}	80.1±.71	69.2±.78	72.1±.70	14.0±.16	22.7±.31	23.0±.26	22.0±.27^{b}	71.6±.67	37.1±.79	
Female*1PPI	156	22.1±.16^{d}	68.6±.33	59.9±.26	62.9±.28	10.9±.08	18.1±.08	19.3±.13	18.6±.10^{d}	63.7±.29	32.8±.28	

Table 2. *(Continued)*

Female*2PPI	240	24.6±.10^{e}	73.6±.24	63.1±.25	66.6±.22	12.3±.06	20.1±.07	20.8±.12	20.0±.07^{e}	67.4±.22	34.6±.25	
Female*≥3PPI	204	27.0±.15^{f}	76.8±.28	65.8±.23	69.9±.20	13.5±.05	21.7±.09	21.9±.09	20.8±.09^{e}	69.8±.24	37.1±.25	

BW = Body weight; HG = Heart Girth; BL = Body Length; WH = Wither Height; EL = Ear Length; HL = Horn Length; RL = Rump Length; RW = Rump Width; RH = Rump Height; TL = Tail Length; SC = Scrotal Circumference; Means with different superscripts within the same column and class are statistically different (at least P<0.05). Ns = non-significant; * Significant at 0.05; **significant at 0.01. 1PPI = 1 pair of permanent incisors, PPI = 2 pairs of permanent incisors and≥3PPI=3or more pair of permanent incisors.

Correlation among Body Weight and Linear Body Measurements

Correlation coefficients of live body weight and linear body measurements for male and female indigenous sheep in the three districts are presented in Table 3. Determining animal live body weight, linear body measurements and their interrelationship and correlation are very important for determining the genetic potential, breed standards and improved breeding programs for higher meat production (Younas *et al*., 2013). All linear body measurements of male sheep and female sheep showed highly significant (P<0.01) positive associations with body weight, except for horn length which was significantly and negatively associated (P<0.05) with body weight in both sexes. Among the measured linear body measurements, body length (r = 0.63), heart girth (r = 0.79), wither height (r = 0.61) rump width (r= 0.70) and rump height (r = 0.65) while for female sheep or ewe body length (r = 0.64), heart girth (r = 0.73), wither height (r = 0.70) and rump height (r = 0.64) were strongly correlated with body weight. The highest correlation of heart girth with body weight than other body measurements was in agreement with literature reports (Tesfaye, 2008; Dejen, 2010; Mohammed *et al.,* 2017). This would imply that chest girth is the best variable for predicting live body weight than other measurements. The high correlation coefficients between body weight and linear body measurements for male and female imply that either of these variables or their combination could provide a good estimate for predicting the live weight of sheep from body measurements.

Table 3. Phenotypic correlations among linear body measurements for both sex; below and above the diagonal is for male and female,

	HeL	HL	EL	HW	HG	BL	RL	RW	RH	TL	SC	BW
HeL		-0.07^{NS}	0.63**	0.62**	0.61	0.63**	0.53**	0.63**	0.60**	0.39**	0.16^{NS}	0.60**
HL	0.04 ^{NS}		-0.16 ^{NS}	-0.08 ^{NS}	-0.22*	-0.28*	0.08 ^{NS}	-0.14 ^{NS}	-0.09 ^{NS}	0.04 ^{NS}	0.12 ^{NS}	-0.31*
EL	0.70**	-0.01 ^{NS}		0.45**	0.65**	0.61**	0.54**	0.65**	0.54*	0.41**	0.26*	0.58**
HW	0.57**	-0.04 ^{NS}	0.57**		0.78**	0.73**	0.65**	0.69**	0.84**	0.62**	0.42**	0.61**
HG	0.55**	-0.01 ^{NS}	0.55*	0.68**		0.79**	0.71**	0.76**	0.78**	0.58**	0.43**	0.79**
BL	0.49**	-0.03 ^{NS}	0.51**	0.61**	0.66**		0.65**	0.72**	0.76**	0.59**	0.26*	0.73**
RL	0.49**	0.02 ^{NS}	0.48**	0.45**	0.50**	0.45**		0.83**	0.67**	0.56**	0.43**	0.56**
RW	0.55**	0.05 ^{NS}	0.51**	0.49**	0.54**	0.49**	0.71**		0.74**	0.59**	0.42**	0.70**
RH	0.52**	-0.00 ^{NS}	0.53**	0.70**	0.74**	0.67**	0.51*	0.53**		0.60**	0.50**	0.65**
TL	0.37**	-0.08*	0.43**	0.40**	0.39**	0.33**	0.36**	0.35**	0.36**		0.26*	0.52**
SC	_	_	_	_	_	_	_	_	_	_		0.38**
BW	0.64**	-0.08*	0.65**	0.70**	0.73**	0.64**	0.50**	0.52**	0.64**	0.51**	_	

respectively.

*=significant at (P<0.05); **=significant at (P<0.01); Ns= not significant at (P<0.05) BL=Body Length; HG=Heart Girth; EL=Ear Length; HeL=Head length HL=Horn Length; HW= height at wither; RH= Rump Height; RW = Rump Width; RL=Rump length; TL=Tail Length; (-) = No value take

Prediction of Body Weight from Different Linear Body Measurements

Multiple regression analysis was presented in Table 4. Regression analysis is commonly used in animal research to describe quantitative relationships between a response variable and one or more explanatory variables such as body weight and linear body measurements especially when there is no access to weighing equipment (Cankaya, 2008). The accuracy of functions used to predict live weight or growth characteristics from live animal measurements is of vast financial contribution to livestock production enterprises (Mohamed *et al.,* 2017). Multiple regression equations were developed for predicting body weight from other linear body measurements.

In the current study, all the body measurements were built-in the regression model and through elimination procedures, the optimum model were identified for both male (ram) and female (ewe). Except for the scrotum circumference (SC) which was not included in the model used for female, linear measurements such as heart girth (HG), height at wither (HW), body length (BL) rump width (RW), rump length (RL), rump height (RH), head length (HeL), ear length (EL), and tail length (TL) were fitted in the model of analysis. Stepwise regression was carried out for each sex by entering all the above traits at a time for male and by excluding SC for females to predict body weight. The fitted prediction model was selected with smaller value of C (p), AIC, SBC, RMSE and higher R^2 and $A.R^2$ values. Heart girth selected first, which explain more variation than any other linear body measurements in both rams (0.62) and ewes (0.53). Similarly, this measurement was reported for Gumuz, Jarso, and Nedjo sheep (Solomon, 2007; Kedjela, 2010). However, predictions of body weight from combinations of LBMs, having these multiple variables possess a practical problem under field settings due to the higher labor and time needed for measurement. Furthermore, the change in R^2 due to inclusion of additional variables in the model was not strong strengthening the preceding argument that chest girth alone could serve as a best predictor of body weight under field condition. Measuring heart girth with tape is easy, cheap and rapid. Thus, body weight prediction from chest girth alone would be a practical option under field conditions with reasonable accuracy.

Two regressor variables with significant contribution to the prediction model which include heart girth and body length were fitted in first and second step for ram whereas five regressor variables like heart girth (HG), height at wither (HW), tail length (TL), body length (BL) and rump width (RW) were first, second, third, fourth and fifth steps for female was best fitted model for study area. The overall equation HG as explanatory variable may be used for the prediction of body weight for male and female sampled sheep population in all districts. Thus, prediction of body weight could be based on regression equation:

$y = -14.21 + 0.57x$ for male sample population and

$y = -3.49 + 0.39x$ for female sample sheep population

Where; y = body weight and x= heart girth,

Table 4. multiple regression analysis of live body weight on different linear body measurements for indigenous sheep for both sexes in the study area

Sex	Model	Intercept	β_1	β_2	β_3	β_4	β_5	R^2	$A.R^2$	C(p)	AIC	Root MSE	SBC
Male	HG	-14.21	0.57					0.62	0.62	12.27	161.51	2.43	166.51
	HG + BL	-17.21	0.41	0.23				0.65	0.65	6.61	156.21	2.34	163.71
Female	HG	-3.49	0.39					0.53	0.53	233.57	713.49	1.81	722.28
	HW+HG	-9.25	0.24	0.25				0.61	0.61	102.46	610.55	1.66	623.74
	HW+HG+TL	-10.08	0.20	0.22	0.14			0.64	0.64	39.96	554.25	1.58	571.83
	HW+HG+BL+TL	-11.94	0.17	0.18	0.12	0.14		0.66	0.66	8.69	523.79	1.54	545.77
	HW+HG+BL+RW+TL	-12.57	0.16	0.17	0.11	0.12	0.13	0.66	0.66	5.80	520.87	1.54	547.25

BW= body weight; BL= body length; HG= Heart girth; RW=Rump width; TL=tail length; R^2 = R- square; MSE= Mean square of error; A.R2= adjusted R^2; C (p) =Mallows C parameters; AIC =Alkaike's Information Criteria; SBC =Schwarz Bayesian Criteria.

Demarcation between Horro and Central Highland Sheep Breeds

Sheep breed/s available in the central highlands of the country including those available in west Shewa zone are generally named as Centeral highland sheep mainly due to lack of proper characterization. On the other hand, reports (Galal, 1983) indicated that Horro sheep breed is distributed in some parts of western Shewa zone. These controversial ideas were persisting for long period of time and there is no geographical demarcation between two breeds. Thus, results of the current study tried to put geographical demarcation based on physical and morphmetrical characters (traits) of sheep. Some qualitative and quantitative traits were used for demarcation of the boundary between the two breeds.

Qualitative traits

Sheep breeds that are previously characterized have more or less their own typical morphological characters. Among these Horro and Central high land sheep breeds are considered under previously characterized breed. Thus, horn, coat color pattern, color types and hair type were the most indicators of qualitative traits that are used for demarcation of these breeds.

Horn

Horn is the typical characters of the Central high land and poldness is the typical character of Horro sheep breed. Results of the current study indicated that about 4.2% from Tokke Kutaye, 41.1% from Ambo and 72.6% from Dandi district sheep were horned, respectively (Table 1). Almost all sheep breed in Tokke Kutaye was hornless, this indicate they share Horro sheep breed characters. On the other hand, majority sheep breed in Dandi district were horned as a result of the share centeral high land sheep breed characters. Although sheep breed in Ambo district was average of the two breeds (Fig.2). Therefore, both breeds are found in Ambo district being mixed.

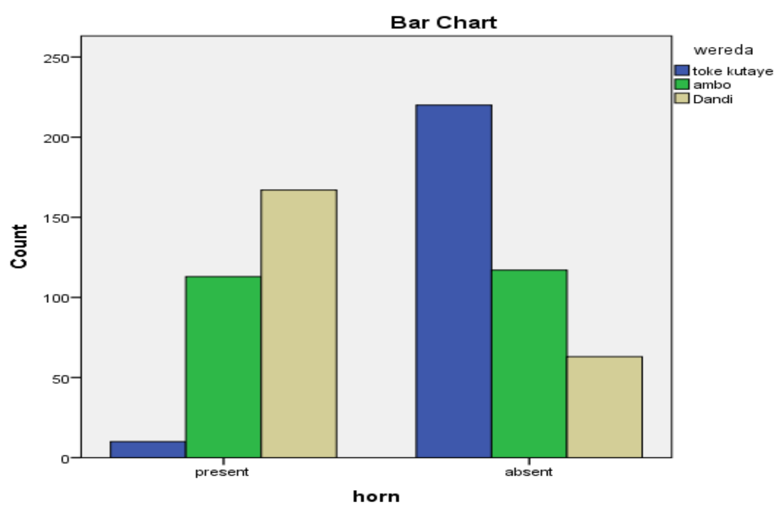

Figure 2. Cluster bar graph showing horn of sheep

Coat color types

Coat color type is one of the most important qualitative traits in discrimination of breed. Previously characterized breed had their own most dominant coat color type. Zewdu (2008) reported that 55.6% of Horro sheep breed had uniform brown coat color. In the current study, about 60.0%, 44.3% and 43.9%

of the sampled sheep population from Tokke Kutaye, Ambo and Dandi districts were brown, respectively (Table 1 and Figure 3). Sheep population in Dandi district had mixed coat color types. On the other hand, sheep population in Tokke Kutaye had more uniform coat color followed by those sheep populations from Ambo district indicating that sheep in Ambo district had the characteristics of sheep population found in Tokke Kutaye and Dandi district.

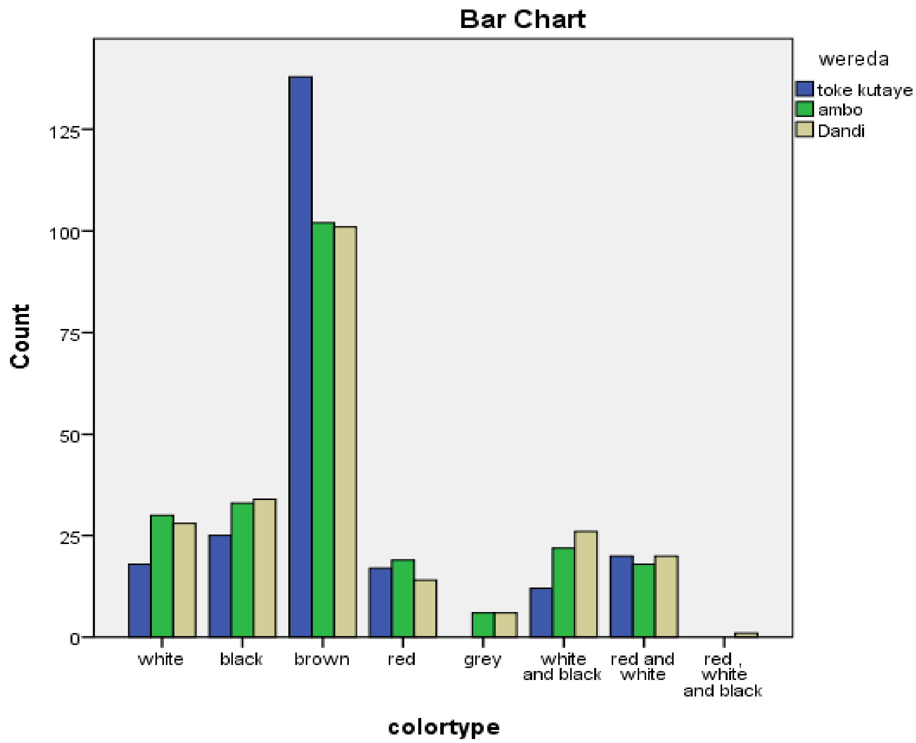

Figure 3 Cluster bar graph showing color types of sheep

Hair type

Hair type was another trait used for identification of breeds in this study. About 90.4% of sampled sheep population from Tokke Kutaye, 71.5% from Ambo and 76% from Dandi districts had coarse and smooth hair type (Tables 1). Tokke Kutaye sheep encompass higher percentage of short and smooth hair type but sheep breed in Dandi district had lower when compared with Tokke Kutaye. Sampled sheep population found in Ambo district was slightly lower than the two breeds with regard to hair type but more approach to sheep breed in Dandi district (Fig. 3).

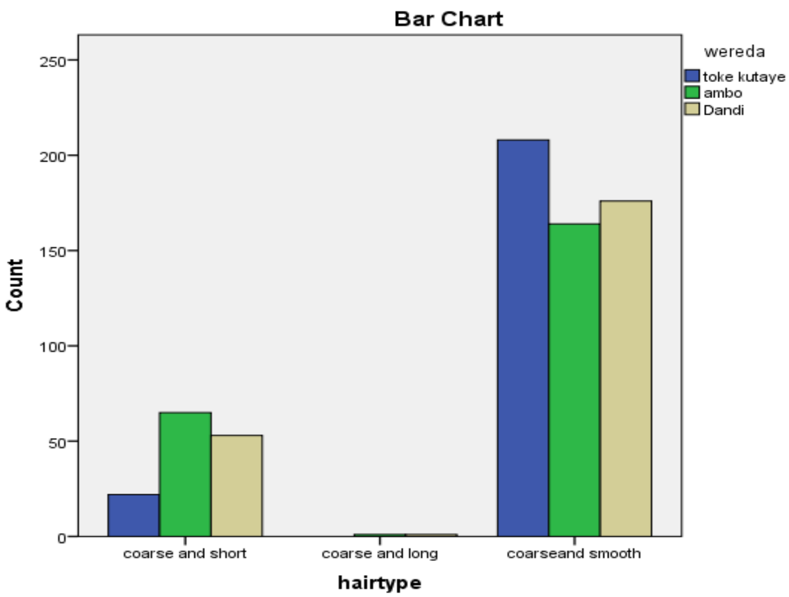

Figure 4 Cluster bar graph showing hair type of sheep

Quantitative traits

Almost all quantitative variables (traits) included under this study were significantly (*P*<0.01) different within districts (Table 2). Among these, the most explanatory variables were taken for demarcation of sheep breeds targeted in study areas. These are body weight (BW), heart girths (HG), body length (BL), wither height (WH) and rump height (RH). The results of current study indicate that the least square means of selected traits were higher in Tokke Kutaye and lower in Dandi districts while the result obtained from Ambo was existed at the middle of the two districts.

Body weight and heart girth were the most explanatory traits among the selected traits. About 28.4±0.24kg, 26.1±0.19kg and 25.9±0.15kg of body weight were obtained, respectively, from Tokke Kutaye, Ambo and Dandi districts. The result obtained from Tokke Kutaye was higher and relatively approach the 29.7±0.68kg live weight reported for Horro sheep by (Zewdu 2008). On the other hand, body weight obtained from Dandi district was lower than Body weight obtained from Ambo district. Similar to body weight heart girth decreases from Tokke Kutaye to Dandi districts. Least square mean (LSM) of heart girth of sheep breed/s were 75.5±0.35 cm form Tokke Kutaye, 74.1±0.34 cm from Ambo and 73.1±0.30 cm from Dandi districts. Therefore, the result obtained from Ambo district falls in between results of the two breeds (Horro and Central Highland sheep).

Body length (BL), wither height (WH) and rump height (RH) were other quantitative traits used for breed identification in study areas. In Tokke Kutaye district BL, WH and RH of the sampled sheep population were 65.3±0.28, 68.6±0.29 and 68.5±0.30, respectively. The results were in line with Zewdu (2008) report on Horro sheep breed. Correspondingly, the results obtained from Dandi district were 63.5±0.25, 66.8±0.27 and 67.3±0.26 for BL, WH and RH, this is agreement with Abera *et al.* *(*2014*)* for local sheep in Salale area which is considered as the Central highland sheep breed. About 63.4±0.29 for BL, 67.3±0.29 for WH and 67.4±0.28 for RH were obtained from the sampled population from Ambo district (Table 2). Except for the body length results obtained from Ambo district were fallen between results obtained from Tokke Kutaye and Dandi districts.

Generally, based on the results obtained from qualitative and quantitative traits geographical demarcation between Horro sheep breed and the Central highland sheep breed is Ambo district, where admixture of the two breeds, Horro and the Central Highland sheep breeds is observed.

CONCLUSION

The current study results showed that sheep population in Tokke Kutaye are Horro sheep breed and those in Dandi district show characters of the Central highland sheep breed. Nevertheless, sheep population found in Ambo district exhibit characters of both sheep breeds, Horro and the Central highland sheep breeds. Therefore, Ambo district is the geographical demarcation of Horro sheep and the Central high land sheep breeds. In fact, further in-depth study supported by molecular characterization is warranted to clearly demarcate the boundary lines of the two breeds and investigate their level of admixture.

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