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Original Article

Morphometrical Characterization and Structural Indices of Indigenous Goats Reared in Two Production Systems

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ABSTRACT

This study was conducted with the aim of morphometrical characterization and structural indices to assess type and function of indigenous goats reared in two production system in Sidama Zone, Southern Ethiopia. The study encompassed both qualitative and quantitative parameters which were taken from 780 head of adult goats of both sexes from age 1PPI to 4PPI. Age was estimated by dentition. The qualitative traits were assessed visually and recorded while; quantitative traits were assessed using self-devised equipment. Thirteen morphometrical measurements were taken per goat and from which also indices were calculated. Data collected by visual observation and linear measurements were analyzed by Statistical Package for Social Sciences (SPSS version, 20) and the value was considered significance at $P<0.05$ and $P<0.01$. The qualitative data were assessed by chi–square test. The observed coat color patterns in studied area for both sexes across the districts were plain. Most frequently observed coat color type from sampled goats at Aroresa district were brown and black while, most frequently observed coat color type at Lokabaya district were white. The results of morphometrical measurements indicated that Does age group of 1 and 2 and 3 and 4 reared at Aroresa district had higher value for most measured traits. Bucks age group 1 and 2 reared at Lokabaya district had higher value for their body length, chest girth, rump length, horn length, body weight, rump height and chest depth except rump width, face length and head width which is higher for the Buck in age group 1 and 2 reared at Aroresa district. The Bucks reared at Lokabaya district had higher values for their neck circumference and body weight while, the Bucks reared at Aroresa district had higher value for their head width. In generally, most morphometric traits were different between the goats reared in the studied districts and these variations indicate the possibilities for selection between the goats in the areas. The regression was done to regress body weight from linear body measurements for different age and sex groups separately. As a result, from multiple regressions, chest girth, body length, chest depth and neck circumference were the best fitted models to predict body weight for different age and sex groups separately.

Keywords*:* Indigenous goat, morphometrical measurements, structural indice.

INTRODUCTION

Goats are amongst the most important livestock which sustain the livelihoods of the smallholder farmers, pastoralists and agro pastoralist alike (Workneh and Peacock, 1993). They are reared for their multifarious roles viz. social security, income generation, milk, manure, chevon and skin to name a few (Tsegahun *et al.*, 2000 & Tesfaye, 2004). They are important livestock species especially in the lowland areas which is accompanied with frequent droughts (Tesfaye, 2009). According to (CSA, 2016/17), the population of goats in Ethiopia is estimated to be about 30.20 million heads. The tropical breeds of goats are moderately tolerant to many locally prevalent diseases and parasites, have good flocking instinct, ability to walk for long distances in search of feed, can endure drought like conditions besides can browse on forages which are otherwise unpalatable to large ruminants (Kosgey *et al.*, 2006). They are owned by the agrarian societies for whom this resource is critical for their family nutrition and income and important as secure form of investment, which happens to be the major farming activity on vast areas of natural grasslands in regions where crop production is sparse (Tadelle & Workneh, 2007). Characterization of native livestock genetic resources (based on morphological traits) are fundamental for the classification of any livestock resources, this classification is usually based on their size and shape which can be to some extent serve as economic indicators for the reasons why they are reared (Okpeku *et al.*, 2011). Morphometrical classification also known as phenotypic classification divided into both qualitative and quantitative traits. Assessment of the former being subjective and influenced by a few pairs of genes with major effects while the later is influenced by several pairs of genes both with major and minor effects (Le Roy *et al.*, 1990), (Andersson *et al.*, 1994). The quantitative traits are influenced by the environment while the reverse was true for the qualitative traits (FAO, 2012). It has evolved through many years of regular experimentation on the day-to-day life and available resources surrounding the community and is essential for maintenance of the genetic resources for the continued survival of the breed/type. According to (Groeneveld *et al.*, 2010), identifying and understanding of a genetic resource in a particular region and its development and proper use of the associated diversity is a global responsibility. Characterization of genotype has been recognized as the primordial approach to the sustainable use of livestock genetic resource (Le Roy *et al.*, 1990). The characterization of native genetic resources depends on the knowledge of the variation of morphological traits, which have played very fundamental roles in classification of livestock based on their size and shape (Ferra *et al.*, 2010). Several studies have been carried out for the identification of breeding objectives, selection criteria, morphological characterization and breeding practices associated with the rearing of indigenous goats in Ethiopia (Belete, 2013 & Mahilet, 2012). The diversity in gene pool and their influence of varied climatic conditions have given rise to different local ecotypes of goats which are repositories of unique genes that should be conserved for future benefits (Adebambo, 2004). However, there are still some lacunas in the previous studies pertaining to the morphological characterization and information on morphometrical traits and besides that, structural indices of these goats have not been assessed so as to identify the type and function of the goats for which traits the goats were developed in Sidama Zone, Southern Ethiopia. Therefore, this study was designed to morphologically characterize and to assess the type and function of the indigenous goats using the structural indices and to identify variation

among the goats reared in two production system in the study area.

MATERIALS AND METHODS

Description of the Study Areas

The current study was conducted in the South Nation Nationalities and Regional State (SNNRS) that has 121 districts of which 23 are situated in Sidama Zone (Figure 1). Two districts (Aroresa and Loka Abaya) were selected for the purpose of the current study based on their potential for goat population and different production environments. The descriptions of the districts are as follows:

Aroresa; It is far from Hawassa city by 186km and from Addis Ababa by 461km. It is situated at about 60 20′ North Latitude and 390 00′ East Longitude. It has variability of topography and its average rain fall is about 733 mm and the mean annual temperature is 18.50C. The district covers an area of about 8,100Km2 and has 33 kebeles of which, 11 kebeles are highland while, the remained are midland (Woinedega). The total human population of the district is estimated to be 226,631 of which, 113,731 are males and 112,900 are females. The total livestock population in the area is estimated to be 138, 529 of which about 127,204 are indigenous cattle and about 11,325 are cross breed, 37,735 sheep, 20,855 goats, donkeys, 3221 horses and 375 mules. Even though livestock rearing has significant importance in the area, the livelihood of the farmers is mainly based on crop production this is mainly because sufficient rain fall which is received in the "kremt from April-August.

Loka Abaya: It is one of the 23 districts found in Sidama Zone and it is bordered with Guji Zone of the Oromia regional state in south, Woayita Zone, Humbo district in the east, Sidama Zone Dale and Aleta chuko district in west and Boricha district in north. The district is situated between 6014 - 7018′North latitude and 370 92 - 39014′East longitude. It is far from Hawassa city by 65 km and represents the moist lowland with altitude varying between 1170 up to 1500m.a.s.l. Out of the total agro-ecology of the district, 79% is estimated to be lowland, 16% midlands and 5% is desert. Annual average rain fall amount is range from 900-1400 mm and annual temperature amount range from10-320C.The total land area of the district is 119000 hectare, of which, 20.2% is crop land, 0.85% expected to be used for crops in future, 6.19% is grazing land, 70% is covered by forest and bushes, 2.63 is covered by others and 0.126 is not usable for agricultural activity. The population number of the district are 116,595 and out of these, 59786 are estimated to be males whereas, 56809 are females. The livestock population in the area is estimated to be 209,132 indigenous cows, 107, 99 indigenous bulls 152 cross breed cows and 42 cross breed bulls, 123,607 goats, 50,814 sheep, 18,065 donkeys, 192 mules and 82 horses.

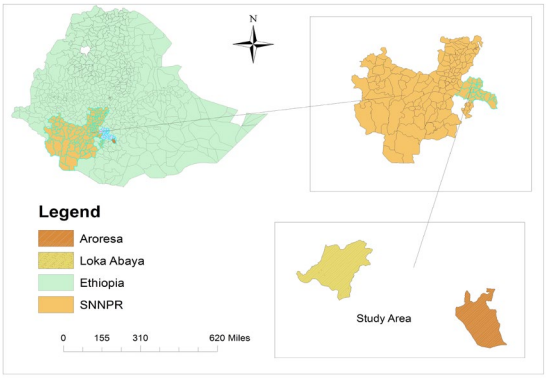

Fig 1. Map of the Study Areas

Sample Size and Sampling Technique.

Stepwise purposive sampling was carried to select the kebeles. A total of six Peasant Associations (PAs), three from each district were selected for the current study. For Morphometrical measurements: 100 Does and 30 Bucks were selected randomly to carry out linear body measurements in each rural kebeles for the study, which make a

total of 780 (600 Does and 180 Bucks of age yearling and above.

Methods of Data Collection

In each sampling site, before starting data collection the selected goat owners were briefed about the importance of the study and asked inquire permission for their willingness before any task of the study was commenced.

Morphological and linear body measurements

Data on the assessment of qualitative characters and quantitative traits were obtained according to (FAO, 2012) descriptor list from a total of 780 goats of either sexes or age categories. Each animal was grouped by its sex, age and sampling site. Dentition record was included, as this was the only reliable means to estimate the approximate age of animal. For the assessment of quantitative (morphometrical) traits, only those Bucks and Does aged one year and above were considered for the purpose of uniformed comparison. These age groups of goats were classified as, one pair of permanent incisors (1PPI) at age of 15- 23 months, two pairs of permanent incisor (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 of over 48 months and sex groups (male and females) (Tatiana, 1999). For qualitative traits data collection: Visual observation was made and morphological features were recorded based on breed morphological characteristics descriptor list of (FAO, 2012) for phenotypic characterization of goat. Each animal was identified by its sex, dentition and sampling site. Qualitative trait data on coat color pattern, coat color type, ear form, presence and absence of wattle, horn, beard, and horn shape and horn orientation and facial profile were observed and recorded for Bucks and Does separately.

Quantitative traits data collection

Morphometrical measurements were made on the quantitative traits of goat using measuring tape after restraining and holding the animals in an unforced position. All measurements are taken in the early morning prior to supply of feed and by the same personnel in each Woreda while goats are in an up-right plane during measurement. Pregnant animals were avoided in sampling because of the effect pregnancy can produce on somebody parameters especially thoracic measurements. The measurement was made on animals based on sex and age group. Animal's age classification was made using dentition technique supplemented with owner's information. The linear body measurement was made using plastic tape (Figure, 3). Additionally, the width and depth measurement was done using a calibrated wooden caliper, while body weight of animals were measured using suspended spring or Slater weighing scale having 50 kg capacity with 0.2 kg precision

Table 1: Methods of calculating the structural indices

Type of index	Calculation
Height Index	Height at withers/body length × 100
Rump Length Index	Length of rump/body length × 100
Over Increase index	Height at rump/height at withersX100
Height Slope	Rump height–withers height
Length Index (1)	Body length/height at withers
Body Weight Index	Body weight/height at withers × 100
Length Index (2)	body length/chest (thorax) depth
Depth Index:	chest depth/withers height
Foreleg Length:	withers height - chest depth
Body Index[a]	Body length *100/chest girth
Body Ratio[e]	Height at withers/Height at rump.
Weight[e]	HG[c]*80
Cephalic Index	Head width*100/head length
Thoracic Development	CG/WH

Source: (Alderson, 1999), (Banerjee, 2015)

Data Analysis

Quantitative and qualitative data generated from field survey and on farm linear body measurements were recorded and entered into computer on a Microsoft Excel spread sheet and analyzed Statistical package for social Science (SPSS of version 20). Simple descriptive statistics compiled the observed categorical variables and the means were compared using Duncan's Multiple Range Test and the value was considered significance at $P<0.05$and $p<0.01$. For adult animals, sex, location and age group of the goats were fitted as independent variables while body weight and linear body measurements were fitted as dependent variables. Least square means with their corresponding standard errors were calculated for each body trait over sex, age. Simple descriptive statistics compile the observed categorical variables best fitted models were selected based on coefficient of their determination (R^2), mean square error and simplicity of measurement under field condition. The collected data were classified based on sex, age and sampling site (four age groups; 1PPI, 2PPI, 3PPI and 4PPI). Mean ± SE for body weight and linear measurement calculated using Statistical package for social Science (SPSS of version 20).

The relationship of body weight and linear body measurements estimated by Pearson correlation (done for both sexes separately to exclude sex effect).

Model $Y_{ijkl}= \mu + D_i + S_j + A_k + e_{ijkl}$

Where:

Y_{ijkl}= The observation on body weight and linear body measurements;

μ = Overall mean;

D_i = Fixed effect of district on morphometric measurement ((Aroresa and Loka Abaya)

Si = Fixed effect of sex (1= male, 2= female)

A_k = Fixed effect of age group (1 = age group 1 (1 &2 PPI) and 2 = age group 2 (3 & 4 PPI)

e_{ijkl}= Random error

In addition for multiple regression,

$Y = \beta0 + \beta1X\ 1 + \beta\ 2X\ 2 + ... \beta nXn + ej$

Where:

Y = the response variable (body weight)

$\beta0$ = the intercept

X1… Xn were the explanatory variables (whither height, rump height, body length, chest girth, ear length and horn length)

$\beta1$... βn are regression coefficients of the variables X1... Xn

ej = random error

RESULTS AND DISCUSSION

Qualitative Traits

The findings pertaining to the qualitative traits of the Bucks and Does reared in the study areas are presented in Table 2. The study indicates that the coat color pattern is mostly plain in both the study areas. The next most common coat color pattern is patchy, which can be fallout of crossings between Bucks and Does of different colors (Hagan *et al.*, 2012). The study also indicates that most of the goats are dark colored (black, red etc). The observations are in close accordance with those of (Hulunim, 2014) and (Oseni *et al.*, 2006). This may be ascribed to the fact that dark colored animals usually secrete substances from the subcutaneous glands which are helpful in protecting the animals against the ecto-parasites (Toth *et al.*, 2006). Studies by Hensen (1990) also indicated that white skinned animals are preferred in the tropics especially in the lowlands as light coat color can be helpful to protect the animals from the high temperature. The result further indicates that the Bucks and Does are horned which has both socio cultural and practical importance, as horned Bucks and Does can effectively fight against the predators (Katongole *et al.*, 1996). The horn shape is straight and backward and upward oriented, the observations are in close accordance with those of Alubele (2015). However, the respondents need to be careful to segregate the flocks effectively as the Bucks tend to compete during the mating season and therefore may harm themselves

in the process (Katongole *et al.*, 1996). Moreover, fighting between different sexes and also age categories within sexes can have serious consequences and may even lead to fatalities within flocks. The study further indicates that the ear of both the sexes are mostly held horizontally which may be a breed character, which too is in close accordance with those of Alubele (2015) for Abergelle breed of goats. The study further indicates that the head profile in most of the cases is straight (irrespective of both the sexes), most of the Bucks and Does are devoid of wattles which too are in close accordance with those of (Hagan *et al.*, 2012) from Ghana. The study further indicates that most of the Bucks have beard (irrespective of the locations) while this too may be a trait which is breed specific.

Table 2: Occurrences (%) of some qualitative traits of goats reared in two different locations in Sidama Zone

		Aroresa			Lokabaya		
Traits	**Class level**	Female (%)	Male (%)	Overall (%)	Female (%)	Male (%)	Overall (%)
Coat pattern	Plain	74	70	73.1	72.3	65.6	70.8
	Patchy	25	30	26.2	25.7	34.4	27.7
	Spotted	1	0.0	0.8	2	0.0	1.5
Coat color type	White	18.7	17.8	18.5	49.3	50	49.5
	Black	21.3	22.2	21.5	2.7	3.3	2.8
	Brown	27.3	23.3	26.4	11.7	5.6	10.3
	Gray	6.3	5.6	6.2	4.7	5.6	4.9
	Red	0.3	1.1	0.2	4	1.1	3.3
	White +Black	16.7	22.2	17.9	14.3	21.1	15.9
	Brown+ white	9	7.8	8.7	6	7.8	6.4
	Light red+ White	0.3	0.0	0.3	7.3	5.6	6.9
Horn	Present	99.3	100	99.5	99.7	100	99.7
	Absent	0.7	0.0	0.5	0.3	0.0	0.3
Horn shape	Straight	81.9	85.6	82.7	90.6	71.1	86.1
	Curved	6.4	6.7	6.5	8.4	12.2	9.3
	Spiral	11.8	7.8	10.9	1	16.7	4.6
Horn orientation	Back ward	91.3	96.7	92.5	93.3	97.8	94.3
	Oblique upward	8.7	3.3	7.5	6.7	2.2	5.7
Ear orientation	Horizontal	82.2	82.2	76.2	68.7	80	71.3
	Dropped	17.3	14.4	16.7	26.3	17.8	24.4
	Forward	8.3	3.3	7.2	5	2.2	4.4
Facial profile	Straight	88	87.8	87.9	91.3	91.1	91.5
	Concave	7	7.8	7.2	4	5.6	4.4
	Slight concave	5	4.4	4.9	4.7	3.3	4.4
Wattle	Present	17.7	12.2	16.4	15.3	11.1	14.4
	Absent	82.3	87.8	83.6	84.7	88.9	85.6
Beard	Present	33	76.7	43.1	38	83.3	48.5
	Absent	67	23.3	56.9	62	16.7	51.5

Quantitative Traits Measured for Goats in the Study Areas.

The findings pertaining to the quantitative traits of the Does and Bucks of the different age categories across both the studied locations are presented in Tables 3 and 4. The findings show that most of the quantitative traits of the Does (aged 1 and 2 years) are higher among those which are reared at Aroresa district. This may be ascribed to the genotype by environmental interaction between the traits. This leads to better skeletal development and therefore the structural differences were observed in both locations, the differences as observed are in close accordance's with those of

Dereje *et al.*, (2013) from West Hararghe. The study further indicates that the however, there were no differences in body weight among the Does reared in the two locations. The results pertaining to the body length (BL) as among the Does in the study are in close accordance with those reported by Hulunim (2014) in the Does of the Bati and Borana goat breed. However, the BL as observed are higher than those of Ghana and Nuer goats as reported by Hagan *et al.*, (2012) and Tsigabu (2015) respectively. The body length and height at withers at any given time reflects the animal's skeletal size and body conditions. Thus, Does with long body usually have enough body capacity and uterine capacity for the fetal development (Mekete, 2016). The chest girth (CG) as observed in the study are in close accordance with those of Tesfaye (2008), however the values are lower than those reported by Dereje *et al.*, (2013). It has been reported in a study by Mwacharo *et al.*, (2006) that the animals which have higher CG have higher capacity to accommodate some of the vital organs viz. heart and liver. Studies by (Halima *et al.*, 2012) have also indicated that CG and body weight of animals are highly correlated. The studies pertaining to wither height (WH) indicates that the values are in close accordance with those of Dereje *et al.*, (2013). However, WH are higher than those reported by Hagan *et al.*, (2012), while higher values too were obtained by Hulunim (2014) in Bati and Borena goat breeds. Findings by Banerjee (2015) have indicates that animals with high withers, rump and long legs have good grazing ability especially in hot climates. High withers also ensure that all the vital organs are well above the blazing heat of the ground and therefore is well adapted to the lowlands (Moshood, 2015). The study also indicates that Does with wide the rump width (RW) and long rump length (RL) usually have high capacity for uterine and fetal development (Mekete, 2016). This ensures that the chances of abortion (due to large fetal size) and dystocia are low (Mekete, 2016). The study also indicates that the trait chest depth (CD) like that of CG is profound importance as the two traits are significantly correlated. In case of the Does it is expected that the neck circumferences (NC) should be narrow and narrowness of the neck is correlated with feminity Takele (2005). The NC as reported in the present study is in close accordance with the values reported by Chiemela *et al.*, (2015) for Boer goat breed. However, the NC that observed in the study is higher than those of Afar goats as reported by (Theodros, 2014). Studies by Hammond *et al.*, (1971) have indicated that long ear length (EL) is observed among the animals adapted to the warm climates. This is because thin skin of the ear has veins at its surface which is exposed to the atmosphere and assists in thermoregulation (Hammond *et al.*, 1971). Thus, the longer the ear, more is the surface area and betters the thermoregulation.

The EL as reported among the Does are in close accordance with those of Alefe (2014) from Shabelle Zone, South Eastern Ethiopia.The face length (FL) of the Does reported in this study is lower than those reported by Weldeyesus and Kumar (2017) for Does of Maefur goat in Tigray. It has been reported that the animals with shorter snout (face length) have problems associated with respiration and are seldom able to take up strenuous exercise and graze for longer distances Banerjee *et al.*, (2014). The head width (HW) of the Does as reported in this study are wider than those reported by Chiemela *et al.*, (2015), however the values are quite similar to those reported by Weldeyesus and Kumar (2017 among Maefur goat of goats in Tigray. It has also been reported that the head width of usually narrower in the female animals and is associated with sexual dimorphism and feminity (Isaac, 2005). The weight of the Does aged 3-4 years as tabulated in the study are in close accordance with the

findings of Ahmed *et al.*, (2015) for indigenous goats breed in Western Ethiopia. The overall value of the trait is closely associated with the genotype and environmental interaction and the management received by the Does Cam *et al.*, (2010). The results related to the average body length (BL) of the Does aged 3-4 years are in close accordance to those reported by Weldeyesus and Kumar (2017) for Maefur goat of Does. However, the findings also show that the trait is higher than those reported by Dereje *et al.*, (2013) and Hagan *et al.*, (2012) for Indigenous Hararghe Highland Goat Breed and Coastal Savannah and Forest Eco Zones of Ghana Goat breed respectively. The CG as observed too are in close accordance with those of Tsigabu (2015) from Nuer Zone. The WH as observed varied across the Does reared in both the locations and the value as observed for the trait was in close accordance with those of Alubele (2015 and Chaco´n *et al.*, (2011) for Abergelle and Central Highland Goat Breeds and Creole goats breed and their crossbred respectively. The differences as observed may have been ascribed to the adaptability of the Does to the different systems of feeding (grazing and cut and carry system of feeding). This is because the animals which are expected to graze for long distances usually have long legs and consecutively long withers (Moshood, 2015). The RH values as recorded are in close accordance with those of Chaco´n *et al.*, (2011) for Creole crossbred goats. The RW and RL as recorded in the study are also in close accordance with those of the Chaco´n *et al.*, (2011) for Creole crossbred of goats. The study also indicated that the NC of the Does was in close accordance with those of Chiemela *et al.*, (2015) Boer breed from Ataye Farm. The study also showed that the FL and HW of the Does was in close accordance with those of Chiemela *et al.*, (2015) for the Cuban Creole goats breed and their crossbred. While the FL was longer among Maefur goat as reported by Weldeyesus and Kumar (2017) while the values of the HW was also wider among Maefur Does as reported by Weldeyesus and Kumar (2017). The BW of the Does varied across the studied locations, which may be ascribed to the quality of the forage available and the amount the Does received across the two locations. The BW as observed in the study are in consonance with the findings of Weldeyesus and Kumar (2017) reported for Maefur goat in Tigray.

Table 3: Comparison of some linear body measurements (Mean± SE) of Does in study areas across the districts in different age groups

	Does age group 1&2			Does age group 3& 4		
Traits	**Aroresa**	**Lokabaya**	P-value	**Aroresa**	**Lokabaya**	P-value
BL	62.31±0.31**	59.96±0.30	0.005	67.16±0.23	67.04±0.21	0.7
CG	66.43±0.31**	65.19±0.32	0.007	71.02±0.29	71.26±0.24	0.5
WH	62.51±0.29**	59.83±0.26	0.001	66.39±0.22**	63.82±0.27	0.005
RH	65.14±0.30**	62.34±0.28	0.002	68.45±0.22**	66.27±0.24	0.001
RW	16.13±0.14**	14.07±0.09	0.006	17.42±0.13**	15.47±0.09	0.009
RL	18.57±014**	16.37±0.10	0.007	20.20±0.10**	18.41±0.09	0.004
CD	27.07±0.16*	26.68±0.15	0.003	29.32±0.13	29.00±0.11	0.07
NC	29.22±014	28.34±0.52	0.12	31.20±0.15**	30.07±0.15	0.007
EL	14.34±0.05	14.28±0.05	0.47	14.44±0.05	14.43±0.06	0.96
HL	7.74±015**	7.01±0.16	0.002	10.03±0.21	10.50±0.16	0.08
FL	15.54±0.06**	14.10±0.07	0.005	16.53±0.06**	15.89±0.07	0.002
HW	10.74±0.06**	9.44±0.03	0.001	11.76±0.5**	9.87±0.04	0.003
BW	25.28±0.24	25.42±0.25	0.7	30.06±0.25	31.45±0.3**	0.005

The values on the same row with same age group are significantly different *(P<0.05) and **(P<0.01)); BL= Body Length(cm), CG= Chest Girth(cm), WH= Withers Height (cm), RH= Rump Height(cm),RW=Rump Width,

RL=Rump Length(cm), CD=Chest Depth(cm), NC= Neck Circumference(cm), EL= Ear length (cm), HL=Horn length (cm), FL=Face Length (cm), HW=Head Width (cm) BW= Body weight(kg).

The results as presented in Table 6 show that there was variation in some skeletal dimensions of the Bucks aged 1 and 2 years reared across the two locations. The differences may be ascribed to the type of nutrition available to them and this is in line with those of Cam *et al.*, (2010) for Turkish hair goats breed. The CG and BL are traits which are correlated with Body weight (Alubele, 2015). The results pertaining to the withers height of the Bucks as observed in the study are in consonance with those values reported for Maefur goats in Tigray region Weldeyesus and Kumar (2017). Differences were also observed in the RH and RL which can be ascribed to the differences in the nutrition available to them. The study also indicated that differences in CD of the Bucks which too are in close accordance with the findings of Alefe (2014) from Shabelle Zone, South Eastern Ethiopia. However, lower CD values were also reported for the Maefur goats in Tigray Weldeyesus and Kumar (2017). The differences in HL as observed too are in close accordance with the reports of Gatew *et al.*, (2015). It has also been reported by that Bucks with longer horns are considered as more masculine and have an adaptive feature to fight predation especially in the tropical zones where production is characterized by extensive system (Katongole *et al.*, 1996). The FL of the Bucks and the HW too varied across the locations and were higher among those reared at A. However, the values of the traits as observed are not in close accordance with those of Bucks of Bale breed (Belete, 2013). The differences in BW as observed among the Bucks may be ascribed to the nutrition available to them. The findings are in close accordance with the observations of Hagan *et al.*, (2012) & Cam *et al.*, (2010) and among Coastal Savannah and Forest Eco-Zones of Ghana breed of goats, respectively. The results also indicated differences in NC and BW among the Bucks (aged 3 and 4 years) reared across the two studied areas are in close accordance with the findings of Chiemela *et al.*, (2015) who reported that NC and BW are highly correlated. The findings also showed that the BL of the Bucks as observed are in close accordance with of the findings reported for Maefur goat Weldeyesus and Kumar (2017). The CG as observed too did not vary across the locations and were in close accordance with those reported in the literatures Halima *et al.*, (2012) & Belete (2013) & Ahmed *et al.*, (2015) and Hulunim, (2014). The BW of the Bucks is also in close accordance with the values reported for BW of Hararghe Highland breed of goats (Andersson *et al.*, 1994).

Table 4: Comparison of some linear body measurements (Mean± SE) of Bucks in study areas across the districts in different age groups

	Does age group 1&2			Does age group 3& 4		
Traits	**Aroresa**	**Lokabaya**	P-value	**Aroresa**	**Lokabaya**	P-value
BL	63.73±0.54	66.17±0.45**	0.001	70.86±0.38	69.67±1.05	0.23
CG	68.26±0.45	70.94±0.47**	0.002	77.08±0.74	80.16±1.22	0.08
WH	63.72±0.40	64.72±0.44	0.11	69.17±0.61	70.67±0.84	0.3
RH	65.97±0.40	67.61±0.47*	0.014	72.65±0.78	73.5±0.61	0.6
RW	15.45±0.23*	14.84±0.16	0.03	18.61±0.27	17.33±0.33	0.06
RL	16.97±0.19	17.86±0.19**	0.008	20.80±0.33	19.83±0.40	0.22
CD	28.37±0.29	29.15±0.23*	0.04	32.71±0.31	33.33±0.33	0.39
NC	31.7±0.3	35.63±0.5**	0.009	37.5±0.7	42±0.57**	0.007
EL	14.30±0.08	14.31±0.06	0.9	14.37±0.16	14.83±0.40	0.25
HL	9.81±0.36	11.38±0.32**	0.002	14.8±0.71	17.17±1.04	0.16
FL	15.78±0.12**	15.03±0.11	0.006	17.2±0.22	16.5±022	0.18

HW	10.82±0.09**	9.93±0.06	0.005	11.67±0.14**	10.00±0.25	0.001
BW	29.08±0.41	36.09±0.61**	0.001	38.83±0.6	46 ±1.14**	0.003

The values on the same row with same age group are significantly different *(P<0.05) and **(P<0.01); BL= Body Length(cm), CG= Chest Girth(cm), WH= Withers Height (cm), RH= Rump Height(cm),RW=Rump Width, RL=Rump Length(cm), CD=Chest Depth(cm), NC= Neck Circumference(cm), EL= Ear length (cm), HL=Horn length (cm), FL=Face Length (cm), HW=Head Width(cm) BW= Bodyweight(kg).

Figure 2. measuring wither height (a), Measuring Chest depth (b) Measuring body weight (c), Measuring ear length (d), Measuring chest girth (e) and Measuring rump width (f) during field work across the districts.

Structural and Functional Indices of Goats in the Study Areas

The results pertaining to the structural indices of the Does and Bucks in the study areas are presented in Tables 5 and 6. The findings (Height index m, HI) show that the length of the Bucks and the height at withers of the Does and Bucks are more or less similar, indicating the animals have a square shape, however differences (P<0,01) too were reported across the study areas. The findings of Length index (LI1) which also indicates that the Does have a compact shape which is near to square. It's expected that such animals have lower incidences of spinal problems vis -a -vis those who have a longer body and shorter height (Chaco´n *et al.*, 2011 & Alderson, 1999). The height index as obtained in the current study is more or less similar to what was reported by Banerjee *et al.*, (2014) from India. The findings pertaining to the over increase index (OII) indicate that the height at rump is more or less similar to those of the withers, however there are incidences where the rump height is higher than the withers height, the findings are in close accordance with those of Banerjee (2015) from India. The front parts of such animals are usually lower than the hind part and hence are prone to dust infestations (Tewelde, 2016). The findings are also related with the height slope (HS), and are in close accordance with those of Khargharia *et al.*, (2015). The findings also show that the rump is approximately 25% of the whole body, which is proportionately good and thus the Does are expected to have a good uterine capacity and therefore the chances of the kid born healthy is also high (Chaco´n *et al.*,

2011 & Chiemela *et al.*, 2015). The findings pertaining to the BW values as estimated from the index show that there are sample scope of its improvement based on the skeletal dimension, the differences as observed may be ascribed to various non-genetic factors such as lack of proper nutrition, presence of internal and external parasites and therefore there are chances of improving the same. The findings pertaining to the depth index shows that the chest depth is approximately 45% of the height of the animals, therefore such Does have a very good lung capacity and thus can graze for longer distances without getting tired and this too especially under strenuous conditions (Chaco´n *et al.*, 2011). The findings from the body index values (BI) indicate that the Does and the Bucks have a very good chest capacity which is approximately 50% of the body length, this indicating that this breed of goats are ideally suitable for long distance grazing and that too at undulating surface (Chaco´n *et al.*, 2011). The findings of body ratio (BR) too correlate with the OII as the height at withers is slightly lower than those of the height of rump, the findings are in consonance with those of (Khargharia *et al.*, 2015).

Table 5: Comparison of body indices (Mean± SE) for assessment of type and function of the Does across various age groups reared in the two different locations

	Does age 1&2			Does age 3& 4		
Indices	**Aroresa**	**Lokabaya**	P-value	**Aroresa**	**Lokabaya**	P-value
HI	100.43±0.38	99.92±0.37	0.34	98.98±0.34**	95.21±0.38	0.001
OII	104.23±0.23	104.20±0.18	0.9	103.13±0.18**	103.9±0.004	0.004
RLI	29.8±0.18	27.35±0.17**	0.003	30.09±0.14**	27.46±0.12	0.005
HS	2.62±0.16	2.50±0.10	0.5	2.05±0.12	2.45±0.11*	0.02
LI(1)	0.99±0.00	1.00±0.00	0.34	1.01±0.00	1.05±0.00**	0.009
BWI	40.43±0.34	42.26±0.34**	0.005	45.26±0.36	49.50±0.34**	0.001
LI(2)	2.3±0.01	2.28±0.01	0.12	2. 29±0.00	2.3±0.00	0.11
DI	0.43±0.00	0.44±0.00	0.06	0.44±0.00	0.45±0.00**	0.009
BI	93.86±0.35**	92.05±0.00	0.009	94.7±0.34	94.13±0.30	0.22
BR	0.96±0.00	0.96±0.00	0.96	0.97±0.00**	0.96±0.00	0.004
W	5314.52±24.96**	5215.43±26.34	0.007	5682.89±23.31	5703.50±19.30	0.49
CI	69.17±0.38**	67.12±0.40	0.002	71.13±3.23	65.17±0.37	0.07
TD	1.06±0.00	1.09±0.00**	0.004	1.07±0.00	1.12±0.00**	0.007

The values on the same row with same age group are significantly different *(P<0.05) and **(P<0.01);HI= Height index, RLI= Rump length index, OII=Over increase index, HS= Height slope, LI1=Length index (1), BWI=Body weight index , LI2=Length index (2), DI= Depth index, BI=Body index[a] , BR=Body ratio[e], W=Weight, CI=Cephalic Index, TD=Thoracic Development.

Table 6: Comparison of body indices (Mean± SE) for assessment of type and function of the Bucks a across the districts.

	Does age 1&2			Does age 3& 4		
Indices	**Aroresa**	**Lokabaya**	P-value	**Aroresa**	**Lokabaya**	P-value
HI	100.17±0.53	97.98±0.50	0.004	97.63±0.84	101.55±1.98	0.07
OII	103.54±0.17	104.47±0.26**	0.009	105.04±0.69	104.03±0.60	0.53
RLI	28.10±0.32**	25.67±0.26	0.001	29.33±0.42	28.49±0.68	0.40
HS	2.25±0.10	2.8±0.17**	0.006	3.48±0.48	2.83±0.40	0.56
LI(1)	0.99±0.00	1.02±0.00**	0.002	1.02±0.00	0.98±0.02	0.08
BWI	45.62±0.55	55.5±0.69**	0.001	56.15±0.73	65.15±1.91**	0.001
LI(2)	2.25±0.01	2.27±0.01	0.25	2.17±0.02	2.09±0.03	0.08
DI	0.44±0.00	0.45±0.00	0.23	0.47±0.00	0.47±0.00	0.87
BI	93.37±0.55	93.32±0.33	0.94	92.10±0.73*	87.04±2.16	0.012
BR	0.96±0.00*	0.95±0.00	0.02	0.95±0.00	0.96±0.00	0.53
W	5461.33±36.37	5677.17±37.69**	0.001	6166.67±59.24	6413.33±97.79	0.87

CI	68.75±0.55**	66.14±0.50	0.001	67.93±0.67**	60.66±1.72	0.001
TD	1.07±0.00	1.09±0.00**	0.002	1.11±0.00	1.13±0.02	0.39

The values on the same row with same age group are significantly different *(P<0.05) and ** (P<0.01);HI=Height index, RLI=Rump length index, OII=Over increase index, HS=Height slope, LI1=Length index (1), BWI=Body weightindex, LI2=Length index (2), DI=Depth index, BI=Body index[a] ,BR=Body ratio[e], W=Weight, CI=Cephalic Index, TD=Thoracic Development

Table 7: Body weight estimation for Does from different morphometrical traits in different age groups across the districts

Location	Age group	R^2- adj	Equations
Aroresa	Age group1&2	0.62	Y= -16.21+0.62(CG)
		0.64	Y= -12.47+0.53(CG) +0.29(BL)
		0.65	**Y= -14.41+0.51(CG)+0.24(BL)+0.20(RW)**
Aroresa	Age group 3&4	0.54	Y= -18.47+0.68(CG)
		0.66	Y= -27.45+0.45(CG)+0.86(CD)
		0.71	Y= -37.55+0.35(CG)+0.70(CD)+0.32(BL)
		0.72	**Y= -38.23+0.30+(CG)+0.65(CD)+0.29(BL)+0.25(NC)**
Lokabaya	Age group 1&2	0.64	Y= -17.04+0.65(CG)
		0.70	Y= -21.56+0.41(CG)+0.34(BL)
		0.74	Y= -20.07+0.34(CG)+0.34(BL)+0.11(NC)
		0.75	Y= -17.6+0.32(CG)+0.30(BL)+0.12(NC)+0.18(HL)
		0.75	Y= -13.7+0.33(CG)+0.28(BL)+0.15(NC)+0.27(HL)-0.35(RL)
		0.77	**Y=-13.92+0.28(CG)+0.29(BL)+0.15(NC)+0.26(HL)-0.42(RL)**
Lokabaya	Age group 3&4	0.48	Y= -23.36+0.77(CG)
		0.61	Y= -40.06+0.52(CG)+0.50(BL)
		0.66	Y= -46.5+0.44(CG)+0.48(BL)+0.89(FL)
		0.67	Y= -47.46+0.42(CG)+0.43(BL)+0.68(FL)+0.14(WH)
		0.68	**Y= -46.32+0.37(CG)+0.39(BL)+0.66(FL)+0.12(WH)+0.20(NC)**

R^2adj = adjusted coefficient of determination; CG=chest girth, BL=body length, NC= neck circumference, WH= wither height, RW=rump width, RL=rump length, CD=chest depth, HL= Horn length, FL= Face length, HW= head width, EL=ear length

Table 8: Body weight estimation for Bucks from different morphometrical traits in different age groups across the districts

Location	Age group	R^2- adj	Equations
Aroresa	Age group 1&2	0.73	Y= -5.33+1.21(CD)
		0.81	Y= -19.6+0.72(CD)+0.41(CG)
		0.85	**Y= -13.68+0.80(CD)+0.54(CG)-0.26(WH)**
	Age group 3&4	**0.67**	**Y=11.37+0.73(NC)**
Lokabaya	Age group 1&2	**0.82**	**Y= -47.41+1.17(CG)**
		0.86	Y= -54.36+0.92(CG)+0.39(WH)
		0.87	**Y= -49.29+0.85(CG)+0.26(WH)+0.22(NC)**
	Age group 3&4	**0.77**	**Y= -5.3+2.58(BL)**

R^2adj. = adjusted coefficient of determination; CG=chest girth, NC= neck circumference, WH= wither height, RL=rump length, CD=chest depth,

Predicting Body Weight from the Value of Correlated Linear Body Measurements

The pertaining to the assessment of body weight of the Does using the morphometrical traits is presented in Table 7. The findings indicate that the most important trait considered for assessing the BW of the Does across the study areas was the CG followed by other skeletal parameters; the observations are in close accordance with previous reports (Halima *et al.*, 2012), (Tsegaye *et al.*, 2013). This may be ascribed to the fact that animals with better thoracic development have higher weight of some vital organs such as heart and lungs (Hammond *et al.*, 1971). The traits such as BL have also a very important implication on the BW of the Does as longer

the body, so is the higher the BW of the Does.

The results pertaining to the assessment of body weight of the Does and Bucks reared across the two study areas taking into consideration the morphometrical traits as presented in Table 8. The regression equations indicate that the trait which is primordial importance is the CD which too is correlated with the CG. The results also indicate that the trait NC is also of importance as the Bucks which have thicker necks usually have higher BW. The study also indicates that WH too is of importance as the animals with longer withers usually have strong fore and hind legs (Mwacharo *et al.*, 2006). Long and thick femur, tibia and meta tarsus have higher surface areas for muscle attachment and is hence correlated with body weight (Banerjee, 2015).

CONCLUSION AND RECOMMENDATIONS

As the results obtained by phenotypic characterization of this study indicate that, most of linear body measurements and body weight, coat color type of goats and some value of structural indices are varied across the districts and as the result of this, there are possibilities for within breed selection among the goats reared across the studied areas. The possible reason for the variation might be due to the difference of location or agro ecology. Structural indices calculated from linear measurements indicated that the Bucks age groups 3 and 4 reared in Lokabaya have good thoracic development than any other age and sex group across the districts. Most important traits obtained across the districts in the study area, which are highly correlated with their body weight and used for future to assess the body weight when a measuring balance is not available were CG, CD, NC and BL, of which CG was the prominent one. Therefore, findings of the current study can be used as an input by the researchers to estimate body weight in the area where the measuring balance is not available. Characterization which is done only on a phenotypic basis is not enough to clearly sate the variation; so that, the further characterizing at molecular level is important hence; it provides sufficient information and enables clearly to identify the existing goat breeds in the study areas.

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