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Research Paper

On

Phenotypic Characterization of Goats (*Capra hiricus)* Reared at South Wollo Zone, Northeast Ethiopia.

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ABSTRACT

The study was carried out to phenotypically characterize Goats (Capra hiricus) Reared at South Wollo Zone, Northeast Ethiopia with the aim to access the production, qualitative and quantitative characteristics of goats and to assess the type and function of goats by using zoometrical indices. The study was performed based on household survey and field measurements. For household survey, 135 households were involved and body measurements were taken from 450 goats of both sexes from 0PPI to 4PPI. Using the body measurements of the goats 10 structural indices was calculated. Both qualitative and quantitative data were analyzed using SPSS versions 26 and indices calculation was performed by Microsoft excel for windows. The qualitative traits were compared by chi-square test while the quantitative variables were compared by Duncun's multiple range tests. The result indicated that the average goat flock size per household shows increasing trend with respect to equine and cattle while decreasing with respect to sheep. There were higher numbers of female goats than male goats per household. Goats were primordially reared as a source of cash income across the three districts which was followed by meat,income and skin for Kelala; meat, wealth and income for Woreelu and wealth,income and meat for Borena District in their order of importance. The goat flocks were provided with house. The majority of households herded their goats with sheep in the dry season while goats alone in the wet season. Bush/shrub and crop aftermath were the main feed sources of the goats flock in wet and dry season respectively. In the dry season majority of the goats flock have access to clean water while muddy in the wet season. Buckling's wean and reach for market at earlier age than doeling's. Across all the districts, there were higher intensions of selling males than females in dare of cash need. Castration was entirely practiced at the age of 1-2 years traditionally with the aim to fatten and team the bucks. Selection was practiced for both male and female where appearance was the most selection criteria for both sexes. Farmers in the study area mainly practice natural and uncontrolled mating systems. Predator was the main production constraints in all of the studied districts. The main frequently observed coat color pattern of goats were plain and the main dominantly observed coat color type were black. Presence of horn was common with dominant curved shape and backward orientation. The absences of wattle and skin pigmentation, concave face profile and long hair (smooth and glossy in respective order) are the main common characteristics of South Wollo goats. There were no significant difference ($p>0.05$) among the districts for body weight and linear body measurements. Many of the linear body measurements have significant and positive correlation with live body weight. Generally, the result from the structural indices indicates that the Longhaired Arsi-Bale goats are adaptive to the highland areas. Therefore, this findingwas put baseline for understanding about production and phenotypic characteristics of longhaired Arsi-Bale goats as a first step in designing a sustainable breeding program in the study area.

Key words.Borena, Kelala, Woreelu, South Wollo goats, phenotypic traits, Structural indices.

1. INTRODUCTION

1.1. Background of the Study

Small ruminants (sheep and goats) are an integral parts of the livestock sub sector in Ethiopia (Zewdie and Welday, 2015). They constitute around 33.14%of the total livestock population of the country (CSA, 2018). They are avital part of the livelihood systems among the agrarian and pastoral communities by contributing to the socio-economic wellbeing of their rearers (Markos, 2006; Tsigabu, 2015). Their prolificacy and fecundity, short generation interval, adaptation in harsh environment and their ability to thrive under limited feed resources, all these make them favorable as an investment and insurance (Tsedeke, 2007). Small ruminants also serve as sources of foreign currency and are exported in large numbers to the neighboring countries (Berhanu *et al*., 2006). It has also been reported in a study by Zelalem and Fletcher (1993) that, small ruminants serve as a source of wealth for the resource challenged members of the society who are unable to invest in large ruminants.

Findings of a study by Getinet *et al*. (2016) have indicated that the country is bestowed with several goat breeds, which are raised under diverse agro climates, which ranges from the arid, semi-arid to the humid and high altitude type conditions. The report by IBC (2004) indicated that there were nineteen goat breeds/ecotypes in Ethiopia. It has been estimated in a study by CSA (2018) 32.74 million heads of goat, of which 70.49 % and 29.51 % with the former being the proportion of the does and doeling's while the later are the bucks and buckling's of which the majority of the goats are of indigenous origin. It has also been reported that most of the goats belong to the breedable age categories followed by the yearlings and just weaned age category. It has been estimated that the region houses 7.766 million heads of goats, which account for 23.72% of the total goat population of the country (CSA, 2018).

The pastoralists in the lowlands of the country raise most of the goats in the country; this is followed by rearing of small flocks by the smallholder farmers residing in the midlands and highlands of the country (Farm-Africa, 1996; Tesfaye, 2004; Adane and Girma,2008). The goats are primordially selected for their adaptive traits while the productivity on an individual basis is small but the overall economic impact comes in rearing them in large numbers (Markos, 2006; Alemu and Merkel, 2008).

However, in spite of their large numbers their overall contribution to the national economy is far below the expectation, this might be attributable to their genetic makeup, environmental and socio-economic factors (Adane and Girma, 2008).Constraints pertaining to their sub optimal productive and reproductive performances can be recognized to seasonal scarcity of feed and forages, lack of veterinary infrastructure, high prevalence of diseases and parasites, lack of records, and lack of scientific management and high levels of inbreeding (Zewdie and Welday, 2015).

1.2. Statement of the Problem

South Wollo zone is characterized by diverse agro-ecology where goats play significant roles for the communities, which rear them. The existing goat breeds in the area are categorized as central highland goat type and are reared under semi intensive system of management (Farm Africa, 1986). The areas are potentially important zone when it comes to the agrarian activities and can be categorized under crop livestock system of management.

According to Groeneveld *et al*. (2010) identifying and understanding of the livestock genetic resource is the prerequisite for any livestock development intervention; this has to be followed by their wise use so as to minimize their genetic erosion. Conservation of these livestock genetic resources relies on their phenotypic characterization, followed by the assessment of their production environments and effective data management (Groeneveld *et al*., 2010). Characterization of any livestock helps to

identify a population of livestock with unique features that differentiate them from the others. Thus, it necessities the understanding of the demography of the livestock/goats and its future (Israel *et al.*, 2013). From the four strategic point of view the priority areas chalked out for the conservation of the livestock as indicated by FAO (2007) are breed characterization, inventory and monitoring of the population trends. The phenotype of the goats are influenced by several factors viz. socio-cultural and economic values of the communities rearing them (Zewdie and Welday, 2015).

In spite of the fact that there have been several documents, which belong to the documentation of the indigenous goat breeds of the country, using morphometrical traits (Alemayehu, 1993; Farm Africa, 1996; Werkneh *et al*., 2004; Deribe, 2009; Halima *et al*., 2012; Dereje *et al.*, 2013). However studies on types and functions of a goat breeds using structural indices are lacking. Structural indices are expected to provide empirical alternative to the limited use of single measurement for the assessment of type and function for which a particular breed was developed (Chacon *et al*., 2011).

Therefore, the present study were performed to fill the information gap on goats at South Wollo Zone with the following objectives.

1.2. Objectives

1.2.1. **General objective**

- ✓ To assess the phenotypic characteristics of goat types in the study area.

1.2.2. **Specific objectives**

- ✓ To study the production characteristics of goats in the study area
- ✓ To assess the qualitative and quantitative characteristics of goats
- ✓ To assess the type and function of goats by using zoometrical indices.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted in South Wollo zone of Amhara Regional state, Southeast Ethiopia. South Wollo Zone has 22 districts and home for 1,756,314 head of cattle, 1,991,087 sheep, 975,070 goats, 79,215 Horses, 34,625 Mules, 505,225 Donkey, 11,609 Camels, 2,100,202 chicken and 132,440 beehives. The Zone has the third highest livestock population in Amhara National Regional State. It ranks first in sheep population and fourth in cattle population compared to other zones (CSA, 2017). Based on the 2007 Census conducted by the Central statistics agency of Ethiopia (CSA), this Zone has a total human population of 2,518,862, an increase of 18.60% over the 1994 census, of whom 1,248,698 are men and 1,270,164 women; with an area of 17,067.45 square kilometers (CSA,2017). The mandate area of the university comprises 11 districts of the Zone of which Kelala, Wereelu and Borena districts were selected purposively for the study.

2.2. Sampling and Data Collection Procedures

2.2.1. **Sampling techniques**

Stratified multi-stage sampling technique were employed for selecting study districts, Kebeles and goat owners. In the first stage, three districts (Kelala, Wereelu and Borena) were selected from the south Wollo zone purposively.

In the second stage, three Kebeles were selected purposively from each district through discussion with the respective districts livestock and fishery officers. In the third stage, the farmers who have at least three adult heads of goats (of both the sexes) and have experience in rearing the goats for at least 10 years were identified within each Kebeles. Thereafter, among the identified rearers potential respondents were selected randomly from each of the identified nine Kebeles.

Focal-groups were established at each Kebele whose members included individuals communally known to have high quality breeding animals, person believed to be knowledgeable about past and present social and economic status of the area and community elders and storytellers.

For physical characterization and morphological measurements, (3-4 heads of goats) totally ***1200 Goats*** were selected randomly (irrespective of the sex and age) from the flocks of the identified respondents. The age of the goats were estimated by recall methods from their owner and for further clarification dentation classes were used. Goats were grouped in to five age categories based on dentation. Age category of goats were performed based on Taiana *et al*.(1999) and, Solomon and Awgchew (2009) viz. goats with no pairs of permanent incisors (0PPI) at weaning age below 12-14 months, one pair of permanent incisors (1PPI) at age of 15-23 months, two pairs of permanent incisors (2PPI) at age of 24-35 months, three pairs of permanent incisors (3PPI) at age of 36-48 months and four pairs of permanent incisors(4PPI) at age over 48 months and sex male and female.

2.2.2. ***Sample size determination for households***

Sample size of the households were determined according to the formula given by Cochran's (1977)

$$n = \frac{Z^2 * (P)(q)}{e^2}$$

n = sample size

Z = standard normal deviation (1.96 for 95% confidence level)

P = 0.5(estimated population variability proportion, 50%)

q = 1-P i.e. (0.5)

e = level of precision (0.05)

Hence base on this formula the sample household's respondent number were 384 HH. Form each house hold 3- 4 goats were used for the study i.e. 1200 goats were used for qualitative and quantitative characterization.

2.2.3. **Data type and collection method**

2.2.3.1. Questionnaire and group discussion

In depth, discussions with each districts livestock and fishery officers were carried out to have an overview about prevalent goat production subsystem in the area. Then preliminary surveys were carried out in the selected Kebeles of each district to assess information prior to the questionnaire preparation to be used for the formal survey. By taking the information gathered by preliminary survey a checklist and modified semi structured questionnaire were prepared by adopting a questionnaire prepared by ILRI (International Livestock Research Institute). Some re-arrangements were made based on the study objectives. Then the questionnaire was administered to randomly selected households to collect the following major information.

1. Socio economic characteristics of the household: Sex, age, educational level, family size, general livestock possession, goat flock size and composition, land holding, livestock production system, importance of goats and responsibility of household member in goat husbandry.
2. Goat husbandry practices: Herding, feeding and watering of goats, housing, castration, weaning, fattening and goat marketing.
3. Breeding practices: Reproductive characteristics, selection criteria of male and female goats, culling and reproductive performance of goats.
4. Veterinary services for goat

5. Goat production and reproduction constraints

2.3.2.2.Morphometric data collection

Based on breed morphological characteristics descriptor list of FAO (2012) for morphological characterizations of goats, both qualitative and quantitative data were collected from all age group (0PPI-4PPI) goats comprising both sexes. To avoid genetic similarity of goats, less than or equal to 4 goats per household were used for both qualitative and quantitative traits recording. Each animal were identified by its sex, dentition and sampling site. Dentitions together with information obtained from the owner were used to classify the goats by age.

Qualitative characters: data on coat color pattern, coat color type, skin pigmentation, hair type, horn presence, horn shape, horn orientation, ear form, face profile and wattle presence were observed and recorded for males and females separately by using visual appraisal and descriptor list of FAO (2012) pertaining to the morphological characterization of goats.

Quantitative characters: The morphometric parameters were obtained using self-devised equipment. All measurements were taken early in the morning prior to feeding and the goats were taken to an up-right position during measurement. Pregnant and lactating does were avoided in the sampling. The linear body measurement were made using plastic tape and caliper, while body weight were measured using suspended weighing scale having 50 kg capacity with 0.2 kg precision. The methods and materials that were used for measuring the traits is presented below in Table 1.

Table 1: Quantitative traits and their definitions

Traits	Definitions	Material
Body weight	Live body weight (kg) measured early in the morning	Weighing scale
Horn length	The distance of horn from the base to the tip (cm)	Measuring tape
Horn width	The bottom width between the two horns	Measuring tape

Ear length (cm)	Length of the ear on its exterior side from its root to the tip	Measuring tape
Head length	The length of the face from the poll of the animal to the end of muzzle in centimeter	Caliper
Neck circumference	Taken as the distance round the mid region of the neck;	Measuring tape
Height at withers (cm)	Height (cm) from the bottom of the foreleg to the highest point of the shoulder when the goat was standing upright	Measuring tape
Chest girth (cm)	Circumference (cm) of the body immediately behind the shoulder blades in a vertical plane perpendicular to the long axis of the body	Measuring tape
Chest depth	The dorsal–ventral distance between the most dorsal point of the withers and the ventral surface of the sternum;	Measuring tape
Cannon circumference	Recorded as the smallest circumference of the foreleg;	Measuring tape
Body Depth	Depth (D) Between Corpus Sterni and the point between the shoulder blades	Measuring tape
Abdominal circumference	Measured as body circumference in front of the sacrum;	Measuring tape
Rump height (cm)	Height (cm) from the bottom of the hind leg to the highest point of rump when the animal was standing upright	Measuring tape
Rump length	Measured from the back of the rump to the hook bones	Caliper
Body length (cm)	Horizontal length(cm) from the point of shoulder to the hipbone	Measuring tape
Pelvic width (cm)	Horizontal distance (cm) between the extreme lateral points of the pelvic bone (tuber coaxed) across the dorsum	Measuring tape
Teat length	The length of the teat measured from the base of the teat to the end of the teat in centimeters	Measuring tape
Scrotum circumference	Measured from the middle of scrotum	Measuring tape

3.3. Indices Calculation

Ranking indices were calculated to provide ranking reason of keeping goats, feed source for goats in dry and wet season, selection criteria for doe and buck, production and reproduction problems of goat rearing according to a formula:

Index = sum of (4 X value of ranks 1 + 3 X values for 2 + 2 X values for 3 + 1 X values for rank 4) given for an individual attribute /response divided by the sum of (4 X value of ranks 1 + 3 X values for 2 + 2 X values for 3 + 1 X values for rank 4) for overall attribute (Belete, 2013; Hulunim, 2014; Yaekob*et al*., 2015).

Also from the linear body measurements 16 (sixteen) structural and functional indices were calculated according to methods suggested by Salako (2006),Chacon *et al*.(2011), Costa *et al*. (2014) and Peter(2015) in order to assess the type and function of the breed of goat under study.

1. Height slope (HS) = Wither height –rump height
2. Length index (LI) or Relative body index = Body length/ height at withers
3. Depth index (DI) = Chest depth/ height at withers
4. Body index (BI) = (Body length/ Heart girth.When this measure is greater than 0.90, the animal is longi line; between0.86 to 0.88 is medigline; and less than 0.85, it is brevigline.
5. Proportionality (Ipr P) = (Height at withers*100/ Body length)
6. Pelvic index (PI) = (Rump width/ Rump length)*100
7. Transverse pelvic (IPT) = (Rump width/ Rump height)*100
8. Longitudinal pelvic (IPL) = (Rump length/ Rump height)*100
9. Relative depth of Thorax (IPRT) = (Chest depth/Height at withers)*100
10. Dactyl thorax index (DTI) = (Cannon bone circumference/ Heart girth)*100. The DTI may not be more than 10.5 in light animals, up to 10.8 in intermediary; up to 11.0 in light meat animals and up to 11.5 in heavy meat type. This index also indicates thoracic development.
11. Thoracic development (TD) = Heart girth/ Height at withers. This indicates thoracic development of the animal, with values above 1.2 indicating animals with good TD;
12. Body ratio (BR) = Height at withers/ Rump height
13. Baron and Crevat (BC) or Conformation index =$(\text{Heart girth})^2$/ Height at withers.
14. Area index (AI) = Height at withers x Body length
15. Relative cannon thickness index = Cannon circumference/ Height at withers x 100
16. Foreleg index: Wither height – Chest depth

3.4. Statistical Analysis

All the collected data were double-checked for any types of errors occurred during data collection and on-spot corrections were made accordingly. All qualitative data were coded and both qualitative and quantitative data from the questionnaire were recorded in separate sheet of Microsoft excel 2010.

Then the data were exported to and analyzed using Statistical Package for Social Science SPSS (V24) for Windows. The qualitative data from the questionnaire were analyzed using descriptive statistics Crosstabs. Percentage were compared across districts using non parametric tests (viz. chi square test), while the quantitative data from the questionnaire were analyzed using descriptive statistics the means and standard deviation (One-way ANOVA) and were compared across the districts using Duncan's multiple Range test, the values were considered significant at $P<0.05$.

Observations on qualitative characters were analyzed for male and female goats separately by using frequency procedure of SPSS and percentage were compared across districts using chi square test. Generalized Linear Model (GLM) procedures of SPSS were employed to analyze the quantitative traits of the goats. Mean comparisons were made for variables showing significant differences at $P<0.05$ between sample populations using Duncan multiple range tests. To analyze the body weight and linear body measurements the following linear model were used.

$$\mathbf{Y_{ij} = \mu + Ai + eij}$$

Where

Yi = the observed (body weight or linear body measurements) in the i^{th} District

μ =Overall mean

A_i= the effect of i^{th} District

eij= random residual error.

Correlations of live body weight with linear body measurement were computed for each sex and age category using Pearson correlation coefficient. Stepwise regression procedure of SPSS (V24) were used to regress body weight for male and female within each age group using Step down and curve fit

regression procedure of SPSS in order to determine the best-fitted regression equation for the prediction of live body weight. Best fitting models were selected based on Adjusted R^2 value. The following models were used for the estimation of live body weight from LBMs.

For Male:

$Y= \beta0 + \beta1X1+ \beta2X2+ \beta3X3+ \beta4X4 +eij$

Y = the response variable (live body weight)

β0= the intercept

X1…. X4 are the explanatory variables

β1 ..., β4 are regression coefficients of the variables X1.., X4

eij = random error

For Female:

$Y= \beta0 + \beta1X1+ \beta2X2+ \beta3X3+ \beta4X4 +eij$

Y = the response variable (live body weight)

β0= the intercept

X1…. X4 are the explanatory variables

β1 ..., β4 are regression coefficients of the variables X1.., X4

eij = random error

4. RESULT AND DISCUSSIONS

4.1. General Characteristics of the Respondent's

The findings as presented in Table 9 showed that the average age of the respondents were 49.48 years. This might have good implications on the data gathered on goat husbandry in the study areas because age of the respondents have a profound implication on livestock husbandry and agrarian activities as experience plays a profound role in traditional livestock husbandry procedures (Dossa *et al*., 2008). The mean age of the respondents in all districts was higher as compared to the report of Alefe (2014) where the average age of the respondents was 39.55 years in Shebelle zone southeastern Ethiopia.

The mean family size (number) in the study area (8.96) was higher as compared to the report of Grum (2010) and Alefe (2014) where average family size was 7.49 in Dire Dawa and 6.93 Shebelle zone, respectively. The higher family size might be better for the higher demand of labor for goat rearing; however, larger family size can be a bane rather than a benefit especially when the land is being fragmented over the years (Solomon *et al*., 2013).

The majority of the respondents across the study areas were males. The occurrence of less percentage of women respondents in the study areas may be due to the workload inside the house and as a result, the probability of getting them outside of the house is less. Moreover, when someone knocks the door of somebody's house, male usually comes out first and respond specially if the household head is male. These observations are in line with the observation of Alubal (2015).

As indicated in the result also most of the respondents were married which too is in accordance with the findings of Behailu *et al*, (2016) in Agarfa district. The results also indicate that many of the respondents were illiterate which too is in line with the findings of Tsedeke (2007) in Alaba, southern Ethiopia. These illiterate respondents may have experience but they may not able to keep pace with the

modern animal husbandry procedures. This may also lead to problems associated with the livestock recording for which is vital for any modern livestock development (Ntume *et al*., 2015). However, under such conditions it is needed to integrate the traditional livestock husbandry techniques with those of the modern and hence the authorities from the Ministry of Agriculture, research stations, ATVET and also universities need to join together to develop appropriate training programs (Adams and Ohene-Yankyera, 2014).

Table 2: General characteristics of the respondents

HH characteristics	Kelala	Woreelu	Borena	
Age (Mean±SD)	45.27 ±1.79[a]	49.73±1.46[ab]	53.44±1.83[b]	
Family size (Mean±SD)	8.51±3.15	9.82±2.85	8.53±3.04	
Sex				
Male	82.2	77.8	89.9	
Female	17.8	22.2	11.1	
$\chi 2$-value				1.99
Marital status (%)				
Married	77.8	82.2	95.6	
Widowed	13.3	11.1	2.2	
Divorced	8.9	6.7	2.2	
$\chi 2$-value				0.15
Educational level (%)				
Illiterate	48.9[c]	40[b]	31.1[a]	
Religious school	17.9[a]	35.6[b]	44.4[c]	
Elementary	24.4[c]	22.2[b]	11.1[a]	
Primary	8.9[b]	2.2[a]	13.3[c]	
$\chi 2$-value				12.71*

[ab]The results with different superscript across the same row are significantly different *(P<0.05).* HH=Household.

4.2. Livestock Composition and Size

The findings as indicated in Table 10, households keep mixed livestock species.This reduce thecompetition for feed,reduces risk bylessening the dependency on one species for meat, milk, and

increases the likelihood of meeting basic consumption needs(Selamawit and Matious, 2015). The finding showed that small ruminants predominated in all the areas studied, followed by those of cattle and the observation was in line with the observation of Belete (2013) in Bale zone. Among the small ruminants, it was the sheep, which predominated over goats; these findings are in close accordance with the earlier observations of Gebrekiros *et al*, (2016) in the western zone of Tigray. The Bale region being a highland area it is expected that the population of sheep would exceed those of goats; this may be ascribed to the adaptability of the former species (Farm Africa, 1996). However, the populations of bovines were lower than those of the small ruminants, whichwasin close accordance with the findings of Yaekob (2016),CSA (2017) and Hulunim *et al*, (2017), where it has been reported that in the highlands of Ethiopia the small ruminants are taking over from the large ruminants. This may be because the small ruminants require less feed, can survive on different types of forages, can graze for longer distances, easy to sell and several of them can be housed in smaller space (Oluwatayo and Oluwatayo, 2012). The numbers of equines in the current study area were higher than the previous study in the same zone (Belete, 2013) which may be because the districts of the present study are mountainous, and hence the equines are required as pack and riding animals.

Table 3: Livestockspeciescomposition and size (number) in the studied districts (Mean±SD)

Livestock species	Kelala	Woreelu	Borena	Overall	P=value
Sheep	16.69±5.30^{b}	12.27±4.35^{a}	16.2±5.33^{b}	15.05 ± 5.35	0.00
Goats	11.42±3.24	10.16±3.40	10.02±3.14	10.53±3.50	0.11
Cattle	6.84 ±1.61^{a}	8.56±2.70^{b}	7.22±1.91^{a}	7.54±2.23	0.00
Chickens	4.02±2.71^{b}	3.24±1.91^{ab}	2.71±1.63^{a}	3.33±2.20	0.02
Donkeys	1.78±0.85^{b}	2.33±1.13^{c}	1.4±0.65^{a}	1.84±0.97	0.00
Horses	1.27±0.78^{b}	1.31±0.79^{c}	1.16±0.70^{a}	1.24±0.76	0.61

Mules	0.16±0.40	0.07±0.25	0.13±0.41	0.12±0.37	0.49

[a,b]The values across the row with different superscript are significantly different *(p<0.05)*

4.3. Flock Structure in the Study Areas

The finding as presented in Table 11 shows that there were no differences (P>0.05) in the numbers of bucks and does across the study areas. Generally residents in all the study districts kept the larger proportions of does and doeling's than bucks and buckling's, and this is in agreement with the result of Tsigabu (2015) for Nuer goats in Gambella region, Dereje *et al*, (2013) for Harerghe highland goats and Tegegn and Askale (2017) for southern Ethiopia goats. This might be recognized to the prevalent practice of keeping does for breeding purposes, which accounted the greater portion of the newly born animals while bucks are either castrated or sold when they reach market age. The numbers of castrates in the study areas indicating that the respondents practiced castration, that is a good practice to prevent unplanned mating and pregnancies (Samuel *et al*., 2008).

Table 4: Goat flock size (numbers) per household in the studied districts (Mean ± SD)

Class of goats	Kelala	Woreelu	Borena	Overall	P=value
Total bucks and buckling's	4.64±1.50	4.13±1.70	4.07±1.43	4.27±1.62	0.09
Total does and doeling's	6.78±2.23	6.02±2.26	5.98±1.97	6.26±2.20	0.10
Does	4.11±1.34	3.84±1.43	3.82±0.94	3.93±1.26	0.58
Bucks	0.93±0.65	0.89±0.71	0.69±0.67	0.84±0.68	0.19
Buckling (<6 months)	1.80±0.66	2.00±0.88	1.91±0.82	1.90±0.79	0.05
Doeling (<6 months)	1.40±0.90[b]	1.36±0.57[b]	1.04±0.67[a]	1.27±0.74	0.04
Buckling(6-12 months)	1.27±0.78[b]	0.82±0.94[a]	1.11±0.88[ab]	1.07±0.88	0.04

Doeling (6-12 months)	0.71±0.71[a]	0.53±0.69[a]	1.13±0.84[b]	0.79±0.79	0.01
Castrated bucks	0.64±0.71[b]	0.42±0.50[ab]	0.33±0.47[a]	0.47±0.58	0.03

[a,b]The values across the same row with different superscript are significantly different *(p<0.05).*

4.4. Trends in numbers of goats reared in the study areas

The findings as indicated in Table 12the goat population becomes increasing with respect to Equines, while decreasing with respect to sheep and cattle. The increasing trend of goats is in close accordance to the study of Mahilet (2012) from east Harerghe. The decreasing trend of goats with respect to cattle might be in Bale zone cattle were the most significant species for draught power and milk sources(Dawit *et al*., 2012), and sheep are grazers and cooperative to herding, hence a species of choice in mixed cropping areas where cereal production dominates (Adane and Girma, 2008).

Table 5: Trends of goat numbers (%) with respect to other livestock in the studied districts for the last five years.

Trends of goat number	Dinsho	Goba	Agarfa	Overall	χ^2
With respect to cattle					1.13
Increasing	46.7	42.2	53.3	47.4	
Decreasing	53.3	57.8	46.7	52.6	
With respect to sheep					5.05
Increasing	-	11.1	6.7	5.9	
Decreasing	100	88.9	93.3	94.1	
With respect to equines					-
Increasing	100	100	100	100	
Decreasing	-	-	-	-	

4.5. Purpose of Keeping Goats

The findings as presented in Table 14 showed that the primordial reason for rearing goats in the study area was for cash income, this finding was in close accordance with those of Adams and Ohene-Yakyera (2014),Ahmed *et al*,(2015)and Byaruhanga *et al*, (2015). It may be because the goats are easy to sell and can serve as banks on hooves because of being small in size the goats like that of sheep are easy to sell for requirements of immediate cash needed by the family members (Ahmed *et al*., 2015). The study further indicates that in the study area the goats also serve as a source of meat for the family members, which too is in close accordance with those of Tsigabu (2007), Belete (2009), Alefe (2014) and Yaekob (2015) from different parts of Ethiopia. The usage of meat from small ruminants are preferred on family occasion as such carcasses can be easily consumed by the family members within a few meals or shared with the neighbors while bovines need to be shared with several households and there was lack of refrigeration in the rural areas which increase chances of spoilage of meat. The observation was in line with the observation ofAhmed *et al*, (2015) from southwest Ethiopia. The goats are also reared as a source of savings by several respondents, which too coincide with the observations of Mekete (2016) from southern Ethiopia. This was evidentamong the Kebeles where banks do not exist besides the traditional nature of the people who believe in converting the extra cash into livestock rather than keeping the same in the bank (Ahmed *et al*., 2015). Generally, knowledge of reasons for keeping Animals is a prerequisite for deriving operational breeding goals (Jaitner *et al*., 2001).

Table 6: Purposes of keeping goats in the studied areas

	Kelala					Woreelu					Borena				
Purposes	1st	2nd	3rd	4th	**I**	1st	2nd	3rd	4th	**I**	1st	2nd	3rd	4th	**I**
Meat	9	9	17	9	**0.24**	6	15	15	9	**0.24**	5	6	8	8	**0.14**

Milk	2	14	7	6	**0.16**	-	7	8	10	**0.10**	4	12	11	11	**0.19**
Cash	32	12	1	-	**0.37**	34	10	1	-	**0.37**	22	12	10	1	**0.32**
Skin	2	9	11	11	**0.15**	1	4	4	9	**0.07**	2	4	4	9	**0.08**
Manure	-	-	3	4	**0.02**	-	-	1	2	**0.01**	-	-	1	2	**0.01**
Wealth	-	-	4	12	**0.04**	4	9	13	12	**0.18**	12	11	8	11	**0.24**
Cultural	-	1	2	3	**0.02**	-	-	3	3	**0.02**	-	-	3	3	**0.02**

The purpose with highest index ranked first

4.6. Member of Household Responsible for Goat Activities

The findings as presented in Table 15 indicated that except for cleaning and milking most of the activities viz. purchase, selling, herding and breeding were predominantly carried out by the male family members of the households, the findings was in close accordance with finding of Alubel (2015) from northern Ethiopia. This may be because purchase, selling and herding require interacting with outsiders besides require visiting the markets and pasture area, which is most comfortably carried outby the males rather than the female members of a household. While, the females family members carried out cleaning of the goat houses and milking too were in close accordance with the findings of Alefe (2014) and Belete*et al*, (2015), from southeastern Ethiopia. Feeding and wateringof goats wre carried out by both the sexes; the findings were in close accordance with the observation ofByaruhanga *et al*, (2015) in Uganda.

Table 7: Member of household responsible for goat activities (%) in the studied area.

Goat activities	Kelala			Woreelu			Borena		
	Male	Female	Both	Male	Female	Both	Male	Female	Both
Purchasing	93.3	-	6.7	97.8	-	2.2	91.1	-	8.9
Selling	95.6	-	4.4	97.8	-	2.2	95.6	-	4.4
Herding	86.7	2.2	11.1	73.3	-	26.7	66.7	2.2	31.1

Breeding	82.2	-	17.8	91.1	-	8.9	93.3	-	6.7
Caring sick	-	11.1[a]	88.9[c]	-	17.8[b]	82.2[b]	2.2	35.6[c]	62.2[a]
Feeding	20	-	80	6.7	-	93.3	6.7	-	93.3
Watering	-	-	100	-	-	100	-	-	100
House cleaning	-	91.1	8.9	-	95.7	4.4	-	94.1	5.9
Milking	-	88.9	11.1	-	88.9	11.1	-	84.4	15.6

[a,b]values show significance difference across districts each sexes (P<0.05)

4.7. Housing of Goats

The findings as presented in Table 16 showed that most of the goats at Woreelu and Borena were housed indoors during the dry and wet seasons, the finding was in close accordance with the observations of Belete *et al*,(2015) from Sinana district of Bale zone. Especially in wet season, this might be because the goats are prone to pneumonia if drenched in the rains **(http://www.age.psu.edu/extension/ip/IP728-26.pdf**).However, if housed indoors the owners of the goats need to ensure that the flooring is properly drained and that the houses are well ventilated too as improper drainage and ventilation can lead to accumulation of dirt and ammonia which can lead to spread of diseases and also in many cases death to the young and sick goats(Sileshi and Desalegn, 2008).

The study further showed that during the dry season all the goats are housed in the homestead thereby preventing from theft and predatory attacks and the findings were in close accordance with the finding of Sisay and Kefyalew (2015) from Degehabure eastern Ethiopia.

It was also indicated in the study that most of the goats are housed alone; however, some of the respondents house the goats with sheep, which too were in close accordance with the findings of Dhaba *et al*, (2012) from southwestern Ethiopia.

The study also indicates that the goats of most respondent were housed in a separate enclosure, which too benefits the owners, and the livestock alike besides it prevents the spread of zoonotic diseases and spread of ammoniac gases to the dwellings of the owners (Jamal *et al*., 2017). The provision of separate enclosures as observed in this study correlates the findings from a previous study by Belete (2013) and Behailu *et al*, (2016) from the same zone of the present study. However, the findings fromeastern part of Ethiopia by Sisay and Kefyalew (2015) have indicated that most of the goat keepers do not provide separate houses for their livestock who share the same dwellings as that of their owners.

Table 8: Housing system of goats (%) in the study areas

Parameters	**Kelala**	**Woreelu**	**Borena**	Overall	χ^2
Goats housed (WS)					
Within HH compound	33.3[a]	100[b]	100[b]	79.3	84.06*
At the pasture area	66.7a	-	-	20.7	
Goat housed (DS)					
At the HH compound	100	100	100	100	
How the goats housed (DS)					
Alone	53.3	64.4	63.6	60.7	1.48*
Together with sheep	46.7	35.6	36.4	39.3	
How the goats housed (WS)					
Alone	84.4[b]	64.4[b]	63.6[a]	70.3	6.22*
Together with sheep	15.6[a]	35.6[b]	36.4[b]	29.7	
Type of house					
Separate house	97.8	100	100	99.3	2.23

Veranda	2.2	-	-	0.7	
Reason for housing					
Prevent from theft	6.7	6.7	5.5	6.2	2.61
To keep them warm	33.3	31.1	32.7	32.4	
Prevent from predators	17.8	31.1	27.3	25.5	
For all reasons	42.2	31.1	34.5	35.9	

[a,b]values with different superscript across the rows show significance difference*(P<0.05).*
WS and DS, wet and dry seasons, respectively.

4.8. Herding of Goats in the Study Areas

As stated by Sölkner-Rollefson (2003), a good understanding of the community's herding practices is crucial to bring sustainable improvement in the smallholders flock through community-based strategies. The findings as presented in Table 17 showed that all of the goat keepers in the study districts herded their goat both in dry and rainy seasons. Alubel (2015) reported similar finding for goat keepers of Ziquala and Tanqua Abergelle districts. The findings also show that during the dry season most of respondent's goats were herded with those of sheep, this assist in proper utilization of forage resources as sheep are grazers and goats are browsers (Silanikove, 1996). While, during the wet season most of the goats are grazed alone and/or along with the sheep. The reason why the goats were grazed alone is because, during the wet season the sheep are grazed along the roads and also besides the fields as the fallow lands are now cultivated and there are chances that the goats can wander away to the fields (Solomon *et al*., 2008). The study further indicates that the pre-weaned kids and nursing doeswere separated out which is contradicted with the finding of Belete *et al*, (2015) in the same Bale zone. This might be because of protecting the kids from predatory attacks.

Table 9: Herding mechanism of goats during dry and wet seasons in the study areas (%)

Variables	**Kelala**	**Woreelu**	**Borena**	Overall	χ2-value
Do you herd your goats?					
Yes	100	100	100	100	-
Goat herded system (dry season)					4.96
Alone	22.2	20	13.3	18.5	
With sheep	64.4	60	57.8	60.7	
Together with cattle and sheep	-	15.6	24.4	17.8	
Together with all other livestock	13.3	4.4	4.4	3	
Goat herded system (wet season)					25.55*
Alone	66.7^{c}	46.7^{b}	40^{a}	51.1	
With sheep	31.1^{c}	40^{b}	20^{a}	30.4	
Together with cattle and sheep	2.2^{a}	11.1^{b}	26.7^{c}	13.3	
Together with all other livestock	0	2.2	13.3	5.2	
Goat flock herding system					
Pre weaned kids are separated	91.1	91.1	75.6	85.9	6.00
Nursing doe and pre weaned kids together	8.9	8.9	24.4	14.4	
Ways of goat herding dry season					16.08*
Individual HH goats alone	31.1^{a}	42.2^{b}	48.9^{c}	40.7	
With neighboring goats	42.2^{b}	57.8^{c}	33.3^{a}	44.4	
Many households together	26.7^{b}	-	17.8^{a}	14.8	
Ways of goat herding wet season					16.36*
Individual HH goats alone	17.8^{a}	28.9^{b}	17.8^{a}	21.5	
With neighboring goats	40^{b}	60^{c}	33.3^{a}	44.4	
Many households together	42.2^{b}	11.1^{a}	48.9^{c}	34.1	

[a,b]Values with the same superscript across the rows are significantly different *(P<0.05)*

4.9. Feed Resources and Feeding Systems of Goats

The Table 18referring to the feed resources available to the goats during the dry and wet seasons in the study areas indicated that the common feed resources were natural grazing (on communal grazing lands), besides browsing on shrubs and also on crop aftermath and crop residues. The current result was in agreement with Tesfaye (2009), Grum (2010), Biruh (2013),Alubel (2015), and Behailu *et al,* (2016) for different parts of the Ethiopia. However, the qualities of the crop residues are quite questionable and the browse species may contain some anti-nutritional factors (Alemu, 2008). Thus, under such conditions, the farmers need to be made aware of improving the quality of feed and its storage for feed during the adverse conditions (Alemu, 2008). The results pertaining to the feed resources during the wet season indicate that the grazing on shrubs and besides those of natural pasture and fallow lands, the quality of the forage is expected to be better than those of the dry season however their might be chances of high incidences of diseases and parasites during that period.

The results as presented in Table 19 showed that most of the goats are allowed to graze freely in the area while some of the respondents too practice cut and carry system, the findings were in close accordance with the findings of Alefe (2015) from southeastern Ethiopia.While, free grazing allows the goats to choose various type of forages some of which may have medicinal properties besides grazing also allows some sort of exercise for the goats (Biruh *et al*., 2017). However, in many cases, the goats are provided forages under cut, carry system, which is generally provided to the goats during the times of rains, and increment weather conditions (during rainy/cold and hot time). This might be helpful for protecting them from the vagaries of` nature and predators.

Table 10: Available feed resources in dry and wet seasons of the year in the studied districts

Feed resources	**Kelala**					**Woreelu**					**Borena**				
Dry season	1st	2nd	3rd	4th	**I**	1st	2nd	3rd	4th	I	1st	2nd	3rd	4th	**I**

Bush/shrub	6	12	14	13	**0.22**	21	15	8	1	0.32	6	12	14	13	**0.22**
Grazing grass	8	16	9	10	**0.24**	5	16	15	8	0.24	8	14	9	10	**0.23**
Crop aftermath	18	14	10	3	**0.30**	12	11	10	10	0.25	18	16	8	1	**0.30**
Crop residues	10	1	4	7	**0.13**	4	1	4	7	0.08	10	1	4	7	**0.13**
Hey	-	2	2	7	**0.04**	-	2	2	4	0.03	-	2	2	7	**0.04**
Grazing fallow land	3	-	2	1	**0.04**	3	-	2	8	0.05	3	-	2	1	**0.04**
Concentrate	-	-	4	4	**0.03**	-	-	4	7	0.03	-	-	6	6	**0.04**
Wet season															
Bush/shrubs	24	17	3	2	**0.34**	22	18	2	3	0.33	18	22	3	2	**0.32**
Grazing grass	18	16	6	5	**0.31**	18	14	7	4	0.29	20	16	5	4	**0.31**
Crop residue	-	1	8	19	**0.08**	-	1	8	19	0.08	-	1	9	19	**0.09**
Hey	-	3	8	9	**0.08**	-	3	8	9	0.08	-	2	10	9	**0.08**
Fallow land	3	8	16	6	**0.16**	5	9	16	6	0.19	7	3	14	7	**0.17**
Concentrate	-	-	4	4	**0.03**	-	-	4	4	0.03	-	1	4	4	**0.03**

Table 11: Grazing/browsing systems of goat in the study districts

Grazing systems	**Kelala**	**Woreelu**	**Borena**	Overall	χ^2
Goat grazing/browsing system dry season (%)					
Free browsing/grazing	80	80	73.3	77.8	0.77
Free browsing and cut and carry system	20	20	26.7	22.2	
Goat grazing/browsing system wet season (%)					
Free browsing/grazing	100[c]	95.6[b]	86.7[a]	94.1	7.44*
Free grazing/browsing and cut and carry system	-	4.4[a]	13.3[c]	5.9[b]	

[a,b] the χ^2-value indicates that there is a significance difference across the same row (P<0.05)

4.10. Watering of Goats in the Study Areas

The findings indicated in Table 20 showed that the main source of water during the dry season was from the river and spring; these findings were in close accordance with the observation of Yaekob (2015) from north Omo, southern Ethiopia. While water from both these sources are of perennial in nature however there might be are chances of contamination (Tsedeke, 2007). The findings also show that during the wet season the source of water was mainly from the rain.

Table 12: Available sources of water for goats

Parameters	**Kelala**	**Woreelu**	**Borena**	χ^2-value
Water source (dry season)				
River	37.8^{a}	46.7^{b}	62.2^{c}	
Spring	37.8^{c}	31.1^{b}	6.7^{a}	13.15
River and spring	24.4^{b}	22.2^{a}	31.1^{c}	
Water source (wet season)				21.18
Bore	24.4^{b}	31.1^{c}	20^{a}	
Pond	2.2	-	-	
River	6.7^{a}	17.8^{b}	20^{c}	
Spring	22.2^{c}	4.4^{a}	6.7^{b}	
Rain water	28.9^{a}	37.8^{b}	51.1^{c}	
River and spring	15.6^{c}	8.9^{b}	2.2^{a}	

^{a,b} the χ^2-value indicates that there is a significance difference across the same row

The result as shown in Table 21; the water was provided for adult goats flock once or at the most twice a day , the former finding were in close accordance with the findings of Alefe (2014) Somalia region of Ethiopia. However, water in general should be provided to the flock at all times so that the animals are not thirsty and the normal physiology can be well-supported (Schlink *et al*., 2010). This is truer for the kids, pregnant and nursing does and diseased goats. Care should also be taken to separate the

diseased goats from the flock and provide them with water or their watering point should be located further downstream (Araujo *et al*., 2010; Alubel, 2015). The study also showed that the quality of the water varied from clean to muddy, which too are in close accordance with the reports of Belete(2013).

Table 13: Water quality, distance and watering frequency of goats (%) in the study areas

Parameters	**Kelala**	**Woreelu**	**Borena**	X^2-value
Water quality (DS)				126.57*
Clean	100^b	95.6^a	-	
Muddy	-	4.4^a	100^b	
Water quality (WS)				41.83*
Clean	100^c	82.2^b	42.2^a	
Muddy	-	17.58^a	57.8^b	
Watering frequency of kids (DS)				0.18
Once a day	40	42.2	37.8	
Twice a day	60	57.8	62.2	
Watering frequency of kids (WS)				1.69
Freely available	26.7	26.7	28.9	
Once a day	57.8	62.2	51.1	
Twice a day	15.6	11.1	20	
Watering frequency of adults(DS)				
Once a day	100	100	100	
Watering frequency of adults(WS)				1.68
Freely available	68.9	80	77.8	
Once a day	31.1	20	22.2	
Distance travelled to water source (DS)				4.87*
<1 km	51.1	44.4	40	
1-5 km	48.9	56.6	55.6	
6-10km	-	-	4.4	
Distance travelled to water source (WS)				2.01
<1 km	100	97.8	100	
1-5 km	-	2.2	-	

* X^2 the values across the rows are significantly different. DS and WS= wet and dry seasons, respectively.

4.11. Marketing and Weaning Age of Goats

As indicated in Table 22 the average weaning age of buckling's and doelings were 5.98 and 7.13 months respectively. The weaning age of buckling's was earlier than the previous studies on AB goats (Belete *et al.,* 2015), where the value was 6.4 months. The result generally indicates that bucklings wean and reach for market at earlier age than doelings, those observation was in close accordance to those of (Alefe, 2014: Alubel, 2015; Belete *et al*., 2015).

Table 14: Average marketable age (months) of male and female goats in the study area

Age	**Kelala**	**Woreelu**	**Borena**	Overall
Average weaning age of buckling	6.00±0.93	6.00±0.85	5.95±0.82	5.98±0.86
Average weaning age of doelings	7.33±0.88	7.22±0.93	6.84±0.74	7.13±0.87
Average marketing age of bucks	10.02±1.45	10.49±1.25	10.22±1.36	10.24±1.36
Average marketing age of does	11.29±1.41	11.78±1.55	11.16±2.45	11.41±1.86

4.12. Goat Classes Sold in Need of Cash

The findings as presented in Table 23 indicate the classes of goats thatwere sold off in need of cash. The findings show that the castrates and the young male kids (6-12 months old) are the ones, which were sold off first. This finding was contradicted from the findings of Belete (2013) in Bale zone where households primarily eager to sold old goats. Selling off the young yearling bucks indicate that there are chances of negative selection among the bucklings (Solomon and Kassahun, 2008). Thus, the respondents need to be made aware of the consequences of negative selection (Solomon and Kassahun, 2008). Studies by Solomon and Kassahun (2008) have indicated that in Ethiopia the consequences of negative selection have been observed, and so are the high incidences of inbreeding within the flocks of small ruminants (Ahemed *et al*., 2015). Selling off of old bucks and does too have been reported by Belete (2013) from the lowland parts of Bale zone.

Table 15: Goat classes sold case of cash needed in the studied areas

Goat classes	Kelala					Woreelu					Borena				
	1st	2nd	3rd	4th	**I**	1st	2nd	3rd	4th	**I**	1st	2nd	3rd	4th	**I**
Male kids (<6 months)	3	1	2	4	**0.05**	1	5	4	7	**0.08**	4	6	3	2	**0.09**
Female kids (< 6 months)	-	4	3	3	**0.05**	3	3	5	5	**0.08**	5	5	4	5	**0.11**
Male kids (6-12 months)	15	3	9	6	**0.21**	5	2	16	2	**0.13**	8	7	7	4	**0.16**
Does kids (6-12 months)	1	10	4	1	**0.10**	7	4	11	2	**0.14**	5	3	6	2	**0.10**
Breeding does		2	-	2	**0.02**	-	6	1	8	**0.06**	-	1	5	5	**0.04**
Breeding bucks	7	4	2	2	**0.10**	3	7	3	4	**0.10**	-	3	10	2	**0.07**
Castrated bucks	7	14	16	11	**0.25**	10	6	3	4	**0.15**	13	6	4	7	**0.19**
Old does	6	5	2	4	**0.10**	8	7	1	9	**0.14**	6	8	3	12	**0.15**
Old buck	6	2	7	12	**0.12**	8	5	1	4	**0.12**	4	6	3	6	**0.09**

4.13. Castration and Fattening of Goats

The results as presented in Table 24 show that castration was commonly carried out in all the studied areas, which is one of the most important farm activities to prevent unwanted pregnancies in the flock, control aggression, and improve meat quality (Needham *et al*.,2017). The findings also show that most of the respondents castrate their bucks by using traditional methods, so the respondents need to be appraised with the modern methods of castration which is not only humane but also leads to lesser chances of infection and mortality (Needham *et al*., 2017). The results regarding the methods used for castration too are in agreement with the findings of Behailu *et al*, (2016) from the highland and midland of Borena district. Most of the respondents castrate their bucks at the age of 1 to 2 years when most of the castrations occur, it may have sired a few offspring's too, which in turn may be a traditional/primitive method of progeny selection. The observations as is in close accordance with

those of Belete *et al*, (2015) from Bale zone of Oromia, Ethiopia. The reason for castration in the study area is to fatten the bucks for selling which too coincides with the findings of Tsedeke (2007) and Alubel (2015). The findings also showed that most of the respondents do not normally practice fattening of goats and which agrees to the findings of Alefe (2014) from Ethio-Somalia region. Among those who fatten the goats do so for the adult buck, which has outlived its productive age and is sold off were in line with the observation of Tsedeke (2007) from Alaba, SNNPR.

Table 16: Castration and fattening practices in the study areas

Parameters	**Kelala**	**Woreelu**	**Borena**	χ^2-value
Do you castrate your goats				
Yes	100	100	100	
No				
Methods of castration				5.02*
Local	53.3	68.9	73.3	
Modern	11.1	11,1	6.7	
Both	35.5	20	20	
Age of castration				1.73*
>6months-<1 year	20	28.9	20	
1-2 years	48.9	44.4	44.4	
>2 years	31.4	26.7	35.5	
Reason for castration				6.52
To fatten and sell	33.3	42.2	57.8	
To tame the goats	35.6	33.3	17.8	
To fatten and tame	31.1	24.4	24.4	
Do you fatten goats?				2.15*
Yes	15.6	15.6	6.7	
No	84.4	84.4	93.3	
Which category of goat you fatten				2.59*
Adult male	57.1	71.4	33.3	
Castrate	28.6	28.6	33.3	
Barren doe and castrate	14.3	-	33.3	

*the chi square values indicate there is significant difference across the same row

4.14. Goat Health Managements

The results pertaining to the veterinary care of the goats as practiced in the area are presented in Table 25. The findings showed that all the respondents were able to access veterinary services for their flocks that was a good practice and are in close agreement with the findings of Clemens (2015). However, studies by Alubel (2014) have indicated that in northern part of Ethiopia most of the respondents relied on ethno veterinary medicines. The study also indicates that, in spite of the fact that veterinary services were available, the respondents have no awareness about vaccinating their goats, and these observations too are in close accordance with the observation of Hulunim (2014) from Bati, Borena and Siti areas of Ethiopia. The study further indicates that none of the respondents vaccinated their goats, which is not at all desirable. Hence, the respondents did not understand, any diseasescan be prevented through vaccinations and that much mortality too can be prevented through it. The study further showed that the vaccinations were not carried out because of lack of availability of the same and also that many of such plans were carried out before were grossly ineffective, these observations too coincide with the reports of Belele (2009) Southeastern Ethiopia. The ineffectiveness of the vaccinations can be fallout of improper cold chain management and also that it desires the implementation of thermo stable vaccinations.

Table 17: Accesses and distance to veterinary service and vaccination (%) in the studied area

Parameters	Dinsho	Goba	Agarfa	χ^2-value
Do you have access to veterinary services				
Yes	100	100	100	
No	-	-	-	
Distance to the nearest veterinary service				
1-5 km	69.9	2.2	-	92.89*
6-10 km	31.1	71.1	42.2	
>10 km	-	26.7	57.8	

Do you vaccinate your goats?				
Yes	-	-	-	
No	100	100	100	
If no, why do not vaccinate?				0.53*
Lack of availability	60	55.5	57.8	
Think is not effective/no know how	26.7	26.7	28.9	
Both	13.3	17.8	13.3	

*the chi square values indicate there is significant difference across the same row

4.15. Selection Criteria for Breeding Does

The findings as presented in Table 26 indicate the trait considered in selection of the longhaired South Wollo does in the studied areas. The findings showed that appearances followed by prolificacy were the two traits, whichwere considered to be of primordial importance while selecting the does; this too was in close accordance with the findings of Yaekob*et al*. (2015) from southern parts of Ethiopia. Prolificacy of the does was also considered as a prioritized trait in selecting does, which is in close accordance with the observation of Tsigabu (2015).

Table 18: Trait preference of the household to select does in the studied districts

	Kelala					**Woreelu**					**Borena**				
Traits	1st	2nd	3rd	4th	**I**	1st	2nd	3rd	4th	**I**	1st	2nd	3rd	4th	**I**
Appearance	6	7	12	13	**0.18**	16	15	7	1	**0.28**	13	8	10	7	**0.23**
Pedigree	1	3	7	1	**0.06**		2		1	**0.02**		2	3	3	**0.03**
Prolificacy	8	6	11	6	**0.17**	6	11	-	-	**0.15**	9	12	7	4	**0.20**
Mothering ability	8	7	1	2	**0.13**	2	-	8		**0.05**		6		2	**0.04**
Milk production		2		2	**0.02**	4		6	13	**0.09**	10	2	7	3	**0.15**
Coat Color	3	1			**0.03**			4	2	**0.02**			3	5	**0.02**
Good growth of	5	2		7	**0.07**	5	9	11	4	**0.17**	9		9	5	**0.13**

kid															
Disease resistance		4			**0.03**			1	1	**0.01**				3	**0.01**
Regular breeder	4	3	9		**0.10**		2	1	8	**0.04**		6	2	4	**0.06**
Early sexual maturity	6	4			**0.08**			7	9	**0.05**	3	6	1	5	**0.08**
Hair length and type	4	6	5	14	**0.13**	12	6		6	**0.12**	1	3	3	4	**0.05**

4.16. Selection criteria for Breeding Bucks

The results pertaining to the criteria used by the respondents in selecting the bucks as presented in Table 27 showed that body conformation, followed by hair length and coat color were the three most important traits used in selecting the bucks. While, conformation (masculinity) were preferred as the primordial trait, were that heavier body bucks showed superior breeding performance, sire heavily kids and fetch good market price, if sold. The observation was in close accordance with the reports of Girum *et al*. (2013) from Dire Dawa and Yaekob*et al*. (2015) from southern Ethiopia.

The bucks with long hair coat are able to survive better in the cold climate of the study areas and hence selection based on the trait is expected to benefit the overall productivity of the flock (Silanikove, 2000). Meanwhile, traits such as coat color too have been considered by several authors in selection of their flocks(Dhaba *et al*., 2013, Alefe, 2014; Belete *et al*., 2015), it may be ascribed to the fact that animals with darker coat color are able to survive better in cold climates while the opposite is true for those animals with lighter coat color (Gaughan *et al*., 2008). According to the respondentsgoats with longer hair prised higher for their costs skin. Accordingly, a single skin can prise 1500- 2000 birr in the local market. This observation was in line with the observations of Farm

Africa (1996) where a single skin prized up to 80 birr. In line with this study body size also used to select breeding bucks in many parts of Ethiopia (Dhaba *et al*.,2013; Alayu *et al*.,2014;Solomon *et al*.,2013).

Table 19: Trait preference of the household to select breeding bucks

	Kelala					**Woreelu**					**Borena**				
Traits	1st	2nd	3rd	4th	**Index**	1st	2nd	3rd	4th	**Index**	1st	2nd	3rd	4th	**Index**
High BW	3	-	13	12	**0.11**	5	7	3	1	**0.11**	3	13	6	9	**0.16**
Coat color	12	6	8	8	**0.20**	5	9	4	3	**0.13**	11	1	9	3	**0.15**
Conformation	16	14	8	7	**0.29**	17	10	10	5	**0.27**	14	12	11	12	**0.28**
Sexual maturity	2	8	11	8	**0.14**	6	7	6	12	**0.15**	3	3	5	11	**0.09**
Pedigree	1	4	2	2	**0.05**	2		5	12	**0.07**	1	2		1	**0.02**
Hair length	9	13	3	5	**0.19**	10	11	15	7	**0.24**	13	11	12	8	**0.26**
Libido	2	-	-	3	**0.02**	-	1	2	5	**0.03**		3	2	1	**0.04**

4.17. Mating and Culling Practices of Goats

The results related to the breeding practice ofgoats prevalent in the study area (Table28 and 29) indicate that breeding was panmectic in nature and occurs mostly in the pastures. This may leads more numbers of offspring is being born from the alpha bucks and hence the chances of inbreeding increased within the flock (Tesfaye, 2011). Therefore, the respondents need to be made aware of the consequences of inbreeding and also rotation of bucks across flocks should be encouraged, the high prevalence of panmectic breeding within a flock too were in close accordance with several studies conducted earlier (Netsanet*et al*., 2016) who reported that farmers in Meta Robi and Konso part of Ethiopia prefer to rear bucks alongside the does. Therefore, buck exchange should be encouraged at all costs to minimize the ill effects of inbreeding.

Table 20: Prevalent mating and culling practices (%) of longhaired South Wollo goats

Parameters	**Kelala**	**Woreelu**	**Borena**	Overall	X^2
Do you control your flock mating					
No	100	100	100	100	
If no, why?					6.31
Goats not separated by sex and mating occur in the pasture	71.1	71.1	68.9	70.4	
Goats not separated by sex, and mating occur in the pasture and at night	20	26.7	31.1	25.9	
Goats not separated by sex, mating occur in the pasture and at night and unable to detect heat sign	8.9	2.2	0.0	3.7	
Are you aware of "inbreeding"					
No	100	100	100	100	

Table 21: Culling of Does and Bucks in the study areas

Parameters	**Kelala**	**Woreelu**	**Borena**	Overall	X^2
Do you practice bucks culling?					0.56
Yes	35.6	35.6	42.2	37.8	
No	64.4	64.4	57.8	62.2	
What you do the culled bucks?					0.28
Castrate and fatten	56.3	50	47.4	51	
Sell them	43.8	50	52.6	49	
Do you practice does culling?					
Yes	100	100	100	100	
From where you get replacement does					2.70
From own flock Kids	64.4	71.1	73.3	69.6	
Procure from market	2.2	6.7	4.4	4.4	
From own flock and or market	33.3	22.2	22.2	25.9	

4.18. Abortion and Kid Mortality

The results as presented in Table 30 is indicative of the incidences of abortion and mortality within the flock, while the incidences of abortion were within the acceptable limit and the respondents can

minimize it further by proper management of the pregnant does, the figures as indicated are quite lower when compared to those reported by Girma *et al*. (2013) from Adami Tulu Jido kombolcha district of East Shawa Zone.The study further indicates that the incidences of mortality were higher among the doe kids when compared to the bucklings, this may be ascribed to the fact that the bucklings usually have higher weight at birth which gives them an additional advantage in survival. The observations pertaining to the differences in survivability of the kids as observed too concur with the findings of Sisay and Kefyalew (2015) from Degehabur zone eastern Ethiopia. Therefore, the respondents need to be made aware of milk replacers for feeding the doelings.

Table 22: Occurrences of abortion (%) and kid mortality (Mean±SD)

Parameters	**Kelala**	**Woreelu**	**Borena**	Overall	
Did abortion occurred in your flock in the previous 1 year?					
Yes	4.5	2.2	8.9	5.2	
No	95.5	97.8	91.1	94.8	
X^2					2.08
Average number of does abort during the last 1 year	0.22±0.54	0.11±0.38	0.11±0.56	0.18±0.50	
Average buckling's mortality in the last two months	0.04±0.21	0.02±0.15	0.04±0.21	0.04±0.20	
Average doelings mortality in the last two months	0.20±0.40	0.13±0.34	0.15±0.36	0.16±0.37	

There is no significance different across the districts *(P>0.05)*

4.19. Occurrences of Most Birth, Ownership and Sources of Breeding Buck

The findings as presented in Table 31 show that most of the kiddings occur between February to April and also between September to November. Studies by Sisay and Kefyalew (2015) have indicated that

ovulation usually occurs after the flushing feed is obtained by the does thereby she accumulates enough body reserves for maintaining the pregnancy, in the study area the flushing period coincides with the rainy season (July to October). The second season of kidding also coincides with the period when the flushing coincides with the short rainy season(March to May) the observation was in agreement with that of Solomon (2014).

The findings as observed in this study further indicates that most of the respondents raised breeding bucks in their homestead which too is in close accordance with the observations of Tegegn *et al*. (2016) and Alefe (2014), in Meanit Shasha, Benji Maji, and shebele Southeastern Ethiopia. Raising bucks in one hand is advantageous as it ensures that very few if any does have missed estrus. However, on the other hand it also results in higher incidences of inbreeding within the flock and sometimes the rate of inbreeding can be very high which can lead to serious consequences and expression of lethal and semi lethal genes in the flock. In case that bucks are not available with the rearers they do not bother much on the issue as the does are usually covered in the pasture at the time of grazing, the findings as suggested too coincide with the observations of Tsigabu (2015) from southwestern Ethiopia.

The average numbers of bucks did not vary across the locations, which also indicates that the numbers are lesser than those reported by Belete (2013) in Meda wolabu, lowland parts of bale southeastern Ethiopia. Fewer numbers of bucks as observed in the study can lead to higher incidences of inbreeding within the flock (Zewdie, 2015).

Table 23: Occurrence of most births, breeding buck ownership and utilization pattern in the area studied

Parameters	**Kelala**	**Woreelu**	**Borena**	Overall	χ^2
Occurrence of most births					3.04
February, March and April	42.2	37.8	31.1	37	
September, October and November	26.7	20	33.3	26.7	
Both	31.1	42.2	35.6	36.3	
Dou you own breeding buck.					3.55
Yes	75.6	71.1	57.8	68.1	
No	24.4	28.9	42.2	31.9	
If yes, source of buck for mating?					4.90
From own flock	54.3	75	76.9	67.7	
From the flock of friends/neighbors	25.7	15.6	15.4	19.4	
From market/ unknown sources	20	9.4	7.7	12.9	
If no, from where you use buck for breeding?					0.01
From Friends/neighbors	30	30.8	31.6	31.0	
Pasture area	70	69.2	68.4	69	
Average number of breeding bucks/HH	0.93±0.65	0.89±0.71	0.69±0.67	0.84±0.68	
What is the age till use breeding bucks	4.30±0.78	4.31±0.99	4.57±0.65	4.40±0.83	

4.20. Reproductive Performance of Longhaired Arsi-Bale Goats

Thereproductive performance of the bucks and does observed in the study area are presented in Table 32. The findings indicate that the average age at puberty of the bucks (7.00 months) and does (8.13) were in close agreement with Solomon*et al*. (2014) who reported for Ethiopian indigenous goat's age at puberty ranges 7 to 15 months. This early age at puberty confirms optimal reproductive performance and such bucks and does can have more numbers of offspring in their lifetime. The age of

puberty in this study was earlier for males and later for females than the previously reportedage for South Wollo buck and doe, 7.6 and 7.9 months, respectively (Belete, 2013), this might be related to the availability of feed in the highland areas. The numbers of kiddings too indicate that the does are regular breeders and hence such does are profitable to be reared (Rume *et al*., 2011). Kidding interval is longer than the finding of Belete *et al*. (2015) and smaller number of Kidding per lifetime. Shorter kidding interval indicates that the does have high fertility and are therefore profitable to rear, the kidding interval also coincides with optimal weaning age of the kids which in this case is around 3 months (Awemu *et al*., 1999)

The average litter size of the does indicate low to moderate prolificacy and hence there are chances that the trait can be further improved through proper management and within breed selection. The observation was in close accordance with Hailu *et al*. (2008) for the AB goats. Prolificacy is a desirable trait among the small ruminants as it ensures higher profitability per numbers of does mated.

Table 24: Reproductive performance of longhaired Arsi-Bale goats (Mean±SD)

Reproductive traits	**Kelala**	**Woreelu**	**Borena**	Overall
Age of male at puberty (months)	7.07±0.86	7.00±0.85	6.93±0.81	7.00±0.84
Age at first mating (months)	7.07±0.86	7.00±0.85	6.93±0.81	7.00±0.84
Female age at sexual maturity (months)	8.30±0.88[b]	8.22±0.93[b]	7.84±0.74[a]	8.13±0.87
Age of female at first service (months)	8.30±0.88[b]	8.22±0.93[b]	7.84±0.74[a]	8.13±0.87
Average number of kidding per life time/(number)	10.20±2.00[b]	10.10±1.83[b]	8.76±1.90[a]	9.67±2.00
Average number of service/year	1.62±0.49	1.62±0.49	1.47±0.50	1.57±0.49

Age at first kidding (months)	13.20±1.30	13.40±1.13	13.10±0.91	13.20±1.13
Kidding interval (months)	8.64±0.98	8.80±1.10	8.80±0.85	8.74±0.97
Average litter size	1.22±0.47	1.11±0.32	1.20±0.36	1.20±0.39
How many parturitions occurred in the last one year	5.20±1.86	4.82±1.85	5.60±2.20	5.20±2.00

[a,b]the values with the different superscripts in the same row are significantly different *(P<0.05)*

4.21. Limitations of Goat Production in the Study Areas

The study revealed that predator and shortage of feed followed by disease, and water (distance to watering point) were the important limiting factors for the longhaired goat production (Table33), which is in agreement with the findings of Belete (2013), Yaekob*et al.* (2015) and Gebreyesus (2013) with different order of importance. Goal keeper at highland area which is situated near to the National Park, the major constraints were predators (Fox), these observations are in close accordance with Yihew *et al*. (2017) as there are influx of the wild animals to the Kebeles from the National Park. Diseases among the goats can be prevented using proper management and vaccinations (Tegene and Fantahun, 2017; Gurmesa *et al*., 2011) in Cheta and Negele districts respectively. Therefore, the respondents need to be appraised about the different early diagnosis techniques.

Table 25: Major constraints of goat production in the study area

	Ranking indices														
	Kelala					**Woreelu**					**Borena**				
Constraints	1st	2nd	3rd	4th	**I**	1st	2nd	3rd	4th	**I**	1st	2nd	3rd	4th	**I**
Feed shortage	19	30	5	3	**0.28**	19	18	6	0	**0.30**	16	28	3	0	**0.34**
Predator	14	8	1	6	**0.35**	18	14	7	6	**0.29**	14	12	3	12	**0.24**
Disease	5	3	22	14	**0.17**	3	1	8	19	**0.11**	8	1	12	19	**0.17**
Labor	1	2	0	15	**0.07**		3	8	9	**0.08**	0	0	13	0	**0.06**
Waterscarcity	6	2	17	7	**0.13**	5	9	16	11	**0.22**	7	4	14	14	**0.18**

4.22. Qualitative Traits of Longhaired South Wollo Goats

The findings as presented in Table 34 and 35 indicate that most of the goats irrespective of sexes are plain coated with only a few of them having patchy coats, the findings of the present study are in close accordance with the findings of Solomon (2010), Belete (2013), and Yaekob*et al.* (2015) for Harerghe highland, South Wollo and Woyto Guji goats, respectively. The farmers may select the plain coat deliberately as the coat of the goats are used as a cushion for the saddlary of the equines and sitting cover in house (Farm Africa, 1996). The coat color as observed in this study shows that most of the goats reared at the study areas have black coat, which is adaptability at higher altitudes(Pant *et al*., 1985) and it also helps to absorb more solar radiation during cold season. The study also shows that white coated goats were rarely available as this may also be ascribed to their problem in adaptability at higher altitudes.Dark coat color could be a form of adaptive mechanism because of the role it plays in temperature regulation especially in the cold season when dark pigmented animals warm up earlier and more quickly than their light-coloured counterparts (Hagan *et al*.,2012). The findings also show that the hairs are long, smooth, and glossy which may be ascribed to the protection of the goats against the rains and cold wind in the mountainous areas. Glossy coats also help the goats to look attractive and protect them against ticks and other parasites (Yakubu *et al*., 2010). The findings also show that all the goats are horned and the orientation of the horns are curved backwards which too are in close accordance with the findings of Gelana and Belete(2016) for the same breed of goat. Presence of horns is important in rearing thegoats; as such, goats are able to fight away the predators much better than their polled counterparts (Katongole et *al*., 1996).

The face of the goats were concave which too are in close accordance with those of Halima *et al*. (2012) in Abergelle goat breeds, which may be a breed character and are in close accordance with the findings of ESGPIP (2010) in Afar breeds of goats . The goats are devoid of any wattles which too

may be a breed character in the cold Bale area despite the numerous benefits associated with the presence of wattles in goats reared under hot and humid environments(Hagan *et al*.,2012).

Table 26: Occurrences (%) of some qualitative traits of Longhaired Arsi-Bale buckling and buck in the studied area

Trait	Attributes	**Kelala**	**Woreelu**	**Borena**	Overall
Coat color pattern	Plain	80.6	80.4	86.7	81.8
	Patchy/pied	19.4	19.6	13.3	18.2
	Spotted	-	-	-	-
Coat color type	Black	49.3	34.8	43.3	43.4
	Dark red	-	-	-	-
	Light red	10.4	6.5	10.0	9.1
	Fawn	19.4	34.8	30.0	26.6
	White	1.5	6.5	3.3	3.5
	Black and white	10.4	2.2	-	5.6
	Light red and black	1.5	10.9	13.3	7
	Black with fawn	7.5	4.3	-	4.9
Skin pigmentation	Pigmented	-	-	-	-
	Non pigmented	100	100	100	100
Hair type	Smooth long	59.7	67.4	66.7	63.6
	Glossy long	40.3	32.6	33.3	36.4
Horn presence	Present	100	100	100	100
	Absent	-	-	-	-
Horn shape	Straight	13.4	19.6	13.3	15.4
	Curved	85.1	80.4	86.7	83.9
	Spiral	1.5	-	-	0.7
Horn orientation	Backward	94	100	93.3	95.8
	Upward	6	-	6.7	4.2
Ear form	Lateral	55.2	63	66.7	60.1
	Straight	13.4	19.6	13.3	15.4
	Dropped	20.9	15.2	10	16.8
	Forward	23.9	21.7	23.3	23.1
Face profile	Straight	3	10.9	3.3	5.6
	Concave	97	89.1	96.7	94.4
Wattle presence	Present	-	-	-	-
	Absent	100	100	100	100

Table 27: Some qualitative traits of Longhaired Arsi-Bale Doeling and doe in the studied area

Trait		Dinsho	Goba	Agarfa	Overall
Coat color pattern	Plain	93.8	79.8	78.1	84.8
	Patchy/pied	6.2	20.2	21.9	15.6
	Spotted	-	-	-	-
Coat color type	Black	50.4	32.6	29.5	38.1
	Dark red	1.8	2.2	1.0	1.6
	Light red	5.3	4.5	7.6	5.9
	Fawn	35.4	40.4	37.1	37.5
	White	0.9	1.1	1.9	1.3
	Black and white	1.8	3.4	5.7	3.6
	Light red and black	0.9	10.1	7.6	5.9
	Black with fawn	3.5	5.6	9.5	6.2
Skin pigmentation	Pigmented				
	Non pigmented	100	100	100	100
Hair type	Smooth long	59.3	59.6	49.5	56
	Glossy long	40.7	40.4	50.5	44
Horn presence	Present	100	100	100	100
	Absent				
Horn shape	Straight	22.1	19.1	24.8	22.1
	Curved	77.9	80.9	75.2	77.4
	Spiral	-	-	-	0.2
Horn orientation	Backward	90.3	94.4	97.1	93.8
	Upward	9.7	5.6	2.9	6.2
Ear form	Lateral	51.3	63.3	58.1	58
	Straight	22.1	19.1	24.8	22.1
	Dropped	25.7	20.2	14.3	20.2
	Forward	23	13.5	27.6	21.8

Face profile	Straight	8	11.2	10.5	9.8
	Concave	92	88.8	89.5	90.2
Wattle presence	Present				
	Absent	100	100	100	100

4.23. Quantitative Traits of Longhaired Bucklings and Bucks

The findings as presented in Table36 indicate that the average body weight of the bucklings aged 0-1PPI , 2PPI and also 3PPI and 4PPI did not vary across the study areas, this may be ascribed to similar agro ecology and management across the study areas. This may also be attributed to the fact that the genotypes studied were quite stable. The weight as observed for the bucklings 0-1 PPI are lower than thefindings of Belete (2013) for AB breeds reared in low land parts of Bale zone in southeastern parts of Ethiopia. Similarlythe study also indicates that the BW of the same age category were higher than those reported by Yaekob *et al*. (2015) for Woyto Guji goats in Sothern parts of Ethiopia. Buckling's with higher BW are preferred as it has a higher body weight at weaning usually leads to high weight at maturity. The results pertaining to the BW at2 PPI indicates that the BW of male goats are lower than Woyto Guji goats of the same sex and age category (Yaekob, 2015). There were non-significant differences in the trait across the study areas, however within breed, selection is possible to improve the trait and the bucks with higher BW fetch higher prices and preferred by the rearers and the buyers alike. The study also indicates that the weight of the bucks with 3 and 4 PPI were also higher than those reported by Mekete (2016) from southern Ethiopia and from the previous studies on the AB breed by Farm Africa(1996), ESGPIP (2010) and Belete (2013).

The results pertaining to horn length of the bucks indicate that, there were no differences across the studied districts. The horn length as observed is higher than the same breed of goats in the lowland

parts of Bale zone (Belete, 2013). Longer horn lengthis preferred among the bucks as it can serve a strong preventive against predators and has aesthetic appeal (Hagan, 2015). The horn length of the bucks aged 3 and 4 PPI as was longer than those reported by Mekete (2016) among the Woyto Guji bucks reared in south Omo, southern Ethiopia. However, bucks with longer horns have to be handled with care as it can lead to injuries for both their flock mates and the owners rearing them.

The study also indicates that the ear length of the bucks did not vary across the studied locations, longer EL of bucks (as obtained in this study) have also been reported by Dereje *et al*. (2013) for Harerghe highland goats, while the EL of the bucks are shorter than which reported by Mekete (2016) from southern Ethiopia. Studies by Peter (2015) have indicated that the goats reared in the tropics usually have longer ears, which serves as a mechanism for surface cooling.

The study also indicates that the head length (HDL) of the bucks did not vary across the study areas, the HDL values as obtained for the bucks aged 0-1 and 2 PPI and also 3 and 4 PPIare higher than the findings of Mekete (2016) with respect to Woyto Guji goat breed reared in southern Ethiopia. Studies have also indicated that the bucks with longer face are able to survive better in the higher altitudes and have lower incidences of sinusitis when compared to those with snouted face.

The study further shows that the height at withers (WH) of the bucks aged 0-1 PPI and 2 PPI age categories are in close accordance with the observations of Yaekob *et al*. (2015), however, the values are lower than those reported by Alefe (2014) from Southeastern Ethiopia for indigenous goat breed of goats in Shebelle zone Somalia region. It ascribes that goats reared in the arid climate usually have higher WH (Alefe, 2014). Similarly, studies have indicated that the goats with longer WH also can travel longer distances and are suitable for rearing under pastoral/transhumance management.

The study also indicates that CG of the bucks of all the studied age groups indicate that the values are in close accordance with the finding of Belete (2013) from low land districts of Bale zone for the same AB goat breed. However, the CG values of the bucks of both the age categories are narrower when compared to the findings of Mekete (2016) forWoyto Guji goats from south Omo, southern Ethiopia. The values as recoded are also wider than those reported by Dereje *et al*. (2013) for Harerghe highland goats from eastern Ethiopia. Studies by Hulunim*et al. (*2015) have also indicated that bucks with wider HG usually have higher BW.

The chest depth (CD) of the bucks as obtained in the study indicated that the values are higher than the observation of Mekete (2016) pertaining to Woyto Guji goat breed and reared in in south Omo. The bucks with wider CD usually have a larger lung capacity and therefore are able to trek for longer distances (Khargharia *et al*., 2015), The study further indicates that the canon circumferences (CC) of the bucks of both the age categories are lower than those reported by Yakubu *et al*. (2010) for Red Sokoto goats, thinner metatarsus usually lead to shorter surface area for muscle attachment and hence the BW of such animals are also lower ((Khargharia *et al*., 2015)).

The study further indicates that the body depth (BD) of the bucks are narrower when compared to those reported by Chácara Pires *et al*. (2013) for Brazilian and Morocco bucks of Alpine and Sanaan breeds. The results also indicate that animals with narrow BD in comparison to the withers height usually are well adapted to either very hot or very cold climate (Sastre, 2003).

The study further indicates that the abdominal circumference/ paunch girth (AC) of the bucks of both the age categories are in close accordance with finding of Mekete (2016). However, the AC values as reported were higher than those recorded by Peter*et al*. (2015) for boar, central highland and their crosses in Ataye farm,Ethiopia andEyduran *et al*. (2013) in Pakistan for local Pakistanian goats. The

trait at times may be misleading for assessing the health of the animals as such animals are usually considered to be healthy, contrary animals which are reared on lower plain of nutrition usually have wider abdomen (Cam *et al*., 2010). This may be ascribed to compensatory growth of the GI tract to digest poor quality feed.

The values pertaining to the rump height (RH) as obtained in this study are more or less in close accordance with those of Belete (2013), and Dereje *et al*. (2013) for AB goats, and Harerghe highland goats and higher than the observations of Gelane and Belete (2016) and Tsigabu (2015) for AB and Gambella goats, respectively . As indicated in the findings the RH is more or less similar to the WH. Animals with RH similar to the height at withers indicate that the spinal process of the animals were straight which is also correlated with high yield in female animals and muscularity of the males (Costa *et al*., 2014).

The body length (BL) of the bucks as obtained in the study are in close accordance with the findings of Halima *et al*. (2012) for Gumz goats, ESGPIP (2010) for Abergelle goats,Alubel (2015) for central highland goats and Tsigabu (2015) for Gambella goat ecotypes, while the values are lower when compared to those of Bati and Boran goat types (ESGPIP,2010), however the BL was longer when compared to the observations of Belete (2013) and, Gelana and Belete*et al.* (2015); for AB goats and Yaekob *et al*. (2015) for Woyto Guji goats. The animals with longer body have higher capacity to hold the GIT and vital organs, which might leads to their higher carcass yield and musculature.

The PW is a trait which is of more importance for the does when compared to the bucks, the PW of bucks as reported in this study were in close accordance to findings of Tsigabu (2015), Alubel (2015) and Yaekob *et al*. (2015) for western lowland, central highland and southern parts of Ethiopia, respectively.

The scrotal circumference (SC) of the bucks as obtained in this study is in close accordance with those of Solomon (2010), Dereje *et al.* (2013) and Yaekob *et al*. (2015) for Keffa, Harerghe highland and Woyto guji goats breeds of Ethiopia. However, the SC of the bucks across both the age categories are narrower when compared to those reported by Belete (2013) among AB goats in the lowland parts of Bale zone, Ethiopia. Studies have also indicated that bucks with narrower SC usually have poor spermatogenesis (Yosef, 2007), and to certain extent is correlated with the body weight (Belete, 2013).

The findings indicated that the bucks reared at Kelala had longer hairs when compared to those reared in the other two locations, this may be ascribed to the fact that the Kelala has a much cooler agro ecology and animals reared at cooler agro ecology usually have longer hairs as a means of body heat conservation.

4.24. Quantitative Traits of Longhaired Doeling's and Does

The results pertaining to the morphometric traits of female longhaired South Wollo goats aged 0-1PPI and 2 PPI and also 3 and 4 PPI are presented in Table 37. The findings show that the BW of the does aged 0-1 PPI and2 PPI were lower than the findings of Belete (2013) for AB goat breed reared in the low land parts of Bale zone, southeast Ethiopia. Correspondingly the BW of the does aged 3 and 4 PPI were in close accordance with those of Hulunim *et al*. (2017) for Borena goat ecotypes. The results also indicated that there were no differences in BW of the does reared across the study locations, this might be ascribed to genetic uniformity and also that their rearing too was more or less similar.

The HL as observed in the study also show that the horns were present in the does of all age categories, which can be a breed character and also that does with horns were able to protect their offspring's better against predatory attacks (Hagan, 2015).The EL of the does also indicated that there was no differences across the studied locations for does of a particular age group, long ears are

characteristics of tropical adaptation and goats with longer ears have better surface cooling mechanisms ((Peter, 2015).

The results pertaining to the HdL also show that the skull is quite long and the values were in close agreement with the findings of Mekete (2016)from southern Ethiopia. Animals with longer skulls have well-developed sinuses and also can also survive in higher altitude regions. The results also indicated that there were no variations across the studied locations among does within an age category.

The findings also show that the NC was narrower when compared to the bucks of the same age category.Studiesby Alderson (1999) have indicated that a female animal of superior type will have a long narrow and long neck. The results pertaining to the WH of the does of different age categories were in close accordance with the findings ofSolomon (2008) for Afar goats .However, the WH of the does are shorter than those reported by Hulunim (2014) for does of Boran goat ecotypes reared at pastoral in Ethiopia.

The findings show that the does have a well-developed thoracic cavity and therefore the CG and CD. Well-developed thoracic cavity is correlated with higher BW besides such animals are able to survive under low oxygen conditions too which is characteristics of high altitude (Alderson, 1999).

The CC of the does as observed in the study also indicates that the trait was higher than those of does of the same age categories of Assam Hill goat breed reared in Eastern Himalayan, India (Khargharia *et al*., 2015) and Woyto-Guji goats reared in Nyangatom and Malle districts of southern Ethiopia (Peter *et al*., 2015. However, the CC of the chevon breeds of goats are wider than those of the non-developed breeds (Peter*et al*., 2015).

The results also indicated that the AC was wider among the does across the different age groups and may be ascribed to the type of nutrition available to them. A study by Khargharia *et al*. (2015) have indicated that under poor quality feed the AC of the animals are usually wider.

The PW of the does need to be wider and such does usually have lower incidences of dystocia (Ngre, 2006; Ebegbulen *et al*., 2011). The study also indicates that there was variation in hair length of the does, which was longer among those reared at Kelala, which too find similarity with the causes discussed ahead for male goats.

Table 28: Average values (Mean±SD) of body weight (kg) and linear body measurement's (cm) of bucks across different age categories and reared at the three studied locations.

Traits	0 and 1PPI				2PPI			
	Kelala	**Woreelu**	**Borena**	Overall	**Kelala**	**Woreelu**	**Borena**	Overall
BW	19.47±5.25	21.06±5.10	19.54±5.66	20.06±5.5.26	29.69±1.25	29.18±1.32	29.50±1.44	29.47±1.32
HL	11.76±1.89	13.32±3.40	11.42±2.16	12.23±2.68	17.38±2.25	17.36±2.33	17.37±2.06	17.37±2.15
HW	3.44±0.43	3.58±0.44	3.34±0.42	3.47±0.43	3.35±0.24	3.32±0.40	3.29±0.26	3.32±0.39
EL	12.41±0.87	12.62±0.80	12.23±1.00	12.43±0.87	13.69±0.72	13.45±0.85	13.58±0.84	13.58±0.79
HDL	15.85±1.40	16.15±1.21	15.20±1.50	15.77±1.38	17.73±0.95	17.32±1.03	17.66±1.11	17.58±1.02
NC	27.47±1.18	27.97±1.24	27.31±1.36	27.61±1.26	29.92±1.03	29.64±1.28	29.66±1.30	29.75±1.18
WH	57.94±3.97	58.94±4.02	57.70±4.31	58.23±4.08	65.15±1.02	65.27±1.10	65.42±1.37	65.28±1.16
HG	60.00±5.10	61.85±5.62	59.84±5.53	60.63±5.37	73.15±3.53	73.00±4.15	72.50±4.50	72.89±3.95
CD	25.41±1.90	25.70±1.57	24.70±2.09	25.32±1.85	29.54±1.39	29.27±1.74	29.17±1.75	29.33±1.58
CC	7.12±0.96	7.03±0.67	7.15±1.07	7.15±1.07	7.09±0.88	7.68±0.64	7.62±0.53	7.68±0.55
BD	26.35±0.93	26.61±0.86	26.15±1.05	26.40±0.94	30.07±1.60	29.45±2.25	29.58±2.15	29.72±1.96
AC	68.64±2.09	69.08±2.03	68.23±2.42	68.70±2.14	75.46±2.78	74.72±2.93	74.91±3.50	75.05±3.01
RH	59.88±4.63	61.17±4.71	59.54±4.71	60.25±4.62	69.85±2.76	69.73±3.66	71.16±6.07	70.25±4.30
RL	12.88±1.11	13.26±0.95	12.77±1.28	12.98±1.10	15.15±0.68	14.72±0.90	15.00±0.85	14.97±0.81
BL	50.17±5.42	52.06±5.51	50.23±6.12	50.87±5.60	62.70±2.05	62.00±2.19	61.91±1.73	62.22±1.97
PW	11.73±1.43	12.12±1.56	11.61±1.75	11.84±1.55	14.27±0.80	14.27±1.10	14.00±0.85	14.18±0.90
SC	16.23±3.38	16.35±2.73	15.38±3.59	16.04±3.18	20.84±1.46	20.45±1.21	20.00±1.75	20.44±1.50
HRL	19.30±5.00	16.82±4.47	16.70±5.44	17.46±5.01	25.15±3.71	23.27±7.43	21.41±7.79	23.33±6.49

There is no significance difference among the values across the three districts *(P>0.05)*. BW=body weight; HL= horn length; HW= horn width; EL= ear length; HDL= head length; NC= neck circumference; WH=whither height; HG=heart girth; CD= chest depth; CC, cannon circumference; BD, body depth; AC, abdominal circumference; RH, rump height; RL, rump length; PL, pelvic width; SC, scrotal circumference; HRL, hair length.

Continued… Average values (Mean±SD) of body weight (kg) and linear body measurement's (cm) of longhaired Arsi_Bale bucks across different age categories and reared at the three studied locations.

	3PPI				4PPI			
Traits	Dinsho	Goba	Agarfa	Overall	Dinsho	Goba	Agarfa	Overall
BW	36.47±3.02	35.60±2.79	35.92±2.89	36.04±2.88	42.14±4.06	41.08±4.54	42.30±3.88	41.91±4.08
HL	21.47±3.71	21.53±3.50	23.43±3.36	22.06±3.58	25.57±4.53	25.66±2.87	25.00±4.16	25.43±3.98
HW	3.23±0.25	3.30±0.31	3.32±0.31	3.28±0.29	3.28±0.29	3.21±0.25	3.34±0.31	3.28±0.29
EL	14.13±0.86	13.96±0.81	14.25±0.75	14.11±0.80	15.14±0.74	15.04±0.69	15.27±0.66	15.15±0.70
HDL	20.42±2.21	19.16±1.60	19.78±1.25	19.84±1.83	22.07±0.74	21.83±0.86	22.07±0.60	22.01±0.73
NC	32.84±2.41	32.20±2.48	33.14±2.14	32.73±2.34	37.23±2.46	36.41±2.67	37.76±2.24	37.17±2.46
WH	70.53±2.77	69.80±2.42	70.07±2.64	70.16±2.59	75.61±3.52	74.50±3.80	75.23±3.56	75.22±3.55
HG	82.52±4.01	81.00±3.00	82.00±3.28	81.89±3.50	87.28±3.71	85.54±3.21	86.07±4.09	86.49±3.70
CD	31.52±1.61	30.90±1.46	30.92±1.59	31.15±1.55	30.04±1.59	33.70±1.68	34.15±1.66	33.99±1.61
CC	8.73±0.63	8.60±9.03	9.03±0.84	8.78±0.75	9.55±0.70	9.41±0.47	9.65±0.82	9.54±0.68
BD	32.89±3.33	32.13±2.92	32.71±3.09	32.60±3.09	37.43±2.00	36.37±2.40	37.61±1.94	37.21±2.10
AC	80.94±3.96	80.66±3.60	80.00±4.11	80.58±3.83	89.85±3.54	8816±4.04	90.15±3.38	89.50±3.64
RH	72.31±4.32	73.33±3.57	72.28±3.51	72.62±3.82	77.71±2.45	77.16±3.37	78.07±2.84	77.67±2.78
RL	15.84±1.12	15.80±1.22	16.07±1.24	15.89±1.16	17.78±1.15	17.79±1.32	18.57±1.10	18.01±1.21
BL	67.15±1.60	66.73±1.58	66.78±1.92	66.91±1.67	68.05±1.16	67.66±1.61	68.46±1.33	68.06±1.34
PW	14.60±0.67	14.56±0.82	14.78±0.82	14.64±0.75	14.90±0.86	14.45±1.37	14.88±1.08	14.78±1.06
SC	23.31±1.11	23.56±1.29	23.28±1.14	23.38±1.16	24.43±1.56	24.79±1.34	24.69±1.84	24.59±1.57
HRL	$31.52±4.9^{c}$	$26.06±7.66^{b}$	$20.64±7.79^{a}$	26.64±8.01	$35.76±3.00^{c}$	$27.83±8.94^{b}$	$21.54±8.94^{a}$	29.67±8.58

^{a,b,c}valus are significantly different across the same row ($P<0.05$). BW, body weight; HL, horn length; HW, horn width; EL, ear length; HDL, head length; NC, neck circumference; WH, whither height; HG, heart girth; CD, chest depth; CC, cannon circumference; BD, body depth; AC, abdominal circumference; RH, rump height; RL, rump length; PL, pelvic width; SC, scrotal circumference; HRL, hair length.

Table 29: Average values (Mean±SD) of body weight (kg) and linear body measurement's (cm) of longhaired South Wollo does across different age categories and reared at the three studied locations.

Traits	0 and 1PPI				2PPI			
	Kelala	**Woreelu**	**Borena**	Overall	**Dinsho**	**Goba**	**Agarfa**	Overall
BW	17.96±3.96	16.35±3.48	18.26±4.36	17.63±3.98	24.43±1.33	24.50±1.25	24.58±1.42	24.50±1.31
HL	9.53±1.06	9.30±1.13	9.81±1.38	9.55±1.17	11.02±1.74	11.21±1.55	11.23±2.02	11.14±1.75
HW	3.38±0.46	3.26±0.39	3.44±0.49	3.37±0.46	3.16±0.28	3.38±0.45	3.29±0.35	3.27±0.37
EL	12.63±1.01	12.23±0.98	12.47±0.97	12.48±0.99	13.54±0.68	13.41±0.56	13.44±0.61	13.47±0.62
HDL	13.76±2.04	13.20±2.39	13.73±2.13	13.61±2.14	17.16±1.16	17.32±1.14	17.00±1.72	17.16±1.34
NC	27.06±1.16	26.41±1.06	27.07±1.39	26.90±1.23	28.24±1.22	28.29±0.98	28.17±1.07	28.24±1.08
WH	56.32±3.16	54.50±2.67	55.74±3.23	55.68±3.10	60.24±2.10	60.47±2.67	61.35±2.03	60.65±2.28
HG	61.70±6.05	58.91±5.34	60.94±5.82	60.76±5.83	71.24±3.27	71.06±3.11	70.70±3.35	71.02±3.19
CD	24.92±2.44	23.62±2.12	24.47±2.43	24.45±2.38	27.66±1.98	27.23±1.48	27.41±2.03	27.45±1.83
CC	6.03±0.76	5.82±0.70	6.03±0.75	5.97±0.74	7.40±1,25	7.15±0.88	7.58±1.42	7.38±1.20
BD	25.00±1.48	24.38±1.04	25.00±1.59	24.84±1.42	27.05±2.04	27.12±2.15	27.00±2.29	27.05±2.11
AC	68.60±5.74	66.41±5.00	68.68±5.39	68.06±5.46	78.00±2.26	77.47±1.91	78.35±1.93	77.94±2.05
RH	59.42±3.97	57.67±3.71	58.68±3.97	58.75±3.91	64.31±2.30	65.26±2.10	64.50±2.78	64.66±2.39
RL	13.03±1.17	12.35±0.91	12.92±1.44	12.82±1.22	14.40±1.26	14.53±1.02`	14.53±1.50	14.48±1.25
BL	50.43±5.74	48.23±5.24	50.76±5.51	49.96±5.56	59.43±1.47	59.94±1.52	59.70±1.61	59.67±1.52
PW	12.05±1.18	11.47±1.04	12.08±1.27	11.91±1.18	13.31±0.91	13.44±0.84	13.26±0.97	13.34±0.89
TL	2.50±0.40	2.21±0.35	2.45±0.37	2.41±0.39	3.16±0.39	3.15±0.29	3.17±0.49	3.16±0.39
HRL	15.63±5.24	15.70±4.21	14.05±3.93	15.19±49.63	21.87±5.79	20.35±7.01	18.29±6.09	20.29±6.34

BW, body weight; HL, horn length; HW, horn width; EL, ear length; HDL, head length; NC, neck circumference; WH, whither height; HG, heart girth; CD, chest depth; CC, cannon circumference; BD, body depth; AC, abdominal circumference; RH, rump height; RL, rump length; PL, pelvic width; TL, teat length; HRL, hair length.

Continued… Average values (Mean±SD) of body weight (kg) and linear body measurement's (cm) of Longhaired South Wollo does across different age categories and reared at the three studied locations.

Traits	3PPI				4PPI			
	Kelala	**Woreelu**	**Borena**	Overall	**Kelala**	**Woreelu**	**Borena**	Overall
BW	28.30±2.50	29.06±2.10	29.04±1.95	28.74±2.23	31.30±2.74	30.74±2.47	31.55±2.26	31.18±2.58

HL	12.75±1.40[a]	13.73±2.20[b]	13.20±1.70[ab]	13.16±1.77	14.04±0.91	14.79±2.01	14.17±1.34	14.34±150
HW	3.30±0.36	3.37±0.34	3.35±0.36	3.34±0.35	3.39±0.39	3.38±0.34	3.40±0.38	3.39±3.37
EL	14.12±0.50	14.31±0.50	14.35±0.56	14.25±0.53	14.43±0.31	14.41±0.40	14.45±0.36	14.43±0.35
HDL	18.25±0.87	18.29±0.73	18.26±0.98	18.26±0.86	19.32±0.70	19.07±0.76	18.55±3.53	19.00±2.04
NC	29.58±1.00	29.83±1.00	29.88±1.01	29.74±1.00	31.47±0.79[b]	30.84±0.94[a]	31.30±0.80[ab]	31.21±0.87
WH	63.94±1.88[a]	64.83±2.20[ab]	65.33±2.10[b]	64.62±2.10	67.78±1.83[ab]	67.45±1.85[a]	68.65±1.18[b]	67.93±1.71
HG	76.10±2.02	76.39±1.94	75.81±2.30	76.10±2.08	77.95±2.00	77.72±1.90	77.80±2.28	77.83±2.02
CD	29.27±1.46	29.66±1.63	29.77±1.50	29.54±1.52	31.52±1.67	31.14±1.32	31.65±1.60	31.43±1.52
CC	8.43±0.81	8.44±0.75	8.38±1.00	8.42±0.84	9.35±0.69	9.04±0.77	9.32±0.78	9.24±0.75
BD	30.83±2.01	30.79±1.81	31.41±2.45	31.00±2.10	33.52±1.08	33.41±1.30	33.85±1.42	33.58±1.26
AC	80.47±2.91	80.25±1.59	81.15±3.30	80.62±2.74	82.43±1.64	82.27±2.03	82.90±2.20	82.52±2.00
RH	66.42±1.33	66.43±1.66	66.70±1.48	66.50±1.47	68.43±1.61	68.04±1.43	68.65±1.63	68.37±1.55
RL	16.00±1.02	16.37±0.93	16.27±1.28	16.18±1.10	17.28±1.16	16.97±1.47	17.80±1.51	17.34±1.40
BL	61.12±10.00	63.52±2.07	64.54±2.33	62.84±7.06	64.00±1.65	64.34±2.00	64.37±2.00	64.37±1.85
PW	14.25±1.00	14.10±0.58	14.20±1.04	14.20±0.95	14.54±0.36	14.36±0.58	14.60±0.45	14.50±0.47
TL	4.10±0.52	4.29±0.67	4.22±0.59	4.20±0.38	4.50±0.45	4.60±0.43	4.57±0.44	4.56±0.44
HRL	26.63±3.78[b]	26.08±10.45[b]	19.85±8.10[a]	24.38±8.02	29.30±3.34[b]	27.04±6.91[b]	21.55±8.11[a]	25.47±7.01

[a,b,c]valus are significantly different across the same row ($P<0.05$). BW, body weight; HL, horn length; HW, horn width; EL, ear length; HDL, head length; NC, neck circumference; WH, whither height; HG, heart girth; CD, chest depth; CC, cannon circumference; BD, body depth; AC, abdominal circumference; RH, rump height; RL, rump length; PL, pelvic width; TL, teat length; HRL, hair length.

4.25. Body Weight Estimation from the Linear Body Measurements

In order to predict body weight from linear measurements multiple linear regressions procedure were carried out for Bucks and Does of different age classes. Predictor traits (independent variable) were selected that had higher positive correlation with body weight. A single linear measurement was used as a live body weight predictor, when the Pearson's correlation between a trait and body weight were higher, otherwise more than one trait were used.

The findings as suggested in Table38indicate that the morphometrical measurements, which were highly correlated with BW, were the ones thatwere used as predictors (Jimmey et al., 2010). The predictors varied across age categories and the sex of the goats. While, the common predictors were the WH, PW, NC and the thoracic measurements across the different age categories of bucks and does, these are in close agreement with the observations of Alubel (2015) from Northern Ethiopia for Abergelle goat breed. The skeletal measurements viz, HW, PW accounted for a large proportion of the structure of the goats, studies by Afolayan et al. (2006) have indicated that skeletal dimensions make up a sizable proportion of BW of livestock. Table 30: Body weight estimation from different morphometric traits of Longhaired South Wollo goats reared in the three study districts.

Districts	Sex	Age group	Adjusted R^2	BW= β0 + β1X1+ β2X2+ β3X3 +eij
Kelala	Bucks	0-1PPI	0.91	-53.97+1.27 WH
		2PPI	0.69	-35.1+0.99 WH
		3PPI	0.68	-4.92+2.99 EL
		4PPI	0.84	-14.50+1.52 NC
	Does	0-1PPI	0.91	-15.38+0.66 BL
		2PPI	0.66	8.75+1.18 PW
		3PPI	0.47	-30.97+0.66WH+0.57CD
		4PPI	0.76	-48.89+2.54HDL+0.46WH

Woreelu	Bucks	0- 1PPI	0.90	-50.43+1.21WH
		2PPI	0.94	12.29+0.57BD
		3PPI	0.59	-27.76+0.91WH
		4PPI	0.92	-18.25+1.63NC
	Does	0- 1PPI	0.96	-28.88+0.68AC
		2PPI	0.81	8.44+1.11RL
		3PPI	0.88	-8.15+0.78CD+1.37TL+0.26BD
		4PPI	0.78	-13.12+0.96CD+2.45TL+0.11HRL
Borena	Bucks	0 - 1PPI	0.94	-54.12+1.28WH
		2PPI	0.57	11.30+0.25CG
		3PPI	0.88	-35.56+1.04WH
		4PPI	0.77	-15.88+1.54NC
	Bucks	0- 1PPI	0.94	-20.88+0.77BL
		2PPI	0.80	-14.03+0.63WH
		3PPI	0.66	-20.24+0.53WH+0.48CD
		4PPI	0.68	-11.16+1.35CD

BW, body weight; PPI, pairs of permanent incisors; WH, whither height; EL, ear length, NC, neck circumference; BL, body length; PW, pelvic width; CD, chest depth; HDL, head length, RL, rump length; AC, abdominal circumference; TL, teat length; BD, body depth; HRL, hair length, CG, chest girth; R^2,coefficient of determination.

4.26. Structural and Functional Indices of Longhaired South Wollo Goats

The study as indicated in Table 39, showed that the height slope values were negative indicating that the height at withers is smaller than the rump height means the gats are shorter in the front than to the hind, such animals usually will have strong fore quarters and will therefore be able to climb heights better than their shorter fore legged counterparts (Salako, 2006).Shorter forequarters too are advantageous for goats as they are browsers and need support of strong forequarters to access forages (Sastre, 2003). The length index values also show that the goats have a longer body with respect to their height; this indicates a good space for the development of internal organs and also better uterine

capacity for the does as suggested by Chacon *et al.* (2011). Such does are expected to parturate bigger and stronger kids that have a higher survivability (Chacon *et al*., 2011). The findings also indicates that the chest depth s around half of that of the wither height, thereby indicating a good thoracic capacity which can help them survive in the higher altitude conditions better , as thoracic capacity is correlated with the capacity of the lungs which is very important for the survival in the highland altitudes(Sastre, 2003). The results pertaining to the body index also indicates that the thoracic capacities of the goats were well developed and hence are adaptable for survival at higher altitude (Khargharia *et al*., 2015). The values of proporationality index was higher across all age categories and sex

The results from the structural indices suggested that the longhaired South Wollo goats are well adapted for high latitude locations (Khargharia *et al*., 2015). The results from the structural indices also indicate uniformity within the genotypes (irrespective of both the sexes) indicating that the genotype studies can be considered as a distinct breed of goat (Alderson, 1999).

Table 31: Zoometric structural and functional indices (Mean±SD) of Longhaired South Wollo goats in the study area

	Buckling and Bucks	Doelings and Does	Overall
Height slope	-2.85±3.02	-2.25±2.24	-2.49±2.59
Length index	0.92±0.05[a]	0.95±0.08[b]	0.93±0.07
Depth index	0.44±0.02[a]	0.45±0.02[b]	0.45±0.02
Body index	82.81±7.69	82.86±6.27	82.84±6.85
Proportionality (%)	109.05±6.13	128.62±38.7	120.92±30.14
Pelvic index (%)	0.90±0.07	0.89±0.06	0.89±0.07
Transverse pelvic	0.20±0.01[a]	0.21±0.01[b]	0.20±0.01
Longitudinal pelvic (%)	0.22±0.01[a]	0.23±0.02[b]	0.23±0.02
Relative depth of thorax (%)	0.44±0.02[a]	0.45±0.02[b]	0.45±0.02
Dactyl thorax index (%)	11±0.01	11±0.01	11±0.01

Thoracic development	1.11±0.07	1.14±0.06	1.13±0.07
Body ratio	0.96±0.04	0.96±0.03	0.96±0.04
Baron and crevat	0.46±0.07[b]	0.41±0.06[a]	0.43±0.08
Area index	4223±902b	3742±702[a]	3931±821
Cannon thickness	0.12±0.01	0.12±0.01	0.12±0.01
Foreleg index	37.34±3.87[b]	34.11±2.75[a]	35.38±3.60

[ab]the values are different across the same row($p<0.05$).

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Phenotypic characterization of indigenous goats types in their existing production system is the prerequisite before making any breed improvement programs. The present study put some base line information regarding goat type and their characteristics. The present study was carried out to phenotypically characterize the south wollo goats and to describe their production environment in the highland districts of South wollo Zone namely Kelala,Woreelu and Borena. The study on production environment and goat management were based on the survey of 135 purposively selected respondents. Characterizations of physical features of the goats were carried out on 1200 heads of goats by observation and measurements.

The result indicated that goats were kept socio economic and cultural purposes. Across the study areas separate house were used to confine the goats at night. The main feed sources were varied with respect to season. During the wet season natural pasture (shrubs and bushes) were the predominant feed resources while in the dry seasons the goats are mainly depend on crop after math. The goat mainly depends on browses freely irrespective of season. In addition, the management with respect to feeding and browsing/grazing was different for dry and wet seasons. During the rainy seasons, the majority of goat owners herd goats alone in the mountainous areas while in the dry season the majority of them herd together with sheep flocks. In the study areas castration was practiced traditionally to tame the buck and to acquire better price by selling the fattened buck. The majority of the goat owners did not practiced goat fattening intentionally. Vaccination was not common in the study areas.

Body conformation, hair length and color were the main criteria's for selection of breeding bucks, whereas, appearance (conformation), prolificacy and hair length were for breeding does.

Red goat coats are the most frequently noticed color, and the frequent observation of this color may be linked to adaptability. Yet, another different type of coat color was also observed. The observation of various coat colors is an indicator that goats are far from the true breed, which is an opportunity for conducting selective breeding. Both within and among studied populations, morphological traits show variation in general. Goat variation within and between populations may be related to adaptation, breed characteristics, and personal satis faction. The metric value of the Merehabete district goat population is better than that of other goat study areas. The variations reflect man agement variation; otherwise, the variation may be due to genetic fac tors. On the other side, the metric values of the studied goat population increase as age increases, which can indicate the health of the goat population. Therefore, intensifying more veterinary services, following proper goat feeding practices, and conducting community-based breeding may result in a better outcome (enhancing the livelihood of farmers). There are differences among the studied population as well as among the central highland goats, as previously reported by FARMAfrica. Therefore, to exploit the variation related to either manage ment or genetics, a further molecular investigation may be needed.

From the reproductive performance of goat population in the areas studied, the goats performed well The major constraints of goat production the study areas were predator, shortage of feed, disease and shortage of water.

The main frequently observed coat color pattern of goats were plain and the main dominantly observed coat color type were black across both sexes and study districts. Presence of horn was common in the study goat populations of each of the three districts with dominant curved shape and backward orientation for all districts. The absences of wattle and skin pigmentation, concave face profile and long hair (smooth and glossy in respective order) were the main common identified characteristics of longhaired South Wollo goats.

There were no significant difference ($p<0.05$) among the district for body weight and linear body measurements of each sexes of the all age classes. The management and the physical environment did not have influence on the body weight and linear body measurements of the longhaired AB goats. The goatswere genetically stable. Wither height were the best predictor of the body weight of goats.At the end the goat's type in the area, have adaptive features to the highland cold region. Generally, the longhaired South Wollo goats were reared traditionally and these goats are genetically stable, light meat type goat, which were adapted to the cold highland regions.

5.2. Recommendations

The following sets of recommendations were forwarded from this study.

- ✓ The phenotypic characteristics of South Wollo goats should be documented.
- ✓ Highland Arsi-Bale goats having long hair need further research to conserve the genetics of the goat in the area.
- ✓ Various stakeholders should do the awareness on vaccination and health management of the goats.
- ✓ To increase the reproduction performance goat proper feeding, housing and health must be improved.
- ✓ Investigation on Major goat disease must be undertaken.
- ✓ Awareness on the effect of negative selection and inbreeding should be provided to the goat keepers.

- ✓ Genetic characterization should be done on the longhaired AB goats and the breeds should be included under DAGRIS list as well as in-situ conservation of those goat types should be taken in to consideration.
- ✓ The goat type should be included with the community based breeding program for the cold areas of the country because they are well adapted and productive.

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5. DECLARATION OF APPLICANTS (investigators):

We the undersigned participants in this study agree to accept responsibility for the scientific, ethical and technical conduct of the research project and for provision of required progress reports as per terms and conditions of the RCSVP in effect at the time of grant if grant awarded as the result of this application. Moreover, we declared that the proposed study is the original work of the investigators.

NAMEOFALLINVESTIGATOR(S)	RESPONSIBILITY	SIGNATURE	DATE
1. Zemedkun Diffe	PI		
2. Teramaj Abebe	CO		
3. Tesfa Kassa	CO		
4. Cheru Tesfaye	CO		

Questionnaire

Questionnaire for Phenotypic Characterization of Goats (*Capra hiricus)* Reared at South Wollo Zone, Northeast Ethiopia.

Questionnaire code_____District _____Kebele

1. General Information about Respondent's

Name….....

Sex: a. Male b. Female Age _____(years)

Marital status

A. Single
B. Married
C. Widowed
D. Divorced

Household head

a. Male b. Female

Family size…….

Educational level:

a. Illiterate (unable to read & write)
b. Religious school
c. Elementary (1-4)
d. Primary (5-8)
e. Secondary (9-10+2)
f. Above(specify)

2. Livestock demography and trend

Species	No	Species	No	Species	No	Species	No
Goats		Sheep		Mules		Chicken	
Cattle		Donkeys		Horse			

3. Goat flock structure and size

Class of goats	Number	Class of goats	Number
Total bucks and buckling's		Bucks	
Total does and doeling's		Buckling (<6 months)	
Doeling (<6 months)		Buckling (6-12 months)	
Doeling (6-12 months)		Castrated bucks	
Does		Bucks	

4. Land holding

4.1. Size and ownership pattern

Land holding	Own	Leased in	Leased out
Crops land			
Fallow land			
Grazing land			
Others(specify)			

4.2.Trend in land holding A. Increasing B. Decreasing C. Stable ..Reason ----------

5. Trends in Goat Number tick √

Trends of goat number	Increasing	Decreasing	Stable
With respect to cattle			
With respect to sheep			
With respect to equines			

5.1.Goat Flock Herding Mechanisms

5.2.How is the goat flock herded during the day time? reason out after selecting

a. buck and does are separated
b. Post weaned kids are separated
c. All classes of goat herded together
d. The nursing does and pre-weaned kids are reared together
e. The castrated bucks and does are reared together

5.3.Types of herding

		Herding system				
	Goats herded alone	Together with cattle	Together with sheep	Together with calves	Together with equines	All herded together
Dry season						
Wet season						

5.4. Way of herding a) Alone b) With neighboring goat c) many households together

Type of herding	Rainy (cropping) season	Dry (non-cropping) season

6. **Members of household and hired labor responsibilities for goat production activities**

Activities	Men	Women	Activities	Men	Women
Purchasing			Caring sick animals		
Selling			Feeding		
Herding			watering		
Breeding			Milking		

7. Purpose of rearing goat

	Purpose						
	Meat	Milk	Income	Social status specify	Wealth status/saving	Manure	Skin
Rank							

8. Feed and feeding of goats

Feed sources	Wet season	Dry season	Feed sources	Wet season	Dry season
Natural pasture			Crop residues		
Communal grazing			Grazing on fallow land		
Established pasture			Concentrates		
Hay			Agro industrial byproducts		

8.1.How the goats graze/browse in dry and wet seasons

System of browsing	Wet season	Dry season
Free grazing/browsing		
Cut and carry system		

9. Which class of goat do you sell in case of dire need of cash? Tick

Class			
Male kid < 6 month		Breeding doe	
Female kid < 6 month		Breeding buck	
bucks 6 month – 1 year		Castrated	
doe 6 month – 1 year		Barren doe	

10. **What is the average weaning and marketing age of bucklings and doelings**?
.....and …….months respectively

11. Housing

11.1. Where are the goats housed in dry and wet seasons?

11.1.1. Housing /enclosure/ for adult goats

With roof	Dry season	Wet season	Without roof	Dry season	Wet Season
In family house			Kraal		
Separate house			Yard		
Veranda			None		
Others (specify)			Others (specify)		

11.1.2. Type of housing material

Type	Floor	Wall	Roof
Iron sheets			
Grass (bushes)			
Wood			
Stone (bricks)			
Earth (mud)			
Concrete			

11.1.3. Are goats housed together with other livestock? A. Yes B. No

With which species dry season …… Wet season …….

Why you provide house for your goat flock?

A. To prevent theft
B. To keep them warm.
C. To prevent from predators
D. All
E. others specify

12. Weaning, castration, fattening, culling

12.1. Do you practice weaning of the kids? A. Yes B. No

12.2. If yes, what is the average age at weaning?

Type of birth	Weaning age	Marketing age
Bucklings		
Doelings		

12.3. Do you practice culling of goat in your flock? A. Yes B. No

12.4. Do you practice castration of the goats? A. Yes B. No
12.5. If yes, why? A. To fatten and sale B. To prevent unwanted breeding
C. To tame them D. Others_____
12.6. if yes for the above At what age you usually castrate the goats? __ _____years (months) and what is the method used for castrating them
A. Traditional methods (using stone, stick, metal) B. Burdizzo (MoARD)
12.7. Do you practice fattening of goat? A. Yes B. No

12.8. If yes which categories of goat do you fatten?

	Type						
	Culled young does	Culled young male	Young females	Young males	Castrates	Older male	Older female

13. Health management of goats
13.1. Did you have access to veterinary service? 1. Yes 2.no
13.2. Distance to nearest veterinary service

	Distance			
	<1 km	1-5 km	6-10 km	>10km
Mark				

13.3. Do you vaccinate the goat? A. Yes B. No If "No" then why don't you vaccinate the goat?

a. Vaccinations are usually not available
b. The vaccinations are usually not quite effective
c. Don't believe that vaccinations work
a. Vaccinations are expensive

15. Watering of goats
15.1. Frequency of watering the goats>

	Dry season	Wet season
Adults		
Kids		

Put Adlibtum, Once a day, twice a day, once in two days, once in three days
15.2. Source of water for the Goat

Source	Dry season	Wet season		Dry season	Wet season
Bore hole/well water			Spring		
Dam/pond water			Pipe water		
River			Rain water		

15.3. Distance to the nearest watering point?

Distance	Dry season	Wet season	Distance	Dry season	Wet season
Watered at home			6-10km		
<1km			>10km		
1-5km					

15.4. Water quality provided to the goat flocks.

Quality	Dry season	Wet season	Quality	Dry season	Wet season
Clean			Brackish		
Muddy			Smelly		

16. Breeding Practices

16.1. Do you practice selection for the bucks and Does?

A. Yes B. No

16.2. If "Yes" what are the traits used for selecting

Criteria for does	Rank	Criteria for bucks	Rank
Appearance		High body weight	
Pedigree		Coat color	
Prolificacy		Conformation	
Good mothering ability		Early sexual maturity	
Highincome production		Pedigree	
Coat Color		Hair length	
Good growth of kid		Libido	
Disease resistance			
Regular breeder			
Early sexual maturity			
Hair length and type			

16.3. Did you make controlled breeding for your flock? A) Yes B) No

15.1. If "No" then why

A. Unable to detect the signs of estrus

B. Mating usually occurs in the night

C. Mating takes place in the pasture

D. The flocks are not separated according to sex and hence difficult to control

15.2. Do you have your own breeding bucks? A. Yes B. No. If 'Yes" then how many

15.3. What are the sources of these bucks?

a. From own flocks
b. From the flock of friends/neighbors
c. From market/ unknown sources
d. Obtained from friends and relatives
e. Obtained from NGO's/ Woreda office

15.4. If "No" for 16.5 then from where is the source of the breeding bucks

a. From Friends/ relatives/ neighbors
b. From NGO's
c. From Woreda office
d. Lease in on payment.

15.5. What do you do with the bucks while culling?

a. Castrate them
b. Sell them
c. Slaughter them
d. Gift them to friends and relatives
e. Fatten them

17. Reproduction characteristics and survival traits

17.1. Reproductive performance of doe and buck

	Average age at sexual maturity (Days/Months)	Age at first mating	Average number of kidding per life time	Numbers of kids weaned(lifetime
bucks				
does				

	Age at first kidding	kidding interval	Average number of kids per kidding
Doe			

17.2. How many parturitions occurred within your flock during the last 1 year?_____

17.3. How many Does aborted in your flock in the last 1 year? _____

17.4. Offspring mortality in the last 2 months__ A. male kids..... B. female kids' ….

17.5. occurrence of most birth Top 3 months…….

18. What are the main constraints for Goat production? Rank them

Constraints	Rank	Constraints	Rank
Genotype		Market	
Feed shortage		Predators (specify)	
Water shortage		Labor	
Diseases		Drought	