# PHENOTYPIC CHARACTERIZATION AND CARCASS EVALUATION OF INDIGENOUS SHEEP IN GEBIRESU ZONE, AFAR REGIONAL STATE, ETHIOPIA

**MSc THESIS**

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**HAWASSA UNIVERSITY**

**COLLEGE OF AGRICULTURE**

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**A THESIS SUBMITTED TO THE SCHOOL OF ANIMAL AND RANGE SCIENCES, SCHOOL OF GRADUATE STUDIES, COLLEGE OF AGRICULTURE**

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**ADVISORS' APPROVAL SHEET**

(Submission Sheet-2)

This is to certify that the thesis entitled "**<u>Phenotypic Characterization and Caracas evaluation of Indigenous sheep in Gebiresu Zone, Afar Regional State, Ethiopia</u>**" **s**ubmitted in partial fulfillment of the requirements for the degree of Master's with specialization in **Animal Breeding and Genetics**, the Graduate Program of the School of Animal and Range Sciences, and has been carried out by **Te'ame Gebremedhin Id. No. SGSK/ 709/09**, under supervision. Therefore, I recommend that the student has fulfilled the requirements and can submit the thesis to the department.

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|---|---|---|
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| Name of major advisor | Signature | Date |
| Dr. Dessie Shiferaw | _______________ | __________________ |
| Name of co-advisor | Signature | Date |

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# DEDICATION

This thesis manuscript is dedicated to my family for their endless love.

## STATEMENT OF AUTHOR

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## ABBERAVIATIONS

| | |
|---|---|
| AFL | Age at First Lambing |
| AFS | Age at First Service |
| AnGR | Animal Genetic Resources |
| ANOVA | Analysis Of Variance |
| CSA | Central Statistics Agency |
| ESGPIP | Ethiopia Sheep and Goat Productivity Improvement Program |
| FAGR | Farm Animal Genetic Resources |
| FAO | Food and Agriculture Organization |
| FGD | Focal Group Discussion |
| GLM | General Linear Model |
| HCW | Hot Carcass Weight |
| ICARDA | International Center for Agricultural Research in the Dry Areas |
| ILRI | International Livestock Research Institute |
| LBM | Linear Body Measurements |
| LS | Litter Size |
| LTLC | Life Time Lamb Crop |
| M.a.s.l | Meter above sea level |
| MOA | Ministry of Agriculture |
| RLS | Reproductive life span |
| SAS | Statistical Analysis System |
| SNNP | South Nation’s Nationalities People |
| SPSS | Software Package for Social Sciences |

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**Te'ame Gebremedhin**

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***ABSTRACT***

*The study was carried out in Gela'alo and Gewane districts of Afar region to phenotypically characterize indigenous sheep populations and evaluate the carcass components. To this effect, 180 households from six kebeles were selected randomly. Five hundred forty sheep of both sexes were sampled for phenotypic characterization study. Based on the morphometric measurements, structural indices were also calculated. Qualitative data were analyzed using SPSS while quantitative data using SAS version 9. The result showed that most of the household heads were male (76.6%) and pastoral system was the dominant production system. Among the livestock species, goats accounted for the largest proportion followed by sheep and the average goats and sheep flock size was 28.5 and 24.2, respectively. The primary purpose of keeping sheep was for milk consumption. The major feed resources for sheep during wet and dry seasons were communal natural pasture. Rivers and tape water were the main water sources for sheep in the study area. The households mainly practiced natural and uncontrolled mating systems. Selection was practiced both for male and female sheep. Appearance, color, age and sexual maturity were the most important traits in selecting breeding rams while milk yield, lambing interval, appearance and lamb growth were reported as traits given emphasis in choosing breeding ewes across the two studied districts. Feed shortages, recurrent drought, and disease were the major sheep production constraints in both districts. The most observed coat color pattern of sampled sheep populations were plain (50.7%) and patchy (49.3%) while the most observed coat color type was different color with white dominant (38.5%) followed by fawn (23.5%). All sampled sheep populations were characterized by short and coarse hair without a horn. Age, sex and districts had significant ($P<0.05$) effect on most of the quantitative variables. The average body weight (kg), body length, chest girth, height wither, rump height and tail length (cm) was 33.6, 57.4, 68.8, 62.1, 61.2 and 21.2, respectively. Positive and highly significant ($P<0.01$) correlations were observed between quantitative traits in both sexes except ear length. Heart girth and rump height were the best-fitted traits to predict body weight for ram and ewe, respectively. The structural indices indicated that the sampled sheep could be characterized as dairy type. The overall dressing percentage and carcass weight were 37.0% and 8.59 kg respectively. It is concluded that understanding the phenotypic characterization, husbandry practices and carcass characteristics of indigenous sheep can be used as base line data in designing a sustainable breeding program in the study area.*

**Key words***: Afar; carcass components; husbandry practices; indigenous sheep; phenotypic characterization; structural indices*

# 1. INTRODUCTION

In the Horn of Africa especially in Ethiopia where the economy is predominantly agriculture-based, sheep and their products play a critical role in the livelihood of millions of farmers and pastoralists (Wilson, R. T., 2011). The economic and agricultural value of sheep is expected to increase because of climate change (Seo, S. N., 2008; Seo, S. N., *et al*., 2010). Sheep production is a major component of the livestock sector in Ethiopia owing to the large population of 33,020,392 head (CSA, 2018/19) and the diverse genetic resources (Solomon Gizaw, 2008). In Ethiopia, sheep are the second most important livestock species next to cattle with nine diverse breeds (Solomon Gizaw *et al*, 2007) which have become adapted to a range of environments from the cool alpine climate of the mountains to the hot and arid pastoral areas of the lowlands (Tadele Mirkena, 2010). Sheep play an important economic role; make a significant contribution to both domestic, and export markets through provision of food (meat and milk) and non-food (manure, skin and wool) products. They also play a major role in the food security and social well-being of rural populations living under conditions of extreme poverty which is particularly the case for eastern parts of Ethiopia (Alvarez I, *et al* 2009; Gemeda Duguma *et al* 2010).

The average carcass weight of Ethiopian sheep (10 kg) is the lowest relative to all countries and the world average, by about 1 kg, 3 kg and 6 kg from east African countries, least developed countries and world, respectively (Getachew Legesse and Mohamadou Fadiga, 2014). The carcass production potential of indigenous sheep in Ethiopia is between 7 to 18 kg/head and increased as supplement level increases (Shashie Ayele and Mengistu Urge, 2019).Ethiopia has favorable opportunities to increase sheep productivity despite of the Constraints and owns large and diverse livestock resources, which are genetically diverse, and this genetic potential is not yet adequately exploited. Some of the breeds have special merits that meet the requirements of certain incentive markets and earn premium prices. For instance, according to Solomon Gizaw *et al.* (2010), lowland breeds are in high demand in the Middle East; Menz sheep produce delectable meat; long-fat-tailed sheep breeds are highly prolific. Indigenous and locally developed sheep breeds are an important asset due to the unique combinations of adaptive traits they have developed and thus can respond effectively to the pressures of the local environment (Buduram P, 2004). Such adaptive traits include tolerance to various diseases, fluctuations in feed quality, extreme climatic conditions and the ability to survive and reproduce for long periods of time (Hammond Keith, 2000). Sheep productivity in Ethiopia is constrained by lack of technical capacity, scarce feed, diseases, insufficient infrastructure, and market information resulting in varying sheep distribution and marketing across space and time (Leta Samson and Frehiwot Mesele, 2014) and inadequate utilization of the indigenous sheep genetic resources. Although several studies have investigated the origin of African sheep breeds, many breeds and populations have yet to be fully characterized. Characterizing genetic diversity is a key aspect of developing sustainable breed improvement strategies (Groeneveld, L., *et al*.,2010) and understanding adaptation to extreme environments (Boettcher, P. J., *et al*., 2015). The genetic diversity and population structure of Ethiopian sheep populations have been examined using non-recombinant (mitochondrial DNA) and selection-neutral markers (Solomon Gizaw *et al*., 2007; Helen Nugussie, 2015). Genetic characterization of local breeds adapted to extreme environments using modern genomic tools can ensure the breeding of hardy sheep populations (Boettcher, P. J., *et al*., 2015; Yang, J., *et al*., 2016). Farm Animal Genetic Resources (AnGR) Characterization is the activities associated with the identification, quantitative and qualitative description, and documentation of breed populations and the natural habitats and production systems to which they are or are not adapted. The aim is to obtain better knowledge of AnGR, of their present and potential future uses for food and agriculture in defined environments, and their current state as distinct breed populations (Rege J.E.O. and Lipner M.E., 1992).

Characterization of AnGR activities should contribute to objective and reliable prediction of animal performance in defined environments, to allow a comparison of the potential performance of different types of AnGR within the various production systems found in a country or region (FAO, 2015). By understanding, the production environment of indigenous sheep would enable a better comparative understanding of the adaptive fitness and performance of the breed (Helen Nigussie *et al.*, 2015).

Gebiresu Zone has high potential of sheep population. However, the indigenous sheep population available in the two study districts is recently not phenotypically characterized; pastoralists' breeding practices are yet reported as to the level of my knowledge. These information, however, are highly required for policy makers, sheep breeders and development practitioners working on sheep production improvement program in the area as a prerequisite for designing sustainable sheep genetic improvement programs and strategies for the future development of indigenous breeds. More specific the aim of the improvement schemes is to increase production, product quality, cost efficiency, maintain genetic diversity and support the conservation and use of specific breeds. Hence, this study is designed to address the following objectives

**General objective**

To describe the morphometric, husbandry practices and carcass components of indigenous Afar sheep population in their natural production environment.

**Specific objectives**

- To describe husbandry practices of Afar sheep in the study districts;
- To characterize the indigenous Afar sheep based on morphometric traits and structural indices and
- To evaluate the carcass components of Afar sheep in the study area.

# 2. LITERATURE RE REVIEW

## 2.1. Origin and Distribution of Sheep

African sheep are thought to be of Near Eastern origin (Epstein, H., 1954; Epstein, H, 1971; Ryder, M.L., 1984; Marshal, F., 2000). The earliest sheep in Africa were thin-tailed and hairy and introduced to East Africa through North Africa (Marshal, F., 2000). The second wave of sheep introduction to Africa constitutes fat-tailed sheep entering North Africa via the Isthmus of Suez straits and East Africa via straits of Bab-el-Mandeb (Ryder, M.L., 1984) Fat rumped sheep entered East Africa much later (Epstein, H., 1954; Epstein, H, 1971; Ryder, M.L., 1984). Accordingly, African sheep have been traditionally described and classified based on their tail type (Epstein, H, 1971; Ryder, M.L., 1984). However, the relation between the traditional classification and genetic variation across currently recognized breeds is unknown. Ethiopia is believed to be one of the major gateways for domestic sheep migration from Asia to Africa (Devendra C. and McLeroy, G.B., 1982). With 18 million sheep (CSA, 2005) and 14 traditional populations, there are highly diversified indigenous sheep populations in the country parallel to its diversity in ecology (Galal, E.S.E., 1983), ethnic communities and production systems. However, causes and patterns of genetic and morphological structuring of Ethiopian sheep have not been investigated. Evidence of sheep on the African continent is much more recent than the Southwest Asian occurrences at the domestication centers. Faunal remains, as well as ancient paintings and rock carvings across the continent, are providing insight on the geographic entry points and subsequent history of sheep husbandry on the continent.

The earliest African domestic sheep remains, dated between 7500 and 7000 BP, derive from the Nile Delta, the eastern Sahara and the Red Sea Hills (Gautier, A., 1987; Close, A. E. 1992; Vermeersch, P. M *et al*. 1996). These sheep likely originated from the Sinai Peninsula, where sheep remains have been dated c. 7000 BP (Oren, E. D. 1979). They entered into the

African continent, perhaps in response to droughts and unstable climates in the Levant. Sheep remains have been positively identified in the Sodmein Cave in the Red Sea Hills with radiocarbon dates 7100–7000 BP (Vermeersch, P. M *et al*. 1994; Vermeersch, P. M *et al*. 1996). The overland dispersal route of sheep was northward to Libya (6500–6800 BP), southwards to that central Nile valley (6000 BP) and westwards to that central Sahara (6000 BP) reaching West Africa by 3700 BP (Close, A. E. 1992; Smith, A. B., 1992; Breunig, P. *et al.* 1996; Holl, A. F. C. 1998; Hassan, F. A., 2000; MacDonald, K. C., and MacDonald, R. H. 2000). Mediterranean maritime trading routes may have facilitated the dispersal of sheep along the northern African coastline (Ryder, M.L., 1984; Pereira, F *et al*. 2006). The depiction of animal forms in ancient rock engravings and paintings provides information on the phenotypes and appearance of these first African sheep. The Tassili rock paintings show flocks of horned sheep with hair coats and thin tails. Numerous representations of sheep are found during the Early Dynastic Period of Egypt (5111–4624 BP). One of the earliest of these pictures is a pre-dynastic Tjehnu palette, dated 5000 BP, in which domesticated sheep with corkscrew horns and long thin tails are represented together with domesticated cattle and asses (Gardiner, A., 1961).

Generally, the paintings of sheep from ancient Egyptian tombs from the Early Dynastic Period of Egypt depict sheep with a straight head profile and Roman nose, spiral horns, long thin legs, a long thin tail reaching the hocks and often black, white or pied coat (Epstein, H. 1971; Chaix, L., and Grant, A. 1987; Marshal, F., 2000). Their phenotypic resemblances with the corkscrew-horned sheep with long legs, lop ears and pied colors found presently in West Africa suggest that the latter may be the descendants of these ancient Egyptian sheep, for example the Uda breed of West Africa, characterized by a striking two-color coat pattern, long thin tail and long legs. The sheep inhabiting northern Africa are today all fat-tailed. We cannot fully exclude the possibility that this phenotype might have emerged independently from the fat-tailed sheep of the Fertile Crescent, but we think it is unlikely in light of the continuous geographic distribution of these fat-tailed populations with their Asian counterparts. The distribution instead suggests that a second major wave of sheep entered North Africa and subsequently replaced and/or introgressed with the local thin-tailed sheep. Accordingly, fat-tailed sheep are depicted more recently in Egypt compared to thin-tailed sheep, during the Middle Kingdom, 3002–2644 BP (Clutton-Brock, J. 1993). Fat-tailed sheep are not found in West Africa. There is, to the best of our knowledge, no evidence of fat tailed sheep in western Saharan rock paintings and/or engravings.

The spread of sheep into East Africa is less well documented. By 4500–3500 BP, sheep are found with cattle in the Lake Turkana basin (Barthelme, J. W. 1985; MacDonald, K. C., and MacDonald, R. H. 2000). Clark, J. D. (1976) suggests that these sheep may have diffused overland from the Nile Valley in response to growing aridity in the north. If so, these would have been sheep of the thin-tailed type, as fat-tailed sheep were not present in the Nile Valley at the time. However, there are also increasing indications of direct trading connections between the Arabian Peninsula and the Eritrean region, including domestic animals (Marshal, F., 2000; Boivin, N., and Fuller, D. Q. 2009). The first East African sheep could therefore have been introduced directly from the Arabian Peninsula. Undated rock paintings from Serkama Cave (Harar Province) in the eastern Ethiopian highlands (Clark, J. D., and Williams, M. A. J. 1978) portray fat-tailed sheep and humpless cows, suggesting that fat-tailed sheep were present in East Africa prior the arrival of humped cattle, for which there is undisputed archaeological evidence dated to around the mid-first millennium AD (Gifford-Gonzalez, D., and Hanotte, O. 2011). It remains unknown if the arrival of fat-tailed sheep in East Africa and in the northeastern part of the continent occurred in the same period. Sheep arrived in Southern Africa in approximately the late third millennium BP (Sealy, J., and Yates, R., 1994; Sealy, J., and Yates, R., 1996), reaching the Western Cape ca. 2000 BP

(Smith, A. B., 2009). Southern African sites yielding sheep remains have been associated with Later Stone Age and early pastoralist Khoi communities (Plug, I., and Badenhorst, S., 2001) as well as Early Iron Age and/or Early Farming communities (Mitchell, P. 2002). The oldest evidence of caprines in Southern Africa is from the Later Stone Age (LSA) site of Leopard Cave, Erongo, Namibia (Pleurdeau *et al.* 2012). It has been dated from 2270±40 BP. Whether the two teeth found represent sheep or goat remains unclear, but the positive identification of sheep bones in the overlying layer supports the presence of sheep rather than goat at the site (Pleurdeau, D *et al.* 2012). In southernmost Africa, the earliest evidence of sheep husbandry dates from 1960 BP from the Blombos site on the Southern Cape coast (Henshil wood, C. 1996). The route that livestock took to reach Southern Africa is still debated, and several hypotheses have been proposed including migrations through and along the coastal areas of the Congo Basin and through tsetse corridors along the highland of the Rift Valley (Smith, A. B.1998, 2009; Gifford-Gonzalez, D., and Hanotte, O. 2011). In addition, it remains debated whether the appearance of caprines in Southern Africa involved immigration of herders from the north or if it was the result of a cultural diffusion process. The tail phenotype of the first Southern African sheep is unknown. Undated rock art depictions of both fat-tailed and thin-tailed sheep have been reported from Zimbabwe (Goodall 1946 cited in Rocha, J. *et al.* 2011) and Southern African rock art depicts sheep as fat-tailed with a hair coat (Campbell, A., and Coulson, D. 2001), similar to present-day East African sheep.

### 2.2. Genetic diversity, Population and Distribution of Sheep in Ethiopia

The ecological, climatological, ethnic, and cultural diversity of Ethiopia is reflected in its large sheep populations (33,020,392 heads) according to (CSA, 2018/19) reports. Which can be phenotypically classified in to 14 native populations (Solomon Gizaw *et al*., 2007) in addition to populations distributed along the northern, southwestern, and western borders of the country that have yet to be described. These local populations are mainly named after the geographic location or ethnic group/community rearing them, or based on phenotypic characteristics; for instance, the 14 Ethiopian sheep populations are broadly categorized according to their tail phenotypes as thin tailed (one breed), fat-tailed (11 populations), and fat-rumped (two populations) (Solomon Gizaw *et al*., 2007). The short fat-tailed population mainly inhabits the sub-alpine regions; long fat-tailed sheep are predominant in mid- to high-altitude environments; and fat-rumped sheep are distributed in dry lowland areas (Solomon Gizaw *et al*., 2007). The fourteen sheep types were categorized into four groups (sub-alpine short-fat-tailed, highland long fat tailed, lowland fat-rumped, lowland thin-tailed) based on their ecological distribution, geographic proximity, tail types and tail form/shape (short vs. long). Earlier studies used tail type MOA, (1975) and eco-regional distribution (Sisay Lema, 2002) to describe some of the sheep types.

### 2.2.1. Subalpine short-fat-tailed group

**Menz sheep;** is Short fat tail turned-up at end; small body size; short legged; long fleece with coarse wool; commonly black with white patches, white, brown, white with brown patches; straight-faced; horned males; short semi pendulous ears with 12% rudimentary ears in the population. Kept by Amhara community (Tesfaye Getachew *et al*, 2012) and Geographic distribution of North Shoa zone of Amhara state 9.1 –14.5ºN and 36.3–39.8ºE (ILRI, 2011).

**Sekota sheep;** is Short fat tail turned-up at end and fused with main part;medium-sized; predominantly brown or white coat, few black with brown belly; white animals have finer hair or woolly undercoat; semi-pendulous or rudimentary ears in Wag Himra and Tigray, predominantly rudimentary in Tekeze valley. Reared by Agew, Tigray and Amhara communities (Solomon Gizaw *et al*.; 2008a) and Geographic distribution of Wag Himra zone of Amhara State and Tigray State (ILRI, 2011).

**Semien sheep;** is Short fat tail; well-developed woolly undercoat; plain brown, plain white, brown/white with white/brown patches, plain black and black with brown belly; unique long laterally spiral horn in males and short horns in most females; largest of the highland woollen sheep. Reared by Amhara community (Surafel Melaku, 2011) and Geographic distribution of North Gondar zone of Amhara state (Debark, Dabat, Janamora, Wegera) (ILRI, 2011).

**Tikur sheep**; is Short fat tail; woolly undercoat; predominantly black (60%) coat; small body size; majority short semipendulous ears,24% rudimentary ears. Reared by Amhara communities (Mohamed; 2012) and Geographic distribution of North Wollo zone of Amhara state (ILRI, 2011).

**Wollo sheep**; is Short-fat-tail with short twisted/coiled end, occasionally turned up at end; Small size; well developed woolly undercoat; predominantly black, white or brown, either plain or with patches of white, black or brown; long hair with woolly undercoat; horned males. Reared by Amhara communities (Sisay Lemma, 2009) and Geographic distribution of 9.1 –14.5ºN and 36.3–39.8ºSouth Wollo zone of Amhara state (ILRI, 2011).

**Farta sheep**; is Short fat tail; medium size; woolly undercoat; commonly white (37.5%), brown (27.5%) and black with brown belly (15%), white/brown with brown/white patches; males are horned. Reared by Amhara communities (Shigdaf Mekuriaw, 2012) and Geographic distribution South Gondar zone; Gondar zuria, Belesa, Dembia districts (ILRI, 2011).

**Washera sheep;** is also known as Agew or Dangla sheep which is mainly in- habits the wet and warmer mid-highlands (1600-2000m above sea level) (Solomon Gizaw *et al*., 2010a). They are Short fat tail; large body size; shorthaired; predominantly brown; both males and females are polled. Reared by Amhara and Agew communities (Shigdaf Mekuriaw, 2012 and

Tesfaye Getachew *et al.*; 2012). According to Solomon Gizaw et al. (2008) and Sisay Lemma (2009) geographically, the breed is distributed in Amhara region (West Gojjam, East Gojjam and Awi zones and Alefa Takusa district in North Gondar zone) and Benishangul-Gumz state (Dangur and Mandura districts) in Ethiopia.

### 2.2.2. Highland long-fat-tailed group

**Adilo(Doyogena sheep)** is Long fat tail reaching the hocks, broad at the base and upper third with long tapering end; large size; shorthaired; males are short-horned and 18.4% of ewes are horned; predominantly brown (43%), brown with white patches (32%), black (16%), and black with brown patch (9%). Reared by Southern nationalities (Amelmal Alemayehu, 2011) and Geographic distribution of Wet, warmer mid-highland (1800–2000 masl), 10.4–5.8ºN and 34.5–40.3ºE North Omo, Derashie,Gedio and Amaro zones of Southern state;some northern Borana districts (1300–2400 masl). (ILRI, 2011).

**Arsi-Bale sheep**; is Long fat tail with twisted end in some animals; medium size; hairy fibre, especially in adult ewes, males have minor wool growth in some parts of body; males and most females (52%) are horned; large size; coat colours are brown (35.1%), brown with white patches (24.3%), black,white, and combinations of above colours. Reared by Oromo communities (Solomon Gizaw *et al*, 2008a) and Geographic distribution in ecology of mainly wet, cool and warmer highlands (2000–3300 m.a.s.l); submoist lowlands,Arsi, Bale, East Shoa,West Hararghe zones, some districts in Borana zones of Oromia; Hadya, Gurage, Kembata and Sidama zone. (ILRI, 2011).

**Horro sheep;** is Long fat tail extending below hock, either straight (51.4%) or coiled/twisted (48.6%) at the tapering end; prominent fat tail in males; large, leggy and prolific; dominant colours are brown and fawn, belly is lighter especially in adult ewes, less frequent are black, white, brown with white patches; both sexes are polled.

Reared by Oromo, Benishangul and Gambella communities (Kedjela Tessema, 2010 and Bosenu Abera, 2012).

**Bonga (Gesha, Menit);** is Long fat tail with straight tapering end (98.4%); hair sheep;large size; predominantly plain brown (57.9%) or with black (0.9%) or white (5.3%) shade, plain white (10.5%) or with brown patches (10.5%), and black (2.6%); both sexes are polled. Reared by Keffa, Sheka and Bench communities (Dejen Assefa, 2010 and Amelmal Alemayehu, 2011).

### 2.2.3. Lowland fat-rumped group

**Afar (Adal, Danakil);** is Wide fat tail, in some large fat tail reaching below the hock; hair fibre; medium size;characteristically uniform creamy white/beige coat; rudimentary ear; polled; dewlap.Reared by Afar, Amhara, Tigray communities (Solomon Gizaw et al. 2008a and Tesfaye Getachew,2008). Geographic distribution mainly arid lowland of Afar state; bordering Tigray, Amhara; East and West Hararghe and East Shoa of Oromia. (ILRI, 2011)

**Black head Somali (Wanke, Ogaden, Berbera black head);** is Short fat rump with a stumpy appendage; uniform white body and black head and neck; polled; convex face,especially in males; short, outward forward drooping ear; well-developed dewlap. Reared by Somali and Oromo, Konso and south Omo communities (Solomon Gizaw *et al.* 2008a and Fekerte Ferew, 2008).

### 2.2.4. Lowland thin-tailed group

**Gumz sheep;** is Long thin tail; somewhat dwarf; convex face profile; long pendulous ear; commonly plain brown or with patch (39.4%), white with brown or black patch (21%), black(15.8%), white, black with white patch, brown with black patch; polled. Gumz and Amhara communities Solomon Gizaw *et al* (2008a) rear it.

## 2.3. Sheep production and management systems in Ethiopia

### 2.3.1. Highland sheep-barley system

This system is found in the highlands above 3000 m.a.s.l. where the major crops grown are barley and pulses. Cropping intensity in these areas is generally low and sheep are the dominant livestock species. The main feed resource-base includes wasteland grazing, stubble and sometimes straw. Sheep flock sizes range from 30 to several hundred head. Although sheep are reared mainly for meat, skins and coarse wool production for the cottage industry of the central highlands are subsidiary products. There is, therefore, a clear possibility of establishing more formal sheep production enterprises using appropriate technology packages (ESGPIP, 2008). Small ruminants are more important than large ruminants in the densely populated higher altitude areas and important livelihood sources for people as reported by (Solomon Gizaw *et al.* 2015).

### 2.3.2. Mixed crop–livestock systems

Crop-based mixed farming system is often found in the highland agro-ecological zones where the altitude ranges between 1500 and 3000 m.a.s.l and the climate is favorable for farming of crops and raising of livestock. In this production system, livestock production is secondary to crop production and it usually comprises of small ruminants with very small flock sizes as a means to generate cash income from sale of animals and produce meat (Tesfaye Alemu, 2004; Solomon Gizaw *et al.*, 2014). Hence, in some areas, free grazing is limited and small ruminants are now tethered (Kidus Nigussie, 2010) though they are herded in others to graze and browse on communal lands (Deribe Gemiyu, 2009; Firew Tegegne, 2012). In addition, due to a gradual shift from keeping large to small ruminants, the relative importance and population of small ruminants is increasing and feeding animals in a limited available grazing lands, crop residues, forages, bushes and shrubs, home left overs and industrial by-products are becoming the features of mixed crop-livestock production system.

### 2.3.3. Pastoral and agro-pastoral Production system

The majority of small ruminants (40% of sheep and 40% of goats) are concentrated in the pastoral and agro-pastoral areas (Asfaw Negassa and Mohammad Jabbar, 2008) kept under extensive systems which make them major sources of livestock products for the Ethiopian export market (Getahun Legesse and Mohamadou Fadiga, 2014). As the arid and semi-arid agro-ecological zones, within altitudes below 1500 masl, receive low moisture in most of the time and feed is scarce in the dry season, pastoralists and agro-pastoralists travel long distances with their animals in search of feed and water. The system is either transhumant (the whole system moving periodically) or sedentary (limited movement) (Solomon Gizaw *et al*., 2008). The pastoral production system is based on wide-ranging communal grazing lands primarily using natural vegetation where thorny enclosures are common while the agro-pastoralists, on the other hand, are characterized by a combination of pastoral and mixed crop-livestock production systems with periodic use of crop residues (Grum Gebreyesus, 2010; Getahun Legesse and Mohamadou Fadiga, 2014). The pastoral production system is based on extensive communal grazing whereas agro-pastoralists are characterized by a combination of both pastoral and mixed crop-livestock production (Asfaw Negassa *et al.,* 2011).

## 2.4. Purpose of keeping sheep

Small ruminants in Ethiopia play very important role in terms of meat, milk, manure, skin, wool, horn, bone, security, gifts, religious rituals, medicine and incentives (Getahun Legesse and Mohamadou Fadiga, 2014; Ali Zahra *et al.*, 2014). According to Mourad Rekik *et al.*, (2015), Small ruminants in Ethiopia contribute 154,000 tons of meat.

Based on CSA (2014/15), farmers keeping their sheep mainly for income, saving, meat, milk, breeding, social function and scarifications. In western and southwestern Ethiopia reported by Zewudu Edea *et al.* (2012), most farmers keep sheep primarily as source of income. Getachew Tadesse *et al.* (2010) stated that sheep enterprise in Ethiopia is being used as a cash income and provides social security in the bad crop years. Small ruminants provide meat and milk to the smallholders and are considered as insurance mainly against crop failure, as saving, socio-cultural and ceremonial purpose (Kosgey, I. S *et al.,* 2004; Markos Tibbo, 2006; Habtemariam Shigdaf *et al*., 2012). According to Zewdu Edea *et al*, (2012) keeping of bonga and horro sheep is for the benefits of (such as regular source of income, meat, and manure). Getachew Terefe *et al,* (2010) also reported that milk production from sheep was the primary objective of pastoralists in northeast Ethiopia (Afar). However, Dhaba Urgessa et *al,* (2012) and Zewdu Edea et *al*, (2012) reported that production and consumption of milk from sheep is not common in mixed crop livestock system where income generation is considered as the primary objective of keeping sheep. The Afar pastoralists primarily keep sheep for their milk followed by their meat and for income generation as reported by (Solomon Gizaw *et al*., 2013a).

## 2.5. Major constraints of sheep production

As reported by Tsedeke, (2010), Sheep production and productivity in Ethiopia is constrained by many factors such as scarcity of feed, lack of infrastructure, high mortality rates, inadequate veterinary coverage, poor quality products and low average reproductive rates. However, high reproductive wastage is the major constraint of sheep productivity, which also greatly reduces selection possibilities. Problems of input supply, credit services and appropriate extension service are also the major constraints of sheep production (Fikru Sisay and Kefyalew Gebeyew, 2015).

## 2.6. Sheep management and husbandry

### 2.6.1. Feeds and feeding systems

According to Assefa Feleke *et al.,* (2015) the main feed resources for sheep production are natural pasture, improved forage and crop residue showing varied availability in different seasons. Natural pasture or indigenous grass was the main feed resource during the rainy season whereas natural pasture, crop residue and improved forage, in the dry season. According to the report of Adugna Tolera *et al*., (2012), feed resources can be classified as natural pasture, crop residue, improved pasture and forage and agro industrial by-products namely, (noug seed cake , soybean meal, wheat bran, etc,) of which the first two contribute the largest share. Addis Getu, 2015 (2015) indicated that available feed resources of small ruminants are natural pasture, crop residue, cultivated forage and industrial by product and other by feed resources derived from herbaceous forages, trees and shrubs, food crop residues, agro-industrial by products, mineral supplements and other by -products. Communal grazing land, roadside grazing, private grazing, riverside grazing and indigenous browser are the major types of grazing for sheep. Although there is difference in utilization across months of the years, communal grazing lands are utilized throughout the year as reported by (Fikru Sisay and Kefyalew Gebeyew, 2015). According to Fikru Sisay and Kefyalew Gebeyew, (2015), sheep and goats sped most of (95.6%) their time grazing and browsing. On average, they only spent about 6.4 hours in days grazing/browsing during the daytime. They are under close supervision throughout the day and in all seasons of the year to protect them from predators. In lowlands areas, where goats are dominating and grazing lands are relatively larger they are also protected from wild animals. Whereas, in the highlands where sheep are dominant there is small grazing time; small ruminants are protected from cropland and from predators. According to Assefa Feleke *et al* (2015), in KembataTambaro Zone**,** on months August and February, serious feed scarcity was prominent and utilize different feeds: agro industrial by-products, tubers and other feed supplements whereas sell their sheep specially lambs to reduce feed requirement of sheep on dearth period. During November, December, June and May, there were excess feed supplies that encourage farmers to fatten their sheep by buying additional sheep from the market.Shrinkage and decline yield of grazing lands driven by increase livestock population and drought was reported to be the leading reasons for feed shortage across all the study sites. Increases of human population and Decline carrying capacity of grazing land are also mentioned to cause feed shortage (Fikru Sisay and Kefyalew Gebeyew, 2015). In most production system of Ethiopia, extensive free grazing in communal lands and stubble grazing are the most common practices of sheep feeding as reported by (Solomon Gizaw et *al.*, 2010).

### 2.6.2. Watering

According to Alemitu Beyene and Abera Anjamain, (2018), Water is very crucial nutrient required by livestock large amount to transport nutrient around the body, regulation of body temperature, formation and maintenance of body tissue. The major source of water was river water, tape water, water harvest and rain fall water in Esera District, of Dawro Zone, Southern Ethiopia. The major sources of water during dry season was river water and water harvest (31.6%) and river water, tap water and water harvest (68.4%) and during wet season was rain water (11.4%), rain and river water (42.3%) ,tap and rain water (33.2%) and river, tap and rain water (13.1%) across all study area. One hundred percent of the respondents in study area were water their small ruminant both in dry and wet season of the year either by harvesting water from different water source or going long distance to the river with their livestock. On average 1.4 ± 0.9 km distance from homestead to the water source was reported in study area.

### 2.6.3. Sheep Housing

A report in Doyogena Woreda by Assefa Feleke *et al.* (2015), keeping sheep in the main house together with the family is very common. Zelealem Tesfay *et al.* (2013), in Northern Ethiopia reported that Farmers put their sheep in separate housing (pen) constructed in the homestead or around the homestead. Traditionally, the pens are constructed in two different ways. The first and most commonly used pen constructed is open ended without roof, which is usually used to confine sheep during dry season at night, and it is locally called“Dembe”. Almost all households keep their flock separately from large ruminants. The second one is mostly used to confine sheep during rainy season to protect them from rain and cold. It is three or two-side wall constructed from local materials such as stone or wood and partially roofed which is locally called“Gebela”. Farmers with this sort of housing keep all types of animals. Based on Yenesew Abebe *et al* (2013) finding, Farmers were used different types of sheep houses in burie district, northwestern Ethiopia. Sheltering sheep in the main house was predominant in the area (58%) followed by sheep houses constructed attached to the main house (33%). Separately constructed sheep house (9%) was also found in the area. Sheep houses were made of locally available materials. The types of materials used for wall construction of sheep houses were different between the highland and the lowland kebeles. The wall was usually made of eucalyptus tree wood in the highland kebeles and while lowland tree wood is used in the lowland kebele. The wall was usually plastered with mud in the highland kebeles while plastering with mud in the lowland kebele was not usually common as the ambient temperature in the area is high. In all places, the roof is usually made of corrugated iron sheet (90%). The dominant floor type was usually earth during both the dry (70%) and rainy (52%) seasons. Wood and stone paving of floors was usually practiced during the rainy season when the floor gets moist and dirty. Wooden paved floors are better for sheep production. However, as it entails wood and labour for its construction it is not widely used in the area. In all places, sheep houses were well ventilated. This condition is important to remove heat, moisture and pollutants (ammonia) from the house.

### 2.6.4. Diseases

As reported by Tajebe Seare *et al* (2011) economic losses due to disease and parasites have quadruplet their effect further when factors such as feed shortage, poor management practices and environmental factors are prevalent. Shortage of feed and inadequate supplementary feeding were reported to be a major cause of livestock mortality and poor performances in highland agro-ecologies of southern and central Ethiopia (Desta Zerihun H. and G. Oba., 2004; Hassen *et al* 2010; Solomon Gizaw *et al*., 2010). Peste des petits ruminants (PPR), foot and mouth disease, pasteurellosis and anthrax are the most important diseases prevalent in Ethiopia, besides the same incidences of teniasis (tapeworm) helminthes problems and ecto-parasitic load (tick and mites) too are prevalent. Assefa Feleke *et al*., (2015), Yenesew Abebe et *al*., (2013), reported in southern Ethiopia major common diseases encountered in various flocks in order of significance were pasteurellosis, Pneumonia and internal parasites, which hamper performance of sheep.

## 2.7. Sheep flock structure

The flock structure or flock composition refers to the age and sex profile of the flock i.e., the relative numbers of sheep with respect to age and sex. The flock structure of lamb and ewe was higher in the dega than weyna dega. This might be attributed to the prevalent practice of keeping ewe for breeding purpose, which accounted the greater portion of the newly born animals, but rams are either castrated or sold when they reach market age (Mengistie Taye *et al*., 2010 and Fsahatsion Hailemariam *et al*., 2013). Proportionally fewer younger males than females (< 1 year of age) of the same age were found in all flocks. Such disparities may arise from early disposal of male lambs. Breeding rams (1 to 5 year old) were only about 1.3%, 0.28%, 0.68% and 4.3% of the respective total flocks in Afar, Bonga, Horro and Menz, respectively. This clearly indicates that there is critical shortage of breeding rams in Bonga and Horro flocks (Gemeda Duguma, 2010). Similarly, Zewdu Edea (2008) also reported that there is critical shortage of breeding rams in both Bonga and Horro flocks. The absence of enough number of breeding rams in the flocks may negatively influence reproductive performances of breeding ewes. It has been also observed from the proportions of ewe lambs (those younger than 1 year) and those of between 1 and 2 year of age, that relatively high off-take rates are practiced for those younger than 1 year of age. This means only a small proportion of ewe lambs are retained for replacement and most of them are disposed before they reach breeding age (Gemeda Duguma, 2010). The average holding of sheep per household in Ethiopia ranges between 3.7 (Yenesew Abebe, 2010) to 31.6 (Getachew Tadesse *et al.* 2010).

## 2.8. Breeding practices of sheep in Ethiopia

### 2.8.1. Mating system and sources of breeding rams

According to Zewdu Edea *et al*. (2012), mating is predominantly uncontrolled in the study area Adiyo Kaka (Southern Nations, Nationalities and Peoples' Regional State of Ethiopia) and Horro (Oromia Regional State of Ethiopia) districts. Out of 229 HHs, about 56.3% and 29.6% kept their own breeding males in Adiyo Kaka and Horro, respectively. When breeding males is not reared in their flocks, the 93.5% of Adiyo Kaka farmers and 34.5% of Horro farmers got the service from neighbors' or communal rams. In areas where families mix sheep in communal flocks like in Horro, mating is take place at random. The majority (75.8%) of breeding rams for farmers in Horro is originated from own flock and 24.2% is purchased from market and for Adiyo Kaka, about 84.2% of the rams is born in the own flock and 15.8% is purchased from market. Males are kept until about two years of average with the range of 1 to 4 years for Adiyo Kaka and 1 to 8 years for Horro.

### 2.8.2. Selection of breeding sheep and trait preferences

According to Solomon Gizaw *et al* (2010), results show that farmers do select their breeding stock (e.g.93% select rams in Menz region), using subjective selection criteria. An investigation on Menz sheep farmers breeding practice Solomon Gizaw *et al* (2011a) showed that the failure to achieve controlled mating hinders genetic improvement in village flocks.The Selection criteria are different between sexes. For example, for males, appearance (Getachew Tadesse, 2008), body size (Zewudu Edea *et al*., 2012), tail type, color and height (Solomon Gizaw, 2008) are given emphasis during selection. On the other hand, rams with black color, poor body condition and small size are not preferred for breeding purpose and male animals of such character are usually culled at a young age, sold, or slaughtered at home. In selecting ewes appearance, coat color and lamb survival (Getachew Tadesse, 2008; Negussie Fasil et *al*., 2013) and liter size and lamb growth (Gemeda Duguma *et al*., 2011) were reported as the most important selection criteria. And those of which are black colored, old aged, poor conditioned and those having long lambing interval are culled (Zewudu Edea *et al*., 2012 and Yenesew Abebe *et al*., 2013). Despite the variation in production system and sex, the small ruminant selection criteria in Ethiopia usually focused on a single market driven trait, like fast growth rate, to produce sheep and goats that can fetch higher market price (Arse Gebeyehu *et al*., 2013; Negussie Fasil et *al*., 2013; Ahmed Seid *et al*., 2015; Alubel Alemu, 2015; Gebreselassie Tsigabu, 2015; Zergaw Netsanet *et al*., 2016).

Milk yield and meat production was the most preferred traits in pastoral and agro-pastoral areas (Getachew Tadesse, 2008; Zewdu Edea, 2008; Belete Shenkute, 2009 Kahsa Tadel Gebre, 2009; Getachew Tadesse *et al.*, 2010; Solomon Gizaw *et al.* 2010; Alefe Takele, 2014; Misbah Feki and Berhanu Belay, 2016). According to Aynalem Haile *et al*. (2011), the adaptive attributes that small ruminants would assume were not considered in the improvement programs and not captured in the economic analysis. This might lead to genotypes that are neither well adapted to the environment nor capable of performing multiple roles. Mengistie Taye *et al.* (2010); Assen Ebrahim and Aklilu Hailemichael (2012); Fsahatsion Hailemariam *et al*. (2013) and Solomon Abegaz, (2014) reported that Social and cultural functions were ranked as other important aspects of small ruminant production. Identification of the selection criteria of farmers and their breeding objectives, in a particular production system and environment, is very crucial to design and implement effective small ruminant genetic improvement programs (Jaitner J. *et al*., 2001; Jimmy S. *et al*., 2010; Maria Wurzinger *et al*., 2011; Niggusie Fasil *et al*., 2013).

## 2.9. Sheep Marketing

Sheep rearing is one of the main cash income sources for the farmers in most of our country as reported by (Yenesew Abebe *et al*., 2013). Farmers sell their sheep to anyone who pays an acceptable price and the buyers are mainly other farmers, traders and final consumers. According to Solomon Gizaw *et al*, (2012) Yearlings of both sexes are sold to market when farmers are in need of cash. According to Estefanos Tadesse *et al*. (2015), about 72.5 % of sheep marketing was based on visual estimation of the weight and on the traditional evaluation of condition score of the sheep while 21.7% of sheep markets were based on live weight using scales. The remaining, 5.8 % of sheep marketing uses both live weight and estimation. In terms of marketing channels, there were primary markets, secondary markets, tertiary markets and terminal markets. The primary markets were mainly at the grass roots while the terminal markets were mainly in the major urban centers (Katiku.P, *et al*., 2013). It was observed that there were no clearly designated primary market yards where farmers could sell their livestock. Berhanu Gebremedhin *et al.* (2015) reported most of small ruminant sold at district market. According to Yenesew Abebe (2010) in Burie woreda, west Gojjam reported that one household sold on average 1.1 heads of sheep per year. The buyers on the market places are mainly farmers (56%), hotel and other food catering owners (21%), civil servants (13%), sheep traders (3%) and others (7%). Berhanu Gebremedhin *et al*. (2015) in highland of Ethiopia reported 62% of farmers buy small ruminants for reproduction purpose, 14.4% for household consumption and 13.8% for trading. Farmers usually sell their sheep and goat during Easter, New Year and Christmas. During this period the demand for sheep increases thereby resulting in steep rise in market prices of sheep. The male animals are either sold or slaughtered for home consumption during festivals. The study of Yenesew Abebe *et al*. (2013) in Burie district, northwestern Ethiopia indicated that, both young ram and ewe lambs aged 6 month to 1 year mostly sold. Farmers sold their animals when they needed cash for home consumption, to pay loan/children's school fees, at time of crop failure or drought and because of difficulty in management (Belete Shenkute, 2009 and Ramesh.D *et al*., 2012).

### 2.10. Reproductive Performances of sheep in Ethiopia

Reproductive performance depends on the factors including age at first lambing, litter size, lambing interval and the lifetime productivity of the ewe, the last one being related to longevity (Sulieman et al., 1990; cited by Amelmal Alemayehu, 2011). As reported by Ermias Belete *et al*. (2014) funding the variations in performances of sheep in Ethiopia are aroused from within and between breeds, and across the agro ecologies. Therefore, it shows that there is a genetic potential and the poor performances also be improved by management of indigenous sheep.According to Mukasa-Mugerwa E. *et al.*, (2002) Poor reproductive performances of Ethiopian sheep can be associated with genetic factors, poor management, seasonal fluctuations in feed resources and diseases.

### 2.10.1. Age at first service/puberty

Ovulation rate is in turn dependent on age of the dam, level of nutrition, type of breed, season and dam body weight at mating (Mukasa-Mugerwa E. and Lahlou-Kassi A., 1995, 1995) and management system (Shigdaf Mekuriaw *et al*., 2013). According to Dhaba Urgessa (2013) and Solomon Gizaw (2007) the sexual maturity (puberty) in local sheep in Illu Abba Bora and Gumuz female sheep was reported to be 5-8 and 7.21 ± 1.75 months, respectively. Amelmal Alemayehu (2011) suggested that, age at sexual maturity (puberty) was 11.05±1.6, 10.88±1.7 and 9.5±1.4 months for males and 11.13±2.7, 10.8±1.9 and 9.5±1.4 months for females in Tocha, Mareka and Konta, respectively. Zewdu Edea (2008) reported that, age at first service for Bonga breeds were 7.51 ± 2.14 and 9.3 ± 2.2 months for males and females, respectively and for Horro breeds were 7.1 ± 3 and 7.8 ± 2.4 months for males and females, respectively. Age at puberty of male and female were reported to be 7.5 and 7.1 months for Bonga sheep 9.3 and 7.8 months for Horro sheep (Zewudu Edea *et al*., 2012). Age at sexual maturity for Afar ram lambs is 7.10 months under pastoral management (Solomon Gizaw *et al*., 2013). The average age of sexual maturity 7.1 months reported by Tesfaye Getachew (2008) for Afar rams. Assen Ebrahim and Aklilu Hailemichael (2012) reported age at sexual maturity 8.42 and 8.8 months for ram in high land and mid land of Tigray region, respectively.

### 2.10.2. Age at first parturition / Age at first lambing

According to Matawork Milkias Gobena and Mitiku Gebre Tona (2017) the majority of studies report the age of first lambing for Ethiopian sheep within the range of 411-475 days.The average AFL of Ethiopian indigenous sheep breeds ranges between 11.5 and 23 months reported, (Zelalem Abate, 2016). Ewes under village management conditions in southwestern Ethiopia, demonstrated a mean age of 404 days at first lambing (Berhanu Belay and Aynalem Haile, 2009). The same pattern was found for Afar sheep under pastoral management as reported by (Solomon Gizaw *et al*., 2013). According to Ermias Belete et al. (2014) funding age at first lambing varied by location and season. The mean average age at first lambing of Dorper sheep was 11.81 months which were comparable with the previous reports of 12 months (Teklebrhan Tsegay *et al*., 2013) in Ethiopia and 11.5 months of ewe sheep of Dorper (Fourie PJ *et al*., 2009). There is micro difference existed due to difference in production systems and climate. According to Fsahatsion Hailemariam *et al*. (2013), the average age at first lambing (AFL) was 12.4 months in Gamo gofa Zone, Southern Ethiopia. Mesfin Lakew *et al*. (2014) reported average AFL of 18.10 months at eastern Amhara region and Yisehak Kechero *et al*., (2013) reported AFL of 15.90, 15.85 and 15.63 months in Seka, Mana and Dedo districts of Southwestern Ethiopia respectively.

### 2.10.3. Parturition interval (Lambing Interval)

According to Amelmal Alemayehu, (2011) the interval between two successive parturitions is called lambing interval and it can be affected by season of lambing or nutritional accessibility, breed and number of parity of ewes and management practice. As reported by Zelalem Abate, (2016) average LI for indigenous sheep breeds is between 6.6 and 13.6 months. Under on-farm management system, first lambing and lambing interval of local sheep breeds occurs at 13.8±0.14 and 8.58±0.14 months (Helen Nugussie,*et al*., 2015), Zeleke Mekuriaw(2014) 12.7 and 7.8 months for local sheep breed respectively. A lambing interval of eight months is achievable in Ethiopian sheep. This means that Ethiopian sheep are capable of three lambing in two years, except where specific management systems are set otherwise. This interval is influenced by several factors, such as previous litter size, parity, and lambing season as reported (Mourad Rekik *et al*., 2016). Reproductive efficiency is related to the length of parturition interval; i.e. ewe with long lambing interval has lower reproductive efficiency as reported by (Deribe Gemiyu, 2009). At least three times lambing is expected per two years under normal circumstances as reported (Girma Abebe, 2008). Breeds of sheep in Ethiopia that had short lambing interval are Menz (8 and half months) and Afar sheep (9 months) as reported by (Tesfaye Getachew, 2008). According to Zewdu Edea (2008), lambing interval was around 8.9 months for Bonga ewes and 7.8 month for Horro ewes. Solomon Gizaw (2007) reported a lambing interval of 6.64 months for Gumuz breed which could reflect that the breed can produce three lambing in two years even under the traditional management system.

### 2.10.4. Prolificacy /Litter size/

Ermias Belete *et al*. (2014) reported, litter size mainly influenced by breed, level of nutrition, season and age extensively. Management system is the major source of variation in litter size as reported by (Shigdaf Mekuriaw *et al*. 2013). Litter size (LS), a trait largely determined by ovulation rate, was reported to be between 1.02 and 1.51 for indigenous Ethiopian sheep (Zelalem Abate, 2016). According to Tsedeke (2007) funding the average litter size was estimated to be around 1.70 per ewe for Arsi-Bale sheep, but the litter size per ewe of Menz and Washera sheep is around 1.11 (Mengistie Taye *et al*., 2010). The average litter size was reported by Fsahatsion Hailemariam *et al*. (2013) in the traditional sheep, breeding practice in the Gamogofa Zone of Southern Ethiopia was 1.3 (130%) lambs per head. Mukasa-

Mugerwa E. *et al.* (2002) reported 1.13 (113%) for Menz and 1.14 (114%) for Horro Ethiopian highland sheep. Hundie Demissu (2015) reported, average litter size per ewes were 1.57±0.52 (157%) in Western Ethiopia Horro Guduru area.

### 2.10.5. Reproductive life span and life time lamb crop

Early maturing females are known to have a relatively long and fruitful reproductive life. Similarly, total lifetime production (lifetime lamb crop) can be increased by encouraging first lambing at an early age (Amelmal Alemayehu, 2011). Zewdu Edea (2008) reported that, the average reproductive life span of Horro and Bonga ewes were 7.9 ± 3.1 years and 7.4 ± 2.7 years, respectively. Based on the report of Solomon Gizaw (2007), reproductive life span of Gumuz breed is (8.5 years for ewes and 3.67 years for rams). According to Amelmal Alemayehu (2011) the average reproductive life span of Tocha, Mareka and Konta local ewes were 9.17±1.70, 9.82±1.51and 9.28±1.62 years, respectively. Results of the study for local ewe produce on average 8.57±3.7 (Tocha), 8.62±4.1 (Mareka) and 10.78±4.7 (Konta) lambs in her life time (Amelmal Alemayehu, 2011).

## 2.11. Characterization of Animal genetic resources

Characterization of animal genetic resources encompasses all activities associated with the identification, quantitative and qualitative description and documentation of breed populations, their natural habitats and production systems to which they are or are not adapted to (FAO, 2007). Characterization is typically differentiated into two categories; phenotypic characterization and molecular characterization (FAO, 2015).

### 2.11.1. Phenotypic Characterization

The term phenotypic characterization of animal genetic resources generally refers to the process of identifying distinct breed populations and describing their external and performance characteristics within a given production environments. Phenotypic characterization is used to identify and document diversity within and between distinct breeds, based on their observable attributes (FAO, 2012a).

## 2.12. Body weight and linear body measurements

Zewdu Edea, (2008) suggested that, for breeding (selection), feeding and health care and for market age determination knowing the body weight of a sheep is important. However, this fundamental knowledge is often unavailable for sheep in the small scale farming sector, due to unavailability of scales. According to Mengsite Taye *et al* (2011), Farta sheep is short fat tailed. 67% of males and 10% of females were horned. The overall mean body weight, wither height, heart girth, body length and pelvic width obtained were 25.8±0.26 kg, 63.6±0.31 cm, 70.4±0.38 cm, 55.4±0.30 cm and 12.7±0.11 cm, respectively. Fixed effects age and sex had affected all the traits considered. Male and older age sheep were consistently larger for all the traits over female and younger sheep respectively. Solomon Abegaz *et al* (2011) reported, Gumuz sheep is a thin-tailed shorthaired sheep. The mean mature body weight (kg) obtained was 31.4 and 34.6 for females and males, respectively. The average body length (cm) obtained were 67.0 and 68.3, height at wither (cm) were 63.6 and 67.3 and chest girth (cm) were 76.1 and 78.0 for mature females and males, respectively.

## 2.13. Morphological indices

The indices are considered an option for assessment of weight because they incorporate measures of desirable conformation, namely, length and balance according to Alderson GLH

(1999). Salako AE (2006) suggested that indices that are obatined from linear body measurements that are more appropriate for assessment of type. Production performances especially in function of meat production can be assessed from body measurements such as chest girth, body length, chest width, rump width and chest depth,which are more closely associated with bone or muscle growth. Structural indices are important for the prediction of milk and meat production performance and indices are important to predict animal performance in terms of fitness good respiratory system and in terms of animal's gravity center and balance (Chacón E, *et al.* 2011). Chiemela PN, *et al*. (2016) suggested that Structural indices were combinations of several linear measurements or morphometric measurement, the results of which are expressed as a percentage and indicate the type and function of a particular breed.

### 2.14. Carcass components of sheep

Shashie Ayele amd Mengistu Urge, (2019) stated that, dressing percentage (DP) is an important measure of the potential yield of meat from an animal. According to Berhe, (2010) the dressing percentage and carcass weights of Ethiopian sheep were to be 42.5% and 11.0 kg and Wood J.D *et al*. (2010) reported that, 55.55% and 18 kg from Bristol, respectively. Moreover, Berhe (2010) indicated that average carcass weight of Ethiopian sheep was 10-12 kg. Sandip Benerjee (2011) reported, that the dressing percentage of the Shahabadi Sheep ewes were 39% from India. Tesfaye Getachew *et al*. (2011) result indicated that, the carcass weight of Washera sheep for feedlot growth were 16 kg. Based on Yadete Getahun Kebede (2014), Ahmed, Seid *et al* (2012), Mohammadi, A.R.*et al* (2011) HCW for Afar sheep were 9 - 12kg, 7 – 11 kg and 9 - 10 kg respectively when they fed various types of basal and supplement feeds. According to the Assefu Gizaw (2012) increased proportion of concentrate from 30 to 50% improved hot carcass weight (HCW) from 7.5 to 9.0 kg and 7.7 to 8.6 kg in

Washera and Horro lambs, respectively. The carcass production potential of indigenous sheep in Ethiopia is between 7 to 18 kg/head (Shashie Ayele amd Mengistu Urge, 2019) and increased as supplement level increases. Horro sheep fed different types of supplement produced 8 to 9 kg HCW (Assefu Gizaw, (2012). The use of concentrate mixture (50% WB, 30% maize, 20% cotton seed cake) supplement with basal diet of natural pasture hay can yield about 15 kg HCW by Horro sheep (Kassahun Awgichew, 2000). The HCW recorded for BHO sheep fed urea molasses and urea Attela blocks is about 5 to 7 kg (Geaush Fesaha 2011).

According to Abebe Girma and Yoseph Mekasha, (2015), Arsi-Bale sheep supplemented with 200 to 400 g/day concentrate mix to urea treated barley straw basal diet had produced HCW between 8 to 10 kg. Higher HCW (13 kg) has been reported for one and half-year BHO sheep fattened for three months following a growth experiment of 90 days (Facil *et al*., 2015). Hararghe Highland (HH) sheep fed grass hay and supplemented with sole wheat bran or its mixture with safflower seed cake had HCW of 9 to 10 kg (Tagaynesh Alemayoh, 2014). urea treated wheat straw as basal diet supplemented with Ensete ventricosum, Atella and their mixture fed to Adilo sheep result in 6 - 8 kg HCW (Girma Hailu *et al*, 2014).

Wilson, R.T. (1992) rervied that feeding is one of the most important factors to influence meat production and carcass quality of small ruminants.

According to the review by Ruvuna, F et al. (1992) dressing percent is known to be affected by breed, age, castration and it is also highly affected by feeding and degree of fattening. Ewunetu Ermias et al. (2006) studied the effect of breed on some carcass and non-carcass components of Horro and Menz sheep of Ethiopia. According to the authors, the two breeds had similar slaughter and carcass weights but have significantly different DP as slaughter body weight basis, which were 40% for Horro and 41% for Menz and the difference was ascribed to the higher gut fill in Horro sheep. The two breeds also significantly differ in edible non-carcass components, which were 4.3 kg for Menz and 4.6 kg for Horro sheep. These estimates represent about 21% and 23% of empty body weight in the Menz and Horro breeds, respectively. In another study, DP (SBW basis) of 49% and 48% has been recorded for Menz and Horro sheep, respectively in a trial compared the two breeds Kassahun Awgichew (2000) but the result of the study did not show significant breed difference for DP since the higher SBW is offset by higher gut content in Horro sheep.

As reviewed Shashie Ayele amd Mengistu Urge, (2019) the DP estimated for Ethiopia sheep ranged between 34% and 49% and 44% and 60% SBW and EBW basis, respectively.

# 3. MATERIALS AND METHODS

## 3.1. Description of the Study Areas

The study was conducted in two districts of Gabi rasu Zone in Afar regional state. Gabi rasu Zone is one of the five Zones of the Afar Region of Ethiopia. This zone is bordered on the south by the Oromia Region, on the southwest by the Amhara Region, on the west by the Administrative Zone 5, on the north by Administrative Zone1, and on the east by the Somali Region. This Zone consists of six administrative districts and one town (zone pastoral administration).The two target districts, Gela'alo and Gewane were among the six districts of the zone in Afar Region.

**Gewane**

Gewane is situated at an altitude ranging from 550 to 650 m.a.s.l., longitude 40° 38′ 43″ E and latitude 10° 9′ 59″ N. The capital of the district is Gewane, which is located at about 350 km from Addis Ababa and 150 km from Semera (the capital city of Afar regional state). The annual mean maximum and minimum temperature of the district is $48C^0$ and $27C^0$, respectively and averagely 37.5 $C^0$. The annual mean rainfall of the district ranged from 800 to 200 mm, average 500mm. The main rainy season of the district is between June to September (long rainy season), short rainy season from March to April, and dry season lasts from October to February and May. The district has ten kebeles. Agroecological zone of the district is low land (500-1500 m.a.s.l).Topographically the district consists of plain (93%), mountain (3%), plateau (2%) and swampy (2%). Gewane district encompasses human population of male 19316 and female 15315 total 34631.The study district has a total of 118720 cattle, 85000 sheep, 132142 goats, 6630 donkeys, and 72000 camels. The production system or farming system of the district is 82% pastoralism and 18% agro-pastoralism (Gewane pastoral Office).

**Gela'alo**

Gela'alo is situated at an altitude ranging from 540 to 660 m.a.s.l., longitude 40° 30′ 0″ E and latitude 10° 20′ 0″ N. The capital of the district is Gela'alo, which is located at about 320 km from Addis Ababa and 180 km from Semera (the capital city of Afar regional state). The annual mean maximum and minimum temperature of the district is 41C$^0$ and 38C$^0$, respectively and averagely 39.5C$^0$. The annual mean rainfall of the district ranged from 450 to 500 mm, average 475mm. The main rainy season of the district is between Julys to September (long rainy season), short rainy season from March to April, and dry season lasts from October to February and May. The district has fifteen kebeles. Agro-ecological zone of the district is low land (500-1500 m.a.s.l).Topographically the district consists of plain (94%), mountain (4%) and plateau (2%). Gela'alo district encompasses human population of male 20718 and female 19128 total 39846.The study district has a total of 160857 cattle, 164387 sheep, 142740 goats, 12193 donkeys, and 54496 camels. The production system or farming system of the district is 89% pastoralism and 11% agro-pastoralism (Gela'alo pastoral Office).

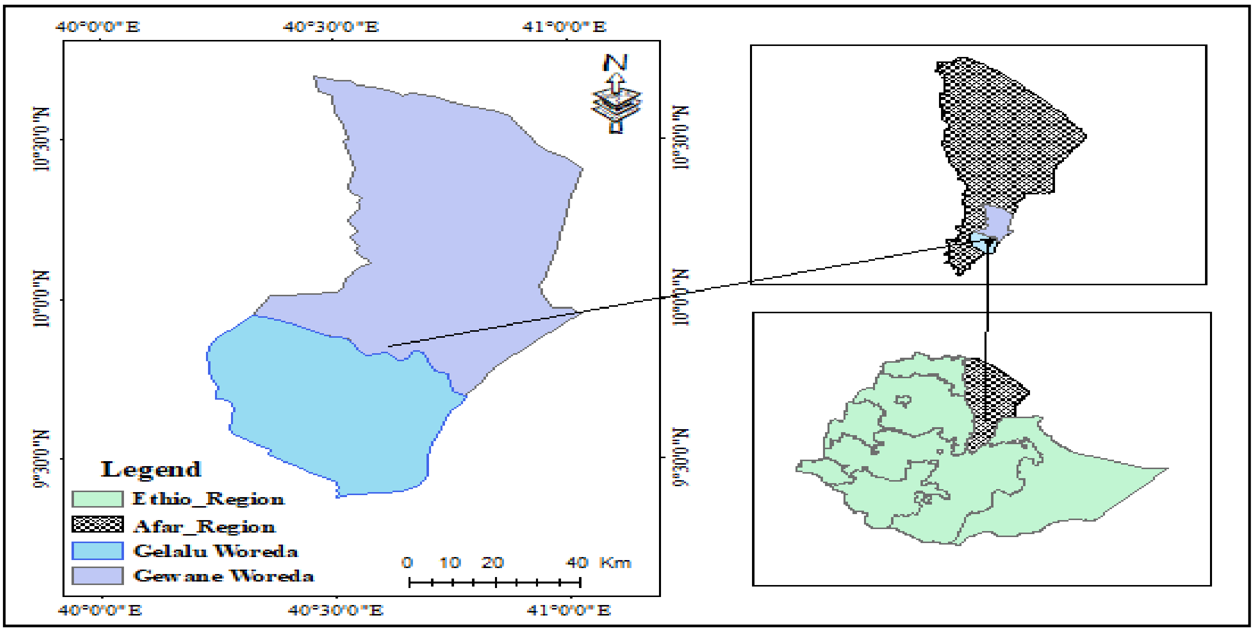


Figure 1Map showing the location of study districts within the region

**Sampling Procedures and sample size determination**

Study sites were selected purposively based on the distribution of sheep population and accessibility of sites. Based on this approach, two districts (Gela-alo and Gewane) were identified. Thereafter, three Kebeles (the smallest administrative unit within district) were randomly selected in each district and then, the households rearing Afar sheep were selected randomly within the Keble. A total number of 180 households (90 from each district) who possess at least three (3) 1 to 4 pairs of permanent incisors and above sheep (of both the sexes) with pertinent experience in sheep rearing for at least three years were selected randomly. The sample size of households was determined according to the Arsham (2002) using the following formula: $N=0.25/SE^2$; Where: N= Sample size; and SE= Standard error (0.0373) with 95% confidence level.

## 3.2. Data collection techniques

### 3.2.1. Questionnaire and group discussion

In depth interview, group and individual discussions with the key informants and concerned officials in the districts were carried out to have an overview about the overall livestock production system in general and particularly on prevalent sheep production system in the study area. Then a preliminary survey was carried out in the selected kebeles of each district to assess information prior to the questionnaire preparation to be used for the formal survey. A semi-structural questionnaire was then developed and administered to sample households. Data on the flock demography, socio economic and husbandry practices flock size and composition, and the flock demography (over the last decade) were collected from each selected households. Moreover, pertinent information was collected on the main uses and special attributes of the sheep type. The traits used for selecting the ewe and rams was identified and recorded. The study further assessed the breeding system and sheep reproductive performance using the semi-structured questionnaire. The major sheep production problems in the study area were assessed. Moreover, secondary data was collected from the district and zonal offices of pastoralists. Training also was organized for the development agents of the PA selected from each district to acquaint them with the questionnaire.

### 3.2.2. Qualitative traits data collection

Visual appraisal regarding the qualitative traits was assessed and morphological characteristics descriptor list of FAO (2012) pertaining to the phenotypic characterization.

Each animal was identified by its sex and sampling site.The qualitative characteristics of traits (coat color pattern, coat color type, hair type, horn presence, horn shape, horn orientation, ear orientation, facial (head) profile, wattles, ruff, Fiber type, Tail type, Tail shape, and rump profile) was observed and judged.

### 3.2.3. Quantitative traits data collection

A measurement of morphological characters, based on FAO (2012) morphometric descriptor was recorded. The measurements were taken on the sheep across the sex and age group.The linear measurements were taken using measuring tape while the body weight was taken using suspending balance having 50 kg capacity with 0.2 kg precision. The body weight was taken in the morning after overnight fasting (FAO, 2012). Pregnant ewes were excluded from sampling. The quantitative traits recorded were: body weight (BW), body length (BL), heart girth (HG), tail length (TL), height at wither (WH), rump height (RH),rump length (RL), rump width (RW), chest depth (CD), chest width (CW), head length (HL), head width (HW), ear length (EL), canon bone circumference (CC), tail circumference (TC), canon bone length (CL), shine circumference(ShC), scrotum circumference (SC) and teat length (TtL).

### 3.2.4. Carcass evaluation

A total number of 30 sheep (15 rams and 15 ewes) were sampled for evaluating the carcass components of the sheep. The sampled sheep were fastened over night and weighed before slaughter. Slaughtering was accomplished by severing the jugular vein and the carotid artery with knife for carcass evaluation. The rams and ewes were suspended with head down. Skin was carefully flayed to avoid attachment of fat and muscle tissues to the skin and then weighted without head,feet and the feet below fetlock joints. Then, the non-edible offal components (head with tongue, skin, spleen, tests with penis, lungs with trachea) and the edible offal and other carcass components (kidney, heart, liver, neck,shoulder with thorax,forelegs,hindlegs,lumbar,spinal cord,loin and flank,tail) were weighed, recorded and documented separately. Then dressed or eviscerated weight, hot carcass weight (HCW) and dressing percentage (DP) were determined individually. Dressed or eviscerated weight was recorded as the difference between pre-slaughter weight and gut contents. HCW was estimated after removal of weight of head, skin, abdominal and pelvic cavity contents as well as legs below the hock. Dressing percentage as proportions of hot carcass weight to pre-slaughter weight and dressed or eviscerated weight was computed for both male and female as follows;

$$\text{Dressing percentage pre-slaughter weight basis} = \frac{\text{Hot carcass weight}}{\text{Pre- Slaughter body weight}} \times 100\%$$

### 3.3. Data management and Analysis

All the collected data were double-checked for any types of errors occurred during data collection process. All data were coded and recorded in Microsoft excel sheet 2013. The qualitative data were analyzed using descriptive statistics (SPSS version 20) for male and female sheep separately. Percentage was compared across districts using non-parametric tests (chi square test). General linear model (GLM) procedures of SAS (version 9.0) was employed to analyze the quantitative traits by fitting district, sex and age as main independent variables. To analyze the body weight and linear body measurements except scrotum circumference and teat length (which were analyzed without sex effect), the following model was used:

$Y_{ijk}= \mu+A_i+S_j+D_k+e_{ijk}$, Where:

$Y_{ijk}$= the observation of body weight and LBMs in the $i^{th}$ age, $j^{th}$sex and $k^{th}$district

$\mu$= overall mean

$A_i$= the fixed effect of $i^{th}$age group (I = 1PPI, 2PPI, 3PPI, 4PPI)

$S_j$= the fixed effect of $j^{th}$ sex (j = female and male)

$D_k$= the fixed effect of $k^{th}$district (K =district 1 and 2)

$e_{ijk}$= random residual error

Correlations of live body weight with linear body measurement were computed using Pearson correlation coefficient. Stepwise regression procedure of SAS (V9) was used to regress body weight for male and female within each age group 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 estimation of body weight from linear measurements;

**For male:**

$Y_j = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 \ldots + \beta_n X_n + e_j$ Where:

$Y_j$ = the dependent variable body weight; $\beta_0$ = the intercept; $X_1$, $X_2$ , $X_3$ , $X_4$ , $X_5$, $X_6$, $X_7$ and Xn are the independent variable BL, HG, HW, HR,CD,CW, RL,RW,TC,CC,SC… Etc.

$\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$, $\beta_5$, $\beta_6$, $\beta_7$ and βn are the regression coefficient of the variable $X_1$,$X_2$ , $X_3$, $X_4$, $X_5$, $X_6$, $X_7$ and, $X_n$

$e_j$ = the residual error

**For females**

$Y_j = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 \ldots\ldots + \beta_nX_n + e_j$ Where:

$Y_j$ = the dependent variable body weight; $\beta_0$ = the intercept; $X_1$, $X_2$ , $X_3$ , $X_4$ , $X_5$, $X_6$, $X_7$and $X_n$ are the independent variable BL, HG, HW, HR,CD,CW, RL,RW,TC,CC,SC……..Etc.

$\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$, $\beta_5$, $\beta_6$ and $\beta_n$ are the regression coefficient of the variable $X_1$, $X_2$, $X_3$, $X_4$, $X_5$, $X_6$, $X_7$ and $X_n$

$e_j$ = the residual error

**Calculation of ranking indexes**

Rankings were calculated to provide ranking of the purpose of keeping sheep, categories of sheep to be fatten, classes of sheep sell in case of cash needed, selection criteria and major constraints of sheep production. Index=sum of (3 × values of rank 1 + 2 × values of rank 2 + 1 × values of rank 3) given for an individual attribute divided by the sum of ( 3 × values of rank 1 + 2 × values of rank 2 + 1 × values of rank 3) for overall attributes (Belete, 2013; Yaekob et al 2015).

**Computing structural and functional body indices**

Sixteen structural and functional indices were also calculated according to the methods suggested by Salako AE (2006) and Chacón E, *et al* (2011) to assess the type and function of the breed of sheep.

Height slope = Height at withers – Rump height

Cephalic index = Head width / Head length * 100

Body index = Body length / Chest girth * 100

Pelvic index = Rump width / Rump length * 100

Relative depth of thorax = Chest depth / Height at withers * 100

Width slope = Rump width/Chest width

Proportionality = Height at withers/ Body length * 100

Balance = Rump length × Rump Width/ Chest Depth × Chest Width

Transversal pelvic index = Rump width /Rump height * 100

Longitudinal pelvic index = Rump length/ Rump height * 100

Relative body index or length index = Body Length /Height at wither

Dactyl thorax index = Canon circumference /Chest girth*100

Thoracic development = Chest girth/Height at wither

Body ratio = Height at wither/Height at rump

Relative canon thickness index = Canon circumference/height at wither * 100

Compact index = (Weight/Height at wither)

Data collected on carcass components were analyzed using the GLM procedure of SAS by fitting sex as main effects. Mean comparisons were made for variables tested significant at F-test using Duncan multiple ranges test. The following model was used:

$Y_i = \mu + S_i + e_i$ Where;

$Y_i$= response variables

$\mu$ = overall mean effect

$S_i$ = sex effect and

$e_i$ = random error

# 4. RESULTS AND DISCUSSION

## 4.1. General Household Information

One hundred eighty households (90 from each district and 30 from each Peasant Association [PA]) were considered for the household survey in the current study. The result of demographic and socio-economic characteristics of the households is presented in (Table 1).The overall households' age in the study area was 52.36 years. Which indicated that the sampled HHs might be had a better expriences in livestock production and management.The current finding was higher than the result of Mengistie Taye, *et al* (2016) that 40.89±11.2 in Doyogena district, Southern Ethiopia. The surveyed sample households ranged with in an age group of Males<15 yrs., Females<15yrs, Males>15yrs and Females>15yrs were revealed the overall results of 1.15, 1.38, 2.31 and 1.18 respectively. This showed that the study area community was with higher proportion of males greater than 15 years. In this study, male-headed household accounted for the largest proportion of the studied samples (respondents) throughout the study areas. Thus, the overall current finding was 76.6%, which may be due to less responsibility of females in the livestock production managements. The current result was slightly lower than that of Shigute Etalema and Anja Abera (2018) who reported (80%) in Misha Woreda, Hadiya zone and Belete Asefa *et al*. (2017) who reported (78.67%) in Bale Zone, Oromia Regional State. However, this report was lower than that of Helen Nigussie *et al*. (2015) who reported 90%, 92.2% and 88.9 % in pastoral, agro-pastoral and mixed crop-livestock system, respectively in Eastern Ethiopia, Jijiga and Shinile (Somali National Regional State), and east Hararghe (Oromia National Regional State) zones. Interviewed households in the study area had different educational backgrounds. The largest proportion of household heads was illiterate. The overall current finding was 67.5%, 20.6% and 11.9% of them were Illiterate, Writing and reading and Grade 1-8 respectively. This current study indicated that on average majority of small ruminant keepers in the study areas was illiterate followed respondents who writing and reading and attended primary school. Thus, this finding was disagree with that of Zewdu Edea *et al*.(2012) who reported Illiterate (22.8%), read and write (3.53%), primary school (70.2%) in Adiyo Kaka and in Horro districts respectively. All of the respondents' religion were Muslim.

Table 1Household characteristics of the study districts

| House hold | Gela'alo | Gewane | overall | P value |
|---|---|---|---|---|
| **Age(mean±SD)** | 49.93±7.10 | 54.79±5.79 | 52.36±6.91 | 0.00 |
| **Family size(mean±SD)** | | | | |
| Males<15 yrs. | 0.87±0.67 | 1.43±0.90 | 1.15±0.84 | 0.00 |
| Females<15yrs | 1.27±0.79 | 1.38±0.98 | 1.32±0.89 | 0.4 |
| Males>15yrs | 1.79±1.05 | 2.82±1.23 | 2.31±1.26 | 0.00 |
| Females>15yrs | 0.93±0.93 | 1.43±0.97 | 1.18±0.98 | 0.001 |
| | **%** | **%** | | **$X^2$** |
| **Sex** | | | | 0.275ns |
| Male | 75.8 | 77.4 | 76.6 | |
| Female | 24.2 | 22.6 | 23.4 | |
| **Marital status** | | | | 1.415ns |
| Married | 74.1 | 74.7 | 74.4 | |
| Widowed | 12.5 | 16.9 | 14.7 | |
| Divorced | 13.4 | 8.4 | 10.9 | |
| **Educational level** | | | | 6.162* |
| Illiterate | 69.7 | 65.3 | 67.5 | |
| Writing and reading | 14.3 | 26.9 | 20.6 | |
| Grade 1-8 | 16 | 7.8 | 11.9 | |
| **Religion** | | | | |
| Muslim | 100 | 100 | 100 | |

SD=standard deviation,$X^2$=chi-square value,* significant,ns=non significant

## 4.2. Livestock holding

The major livestock species in the study districts were Cattle, Sheep, Goats, Donkey and camels (Table 2). The largest average number of livestock possessed by the two districts was goat, sheep, followed by cattle. Because of the fact is that goat and sheep have short lambing interval, better drought tolerance and feeding behavior (browse),early market age and high economic value(income and milk). There was significant difference between districts in sheep population (P<0.05). The sampled respondents in Gewane had significantly higher number of sheep than Gela'alo district. The overall sheep flock size per household was 24.21, which is consistent with the report of Yenesew Abebe (2010) and Getachew Tadesse *et al*. (2010) that the average holding of sheep per household in Ethiopia ranges between 3.7 to 31.6. On contrast, the current finding was higher than that of finding of Mengistie Taye, *et al* (2010) with 9.58 of Washera sheep in the western highlands of the Amhara National Regional State and lower than that of Feyissa AA, *et al* (2018) reported 30.2, 25.4 in Pastoral and Agro pastoral areas of Borana lowland, Southern Ethiopia.

Table 2Average livestock species composition in Gela'alo and Gewane districts (Mean±SD)

| Livestock(head) | Gela'alo(N=90) | Gewane(N=90) | Overall | P-value | TLU |
|---|---|---|---|---|---|
| Cattle | 5.47±1.66 | 8.80±3.56 | 7.13±3.24 | 0.0001 | 5 |
| Sheep | 21.23±8.68 | 27.19±7.57 | 24.21±8.65 | 0.0002 | 2.42 |
| Goats | 23.70±8.07 | 33.36±9.01 | 28.53±9.81 | 0.00 | 2.9 |
| Donkey | 0.19±0.51 | 0.28±0.60 | 0.23±0.56 | 0.29 | 0.12 |
| camels | 3.25±1.90 | 3.53±2.05 | 3.39±1.98 | 0.35 | 4.75 |

SD=standard deviation, N=number of households, TLU=tropical livestock unit

### 4.3. Sheep flock Structure

The flock structure or flock composition refers to the age and sex profile of the flock i.e., the relative numbers of sheep with respect to age and sex. A total of 4396 sheep from 180 households were classified according to age and sex (Table 3). There was significant difference between districts (P<0.05) in all age and sex categories except castrated males.

The mean sheep flock size was higher for Gewane district than Gela'alo district. The flock structure of breeding ewe and lamb was higher in all districts of the study area as compared to other age classes. This is the practice of keeping ewe for breeding purpose, which accounted the greater portion of the newly born animals. The higher proportion of breeding ewes in the current study was in agreement with those of Mengistie Taye *et al*., (2010) and

Fsahastion Hailemariam *et al*., (2013) and Amare Berhe et al (2019). The breeding ewes were taken the major portion (57.6%) followed by lambs (18.6%) and ewe lambs (13.9%) and in Kafta Humera breeding ewes were dominant (59.2%) followed by lambs (29.5%) and ewe lambs (21.5%) of the western zone Tigray, Ethiopia. The overall current result of breeding males (2.8±1.32) in the study area was small in number. This is because of rams were either castrated or sold when they reach market age. This result was higher than that of Gemeda Duguma, (2010) reported 1.3, 0.28 and 0.68 in Afar, Bonga and Horro respectively. In the study area matured female greater than one year constitute 46.27 % of the whole sampled population while males of greater than one year or intact were 11.35% of the population. The present findings was lower than the finding of Getachew Tadesse, *et al*. (2010) 49.2% for Menz sheep breeding ewes. The ratio between matured male and matured female was 1:4.08. The result of this survey was lower than the report of Solomon Abegaz *et al* (2011) with 1:7 for Gumuz sheep,Amare Berhe et al (2019) with 1:13.9 in Setit Humera and 1:10 Kafta Humera for Begait sheep in western zone Tigray, Ethiopia and Tesfaye Getachew (2008) reported 1:17.4 for Afar sheep. On the other hand, this ratio was comparable with the report of Tadesse Abate *et al* (2017) with 1:4.2 in Bale Zone, Oromia Regional State.

Table 3Flock size and composition (Mean±SD)

| Sheep categories | Gela’lo | Gewane | Overall | P=value |
|---|---|---|---|---|
| lambs <6 months | 3.69±1.45 | 4.98±1.61 | 4.3±1.7 | 0.00 |
| male>1year(intact) | 2.36±1.21 | 3.19±1.30 | 2.8±1.32 | 0.00 |
| male 6 month to 1 year | 1.58±1.38 | 2.29±1.73 | 1.93±1.6 | 0.003 |
| female>1 year | 9.96±4.04 | 12.64±5.39 | 11.3±4.94 | 0.00 |
| females 6 months to 1 year | 3.24±1.89 | 3.99±2.41 | 3.62±2.19 | 0.02 |
| castrated male | 0.40±0.69 | 0.53±0.91 | 0.46±0.81 | 0.27 |

SD=standard deviation

### 4.4. Population trend in major livestock species

As indicated in (Table 4), majority of the households both in Gela'alo and Gewane districts reported a decreasing trend in Sheep, cattle, Goat and camel population (94.7%, 100.0%, 91.3%, 95.6% and 96.8%, 100.0%, 70.2%, 72.0%) respectively. The overall finding of present study for sheep, cattle, goat and camel population trend was 95.75%, 100%, 80.75% and 83.8% respectively. The main reasons of decreasing trend in livestock population in the study area might be due to drought, feed shortage and conflict. The present result was not in agreement with that of Amelaml Alemayehu *et al* (2015) who reported an increasing trend in sheep population 53.7%, 58.3 % and 86.4% in Tocha, Mareka and Konta districts respectively. In the other hand, the current finding was similar to the previous report of Amare Berhe *et al* (2019) who revealed decreasing trend of cattle, Sheep and Goats 75.4%, 53.9% and 89.4% respectively in the western zone of Tigray regional state, Ethiopia. However, according to the focal group discussion there was drought, feed shortage and conflict occurrence across the study area for the last decades, which was significantly affected on the livestock population trend.

Table 4. Population trend in major livestock species (%)

| species | Gela'alo | Gewane | Overall | $X^2$ |
|---|---|---|---|---|
| **Sheep** | | | | 0.206ns |
| decreasing | 94.7 | 96.8 | 95.75 | |
| stable | 5.3 | 3.2 | 4.25 | |
| **Cattle** | | | | |
| decreasing | 100 | 100 | 100 | |
| **goats** | | | | 14.07* |
| decreasing | 91.3 | 70.2 | 80.75 | |
| stable | 8.7 | 29.8 | 19.25 | |
| **camel** | | | | 20.68* |
| increasing | 0.00 | 1.1 | 0.55 | |
| decreasing | 95.6 | 72.0 | 83.8 | |
| stable | 4.4 | 26.9 | 15.65 | |

$X^2$=chi-square value,*significant, ns= non significant

### 4.5. Purpose of keeping Sheep

Table (5), showed the ranks of the sheep production purposes by smallholder households. The reasons for keeping sheep were related to the households’ needs in the long or short term. The results of this survey showed that sheep play multi-functional roles in all production systems with almost similar production purposes. The results indicated that the most importance of tangible benefits of sheep keeping were (such as income generation, meat consumption and milk consumption).The primary reason for keeping sheep in the study area was milk consumption with the index of (0.36, 0.30 and 0.34) milk, Meat and income for Gewane and (0.39, 0.27, 0.34) for Gellalo respectively. This result was in line with that of Getachew Terefe *et al*, (2010) reported that milk production from sheep was the primary objective of pastoralists in northeast Ethiopia (Afar). on contrast, the present finding was not in agreement with that of Helen Nigussie *et al*. (2013); Arse Gebeyehu, *et al*.( 2013); Alubel Alemu, (2015), Hundie Demissu and Geleta Gobena,( 2015) reported that the primary objective for keeping sheep in eastern Ethiopia was income generation followed by milk and meat production. Moreover, Alemitu Beyene and Abera Anjamain (2018) reported that the main reason of keeping sheep was to generate cash income and saving and none of the respondents was used as source of milk in Sodo Zuria District Wolaita Zone Southern Ethiopia.

Table 5. Purpose of keeping sheep in the study area (top three)

| Purpose | Gewane | | | | Gellalo | | | |
|---|---|---|---|---|---|---|---|---|
| | R1 | R2 | R3 | **Index** | R1 | R2 | R3 | **Index** |
| Milk | 34 | 56 | 0 | **0.36** | 62 | 22 | 0 | **0.39** |
| Meat | 0 | 0 | 90 | **0.3** | 0 | 1 | 83 | **0.27** |
| Income | 55 | 28 | 0 | **0.34** | 28 | 51 | 1 | **0.34** |

Index=sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each variable divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all variables, R= rank

### 4.6. Husbandry Practices

#### 4.6.1. Feed resources and feeding system

Available feed resources for sheep commonly used by pastoralists in the study area in different Seasons are presented in Table (6). The feed resources reported in all across the study areas were natural Pasture. According to the respondents in the study area, natural pasture (100%) from the communal rangeland were the main feed source for sheep in all seasons of production. The finding of the present study was in line with previous observations of Alemitu Beyene (2018), who reported that, small ruminant production was heavily dependent on grazing from natural grazing pasture in Esera District, of Dawro Zone, Southern Ethiopia.  The current result was also comparable with the report of Solomon Gizaw *et al*. (2010) that, in most production system of Ethiopia, extensive free grazing in communal lands, and stubble grazing were the most common practices of sheep feeding. None of the respondents have been practicing feed supplementation in the time of feed shortage. According to the focal group discussion and key informants during feed shortage the pastoralists were move their animal to the place where good feeds are available and to the bunks of Awash River.

Table 6. Available feed resources of sheep during different seasons (%)

| Feed sources | Gela'alo | Gewane | Overall |
|---|---|---|---|
| **Dry season** | | | |
| Natural pasture | 100 | 100 | 100 |
| Established pasture | _ | _ | _ |
| Hay | _ | _ | _ |
| Crop residues | _ | _ | _ |
| Fallow land | _ | _ | _ |
| concentrate | _ | _ | _ |
| **Wet season** | | | |
| Natural pasture | 100 | 100 | 100 |
| Established pasture | _ | _ | _ |
| Hay | _ | _ | _ |
| Crop residues | _ | _ | _ |
| Fallow land | _ | _ | _ |
| concentrate | _ | _ | _ |

### 4.6.2. Types of grazing land and ownership, Grazing method and herding

According to the respondents, communal grazing areas were decrease due to highly bush encroachment, conflicts and investments. All of the respondents (100%) practice free grazing and herding (free grazing with herding) across the study areas in dry and wet season. Length of grazing time during wet season and dry season across the study areas were practiced (almost similarly for the two seasons) full days grazing (morning 8:30 AM to 4:00PM afternoon) time. The current report was comparable with the literature review of (Fikru Sisay and Kefyalew Gebeyew, 2015). The respondents reported that, all of them were herd their sheep together with goats but separately from other livestock. The current report was not in agreement with the report of Mengistie Taye *et al.* (2016), that the most respondents (63.2%) in Doyogena district, Southern Ethiopia were herd their sheep flock with other livestock. Within flock of sheep, lambs were separated (retained at home).The reason is that the lambs in the herd were not able to graze or trekking long distance or wide area of the rangeland and for milk consumption of the households. This finding was in agreement with the finding of Bosenu Abera *et al.* (2014) in Selale Area, Central Ethiopia and comparable with finding of Alemitu Beyene, *et al* (2018) in Esera District, of Dawro Zone, Southern Ethiopia. Mixing of sheep flocks of several households was not practiced and they run their own flock.The current finding was disagreement with the report of Helen Nigussie *et al*., (2015) that about 70% of mixed crop livestock and 55.6% of agro-pastoral were practice mixing of flock of several household. The most common communal grazing land type in the study area was bush/shrub grassland, tree covered grassland and open grassland.

Table 7Grazing methods and herding of sheep in the study districts (%)

| Grazing method | Gela'alo | | Gewane | |
|---|---|---|---|---|
| | Wet season | Dry season | Wet season | Dry season |
| Free grazing | _ | _ | _ | _ |
| Herded | _ | _ | _ | _ |
| Paddock | _ | _ | _ | _ |
| Tethered | _ | _ | _ | _ |
| Zero grazing | _ | _ | _ | _ |
| Free grazing and herded | 100 | 100 | 100 | 100 |
| **Sheep flock herded** | | | | |
| lamps are separated | 100 | 100 | 100 | 100 |
| **Sheep flock is herded** | | | | |
| together with goats | 100 | 100 | 100 | 100 |
| **Way of herding** | | | | |
| sheep of house hold run as a flock | 100 | 100 | 100 | 100 |

Table 8Grazing land type and ownership in the study area

| types of grazing land(communal) | Gewane | | | | Gela'alo | | | |
|---|---|---|---|---|---|---|---|---|
| | RI | R2 | R3 | Index | R1 | R2 | R3 | Index |
| Open grass land | 2 | 33 | 55 | **0.28** | 13 | 73 | 4 | **0.36** |
| Tree covered grass land | 7 | 49 | 34 | **0.31** | 0 | 4 | 86 | **0.29** |
| Bush/Shrub grass land | 81 | 8 | 1 | **0.41** | 77 | 13 | 0 | **0.35** |
| Swampy grass land | 0 | 0 | 0 | **0** | 0 | 0 | 0 | **0** |
| Stone covered grass land | 0 | 0 | 0 | **0** | 0 | 0 | 0 | **0** |

Index=sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each variable divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all variables. R=rank

### 4.6.3. Sheep fattening

Sheep fattening was a common practice of in the study areas. The overall finding of fattening practice in the study area was 63.15%. All respondents (100%) across the study area were fatten sheep from their own flock for market and home consumption (fat-tail). The fattening practice was traditionally without providing supplementary (concentrate) feed. Among the sampled respondent, 12.85% of them were fatten in the summer (kerma) and 50.3% in the summer and autumn (kerma ke sugum) seasons of the year as per the availability of feed. The current result was not in line with the result that has been reported by Mengistie Taye, *et al*

(2016) in Doyogena district, Southern Ethiopia that the fattening was practiced 34.9% in the dry season, 17.9% in the wet season and 28.3% during any time of the year. The duration of fattening was 6.2%, 30.5%,20.9% and 5.6% for about one to two month, two to three month, three to four month and four months and above respectively. According to the current report castrated males were predominantly fattened followed by older male and young males.

Table 9Fattening practices of sheep in the study area (%)

| Parameters | Gela'alo | Gewane | Overall | $X^2$ |
|---|---|---|---|---|
| Do you practice fattening of sheep? | | | | 0.85ns |
| Yes | 61.7 | 64.6 | 63.15 | |
| No | 38.3 | 35.4 | 36.85 | |
| At which period of the year do commonly fatten sheep? | | | | 6.11ns |
| Summer(kerma) | 14.9 | 10.8 | 12.85 | |
| Summer and autumn(kerma ke sugum) | 46.8 | 53.8 | 50.3 | |
| Fattening duration | | | | 29.08* |
| One to two months | 9.1 | 3.3 | 6.2 | |
| Two to three months | 41.9 | 19.1 | 30.5 | |
| Three to four months | 9.6 | 32.2 | 20.9 | |
| Four months and above | 1.1 | 10.0 | 5.6 | |

$X^2$=chi-square value,*significant, ns= non-significant

Table 10 Categories of animal fattening in the study area ranked top three

| animal categories | Gewane | | | | Gella'alo | | | |
|---|---|---|---|---|---|---|---|---|
| | Rank1 | Rank2 | Rank3 | Index | Rank1 | Rank2 | Rank3 | Index |
| Culled young female | 0 | 0 | 0 | **0** | 0 | 0 | 0 | **0** |
| Culled young male | 0 | 0 | 0 | **0** | 0 | 0 | 0 | **0** |
| Young female | 0 | 0 | 0 | **0** | 0 | 0 | 0 | **0** |
| Young male | 0 | 33 | 12 | **0.24** | 0 | 11 | 23 | **0.21** |
| Castrated | 59 | 0 | 0 | **0.41** | 51 | 0 | 0 | **0.36** |
| Older males | 0 | 26 | 34 | **0.29** | 0 | 39 | 12 | **0.33** |
| Older females | 0 | 0 | 14 | **0.06** | 0 | 0 | 17 | **0.1** |

Index=sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each variable divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all variables.

### 4.6.4. Watering sources, distance and watering frequency

The main sources of water, frequency, and distance of water for sheep in the study are shown in the Table 11. As reported by the respondents, river was the major water source in dry and wet seasons in all the study districts. During the dry and wet season, the overall respondents provide water to their flock from tape water were 31.35%. The distances to watering points varied during the dry and wet seasons. The majority of the respondents (85.75%) trek their animals 1 to 5 km per day in search of water during the dry season, but during the wet season distance for 71.9 % of respondents were reduced to < 1 km. This result was similar to the finding of Mulata Hayelom (2013) that the majority of the respondents (86.67%) trek their animals 1 to 5 km per day in search of water during the dry season, but during the wet season distance for 96. 11% of respondents were reduced to < 1 km in southeastern and eastern zones of Tigray. During the dry season 100% of the respondents were watered their animals twice a day. In wet season, however, 53.65% of the respondents watered their sheep freely, 45.6% once a day and about 0.8% watered twice a day. Which indicated that watering frequencies were higher in dry season, which is related with less moisture content of the feed during dry season.The current report, was in agreement with the report of Alemitu Beyene, *et al* (2018) that in dry season 97.2% watered twice a day in Esera District, of Dawro Zone, Southern Ethiopia.

Table 11Available sources of water, distance and watering frequency of sheep (%)

| **Parameters** | Gela'alo | Gewane | Overall | X² |
|---|---|---|---|---|
| **Water source (dry season)** | | | | |
| River | 37.3 | 100 | 68.65 | 90* |
| Tape water | 62.7 | 0.00 | 31.35 | |
| **Water source (wet season)** | | | | |
| Bore hole or water well | 0.00 | 34.1 | 17.05 | 46.6* |
| River | 7.8 | 15.9 | 11.85 | |
| Tape water | 62.7 | 0.00 | 31.35 | |
| Rain water | 29.5 | 50 | 39.75 | |
| **Distance to nearest watering point(dry season)** | | | | 0.35ns |
| <1Km | 13.9 | 14.6 | 14.25 | |
| 1-5 Km | 86.1 | 85.4 | 85.75 | |
| **Distance to nearest watering point(wet season)** | | | | 9.46* |
| <1Km | 81.4 | 62.4 | 71.9 | |
| 1-5 Km | 18.6 | 37.6 | 28.1 | |
| **Watering frequency (dry season)** | | | | |
| Twice a day | 100 | 100 | 100 | |
| **Watering frequency (wet season)** | | | | 2.29ns |
| Freely available | 50 | 57.3 | 53.6 | |
| Twice a day | 0 | 1.6 | 0.8 | |
| Once a day | 50 | 41.1 | 45.6 | |

$X^2$=chi-square value,*significant,ns= non significant

### 4.6.5. Housing

All of the HHs across the study districts housed their sheep were during the night. Overall Sheep keepers were keep their sheep 78.6% in Kraal without shelter, 18.6% in yards and 2.8% house with roof at night in all seasons. The type of material used for wall construction of sheep houses were woods and branches of local available trees and the roofed houses were thatched with corrugated iron sheet. According to the present report, lambs were housed separately from adults for milk consumption and sheep were not housed together with cattle but with goats. Earth flooring was commonly used between the two study districts. On average, the current reports were not in agreement with the report of Assefa Feleke *et al.* (2015) in Doyogena diatrict, southern Ethiopia, Zelealem Tesfay Gebretsadik *et al*. (2013), in Northern Ethiopia and Yenesew Abebe *et al* (2013) in burie district, northwestern Ethiopia. In the contrast, the results obtained in this study were inconvenient with the previous finding of Helen Nigussie *et al* (2015) in agro-pastoral and pastoral production systems of eastern

Ethiopia and Belete Asefa *et al* (2017) in pastoral district of Bale Zone, Oromia Regional State, Ethiopia.

Table 12Housing system of sheep in the study areas

| house type | Gella'alo | Gewane | Overall | $X^2$ |
|---|---|---|---|---|
| With roof house | 0.00 | 5.6 | 2.8 | 31.81* |
| Kraal without shelter | 65.8 | 91.4 | 78.6 | |
| Yards | 34.2 | 3 | 18.6 | |
| Type of housing materials(roof) | | | | 5.14* |
| Iron corrugated sheet | 0.00 | 5.6 | 2.8 | |
| Type of housing materials(wall) | | | | |
| Wood | 100 | 100 | 100 | |
| Type of housing materials(floor) | | | | |
| earth | 100 | 100 | 100 | |
| Are lambs housed with adults? | | | | |
| no | 100 | 100 | 100 | |
| if no specify | | | | |
| housed separately | 100 | 100 | 100 | |
| Are sheep housed together with cattle? | | | | |
| no | 100 | 100 | 100 | |

$X^2$=chi-square value,* significant

## 4.7. Breeding practices

### 4.7.1. Source and purpose of keeping rams

About 95.45% of the respondents in the study area owned local breeds of rams and 4.55% had no breeding ram. This finding was not in agreement with that of Belay Duguma, (2013) who reported that about 26% of the respondents own their own breeding rams, while 74% of the respondents share breeding rams with their neighbors in Ilu Abba Bora Zone of Oromia Regional State, Ethiopia. The current observation was also similar to the report of Abegaze Beyene *et al*, (2018) that One hundred percent of the respondents owned local breeds of small ruminants in Esera District, of Dawro Zone, Southern Ethiopia. Across the study districts, the breeding rams (100%) originated from within the flock. The current result was similar to the previous finding of Getachew Terefe *et al* (2010) that the majority of the breeding rams (90%) in Menz and all the breeding rams in Afar were originated from within the Flock. In addition, the current result was disagreement with that of Manzoor Ahmed Kirmani, *et al* (2016) who reported that the majority of respondents were using neighbors ram for mating in the three AEZs of Ada Barga and Ejere Districts of West Shoa Zone, Oromia, Ethiopia. The mean ram ownership was 2.78±1.29. About (66.7%) of the sampled respondents were keep rams for breeding (male to female ratio), 20% for fattening/castrate and 0.55% for emergency in the study districts. All (100%) of ram owners were not given special management for the ram. The present findings were different from the finding of Mengistie Taye, *et al* (2016) who reported that about 47.2% of the respondent farmers own ram for breeding only (17%), fattening only (30.2%), breeding and fattening (27.4%) and breeding and prestige (1.8%).

Table 13Sources and purpose of keeping rams in the study districts (%)

| parameters | Gela'alo | Gewane | Overall | $X^2$ |
|---|---|---|---|---|
| Do you have crossbreed rams? | | | | |
| no | 100 | 100 | 100 | |
| Do you have local rams? | | | | 2.09ns |
| Yes | 93.6 | 97.3 | 95.45 | |
| no | 6.4 | 2.7 | 4.55 | |
| If yes, how many rams?(mean±SD) | 2.40±1.16 | 3.17±1.32 | 2.78±1.29 | |
| If more than one, why do you need to keep more than one rams? | | | | 8.07ns |
| male to female ratio | 68.6 | 64.8 | 66.7 | |
| fattening/castrate | 12.6 | 27.4 | 20 | |
| for emergency | 0.00 | 1.1 | 0.55 | |
| Is there any special management for breeding rams? | | | | |
| no | 100 | 100 | 100 | |
| Purpose of keeping rams | | | | |
| mating | 100 | 100 | 100 | |
| Source of ram | | | | |
| born in the flock | 100 | 100 | 100 | |
| If you do not have breeding ram, how do you mate your ewe? | | | | 20* |
| neighboring ram | 80 | 100 | 90 | |
| unknown | 20 | 0.00 | 10 | |

$X^2$=chi-square value,*significant, ns=non significant

## 4.8. Selection practices of sheep

### 4.8.1. Criteria of trait preferences of ram and ewe

About 92.8% and 73.4% of the pastoralists in the study area practices selection for breeding male and female respectively. Ranking of selection criteria of the pastoralists for their breeding rams and ewes are presented in Table 14. In selecting a breeding ram, appearance and/or conformation ranked first for both Gewane and Gellalo owners with an index of 0.42 and 0.36, respectively. In Gewane age, coat color, Growth and Dairy Character were ranked high with indices of 0.26, 0.23, 0.07, and 0.02, respectively. In Gellalo Color, Libido, Age, Dairy Character and Growth were ranked second, third, fourth, fifth and sixth important traits with indices of 0.28, 0.23, 0.08 , 0.04 and 0.02 respectively. The result obtained in the present survey was in line with the report of Belete Asefa *et al* (2017) where appearance was selected as the first criteria of selection in all of the study area of Bale Zone, Oromia Regional State, Ethiopia, Weldeyesus Gebreyowhens (2016) for Highland Sheep in Northern Ethiopia, Bosenu Abera, *et al* (2014) and Wossenie Shibabaw, *et al* (2014) who revealed that traits like appearance was the most considered characters in selection of rams in Selale area and East Hararge, respectively. In Gewane sheep breeders consider Milk yield, Lambing interval, appearance/confirmation, coat color, lamb Survival, Age at first sexual maturity and lamb growth as the important reasons for selecting breeding ewes with an index of 0.36, 0.22, 0.14, 0.13, 0.03, 0.02 and 0.1 respectively. On the other hand, Gellalo sheep breeders consider milk yield, lamb growth, appearance or conformation, lamb Survival, Color, Lambing interval, Age at first sexual maturity and Twining Ability as the important traits for selecting breeding ewes with an index of 0.32, 0.25, 0.17, 0.13, 0.08, 0.03, 0.02 and 0.01 respectively. The current finding was different with the reports of Manzoor Ahmed Kirmani *et al* (2016) that the body size was ranked first by farmers for selection of breeding ewes in all three Agro-ecological zones of the study area in Ada Barga and Ejere Districts of West

Shoa Zone, Oromia, Ethiopia. On the contrary, the current report was in agreement with the finding of Solomon Gizaw *et al*. (2010), Alefe Takele, (2014) and Misbah Feki and Berhanu Belay, (2016) who reported milk yield was the most preferred traits in pastoral and agro-pastoral areas.

Table 14Selection criteria for breeding rams and ewes in the study districts

| Selection Criteria Ram | Gewane | | | | Gellalo | | | |
|---|---|---|---|---|---|---|---|---|
| | R1 | R2 | R3 | Index | R1 | R2 | R3 | Index |
| Appearance/confirmation | 68 | 5 | 7 | 0.42 | 73 | 4 | 1 | 0.36 |
| Color | 3 | 27 | 30 | 0.23 | 3 | 39 | 24 | 0.28 |
| Character/Docile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Growth | 0 | 1 | 20 | 0.07 | 0 | 0 | 4 | 0.02 |
| Age | 4 | 42 | 16 | 0.26 | 0 | 6 | 14 | 0.08 |
| Libido | 0 | 0 | 1 | 0 | 2 | 28 | 24 | 0.23 |
| Dairy Character | 1 | 0 | 5 | 0.02 | 1 | 0 | 9 | 0.04 |
| Selection Criteria Ewe | | | | | | | | |
| Twining Ability | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.01 |
| lamb Survival | 0 | 0 | 6 | 0.03 | 4 | 5 | 15 | 0.13 |
| Appearance/confirmation | 12 | 10 | 7 | 0.14 | 4 | 13 | 13 | 0.17 |
| Color | 1 | 8 | 19 | 0.13 | 1 | 5 | 8 | 0.08 |
| Character/Docile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| lamb growth | 2 | 7 | 13 | 0.1 | 4 | 26 | 15 | 0.25 |
| Milk yield | 46 | 19 | 4 | 0.36 | 45 | 8 | 3 | 0.32 |
| Ageatfirstsexual maturity | 0 | 0 | 4 | 0.02 | 0 | 1 | 3 | 0.02 |
| Lambing interval | 6 | 24 | 17 | 0.22 | 1 | 3 | 1 | 0.03 |

Index=sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each variable divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all variables.R=rank

## 4.9. Breeding/mating system and Mating Management

As stated in Table 15, Breeding was generally uncontrolled in the study areas due to the ram grazing together with the ewes or having common grazing area (94.65%) and lack of awareness (5.35%). This was consistent with the report of Gebremariam B (2019) that mating was predominantly uncontrolled in most of the production systems in Ethiopia and Mulata Hayelom, (2013) showed that about 100 % of the mating system was uncontrolled in southern, south eastern and eastern zones of Tigray. Reasons of uncontrolled mating in the current finding was similar with Belete Asefa *et al* (2017) reported that the main reason of uncontrolled mating was sheep graze together (43%) followed by lack of awareness (33.7%) in Bale Zone, Oromia Regional State, Ethiopia. When breeding males is not reared in their flocks, the 90% HHs were got the service from neighbors' rams. Whereas 10% mating was, take place at random while families mix sheep in communal flocks. The present reports were comparable with the finding of Zewdu Edea *et al* (2012) for Adiyo Kaka and Horro sheep in western and south-western Ethiopia and Sisay Tilahun *et al* (2006) reported that pastoralists who didn't have male animals for mating, allowed their ewes to stay with rams of their neighbors or their relatives in Jijiga and Shinile Zones of Somali Regional State, Ethiopia. About 46.85% of pastoralists claimed that they were able to identify the sire of the lamb by relating lamb with the color, appearance/conformation of rams. This report was similar with the result obtained by Getachew Terefe *et al* (2010) that About 63% of farmers in Menz area and 77% of pastoralists in Afar area were able to identify the sire of the lamb by relating lamb with the color and appearance/conformation of rams. In the current survey areas, 100% respondents reported allow their ram to mate his mother, daughter and sister, ewe other than own flock and allow the ewe to be served by anyone else rams. According to the focal group discussion, they were avoid dry season (drought) lambing by using the methods like tying of a cord around the neck of the scrotum and looped over the prepuce to prevent extrusion of the penis of the ram to control mating. Berhanu Belay and Aynalem Haile, (2011); Mengestie Taye *et al*, (2011) and Milan P. *et al*., (2011) revealed that season was effect on lamb mortality in Ethiopian condition.

Table 15Mating/breeding systems of the study districts (%)

| Description | Gela'alo | Gewane | overall | $X^2$ |
|---|---|---|---|---|
| breeding/mating system | | | | |
| uncontrolled | 100 | 100 | 100 | |
| If uncontrolled, what is the reason? | | | | 1.05ns |
| sheep graze together | 93.6 | 95.7 | 94.65 | |
| lack of awareness | 6.4 | 4.3 | 5.35 | |
| Could you able to identify the sire of lambs? | | | | 5.7* |
| yes | 36.9 | 56.8 | 46.85 | |
| no | 63.1 | 43.2 | 53.15 | |
| criteria used to identify | | | | 16.86* |
| color | 30.2 | 25.7 | 27.95 | |
| body appearance/conformation | 6.7 | 31.1 | 18.9 | |
| If you do not have breeding ram, how do you mate your ewe? | | | | 20* |
| neighboring ram | 80.0 | 100 | 90 | |
| Unknown | 20.0 | 0.00 | 10 | |

$X^2$=chi-square value,* significant, ns=non significant

### 4.10. Castration

In the study area, the overall respondents (64.45%) were practice castration using traditional method. Castration was usually done at the age of 3-6 months (44.9%), greater than 6 months (18.9%) and less than 3 months (0.65%) in both study districts.This indicated that, the HHs were castrated mostly after weaning age time. According to the sampled households, the reasons for castration were to improve fattening only. These current results were not in agreement with the results that has been reported by Getachew Tadesse *et al* (2010) in a mixed crop-livestock and a pastoral system of Ethiopia. However, these findings were in line with the report of Yenesew Abebe *et al* (2013) in Burie District, North Western Ethiopia. The reasons for not practicing of castration mentioned by the respondents were draught (13.55%) and for breeding (22%). Seasons of castration reported by the study districts were wet season (13.45%), summer and autumn (51%) with no supplementary feed in all seasons. Similar finding was reported by Yadeta Neme (2016) in ada barga and ejere districts of west shoa zone, Ethiopia.

Table 16Castration practices of rams in the study areas (%)

| Description | Gella'lo | Gewane | Overall | $X^2$ |
|---|---|---|---|---|
| Do you castrate rams? | | | | 0.87ns |
| yes | 61.5 | 67.4 | 64.45 | |
| No | 38.5 | 32.6 | 35.55 | |
| if yes, reason for castration | | | | |
| improve fattening | 61.5 | 67.4 | 64.45 | |
| if no, give reason | | | | 0.88ns |
| draught | 14.5 | 12.6 | 13.55 | |
| for breeding | 24 | 20 | 22 | |
| At what age do you castrate? | | | | 5.2ns |
| < 3 months | 1.3 | 0 | 0.65 | |
| 3-6 months | 38.7 | 51.1 | 44.9 | |
| > 6 months | 21.5 | 16.3 | 18.9 | |
| season of castration | | | | 1.34ns |
| wet season | 48.9 | 53.1 | 51 | |
| summer and autumn | 12.6 | 14.3 | 13.45 | |
| Do you give supplementary feed for castrated sheep? | | | | |
| No | 61.5 | 67.4 | 64.45 | |
| types of castration method | | | | |
| local(traditional) | 61.5 | 67.4 | 64.45 | |

$X^2$=chi-square value, ns=non significant

### 4.11. Marketing of sheep

The survey result revealed that the nearby traditional (local and districts) market was available around the sheep keepers throughout the year. Sheep keepers mainly sold their sheep to traders, butchers, and consumers. Most of sheep keepers across the study areas were sold their sheep when they got financial problems to cover different expenses (closing, medical, agricultural inputs (food), when droughts happen and as regular income generation). However, respondents across the study areas reported that they usually sell their sheep classes by making priority unless they are forced to sell due to urgent money demand in the household. The overall average market age of male and female sheep was 6.02±1.39 and 6.53±1.57 months respectively. The current finding was smaller than the report of Amelaml Alemayehu *et al* (2015) who reported the average market age of male sheep was 11±2.74, 11.4 ±1.37 and 12.43 ±4.8 months and female 12.78 ±2.46, 12.05 ±2.19 and 13.8 ±5.7

months in Tocha, Mareka and Konta, districts of South Region of Ethiopia respectively. The current result was also higher than the report of Alemitu Beyene, *et al*. (2018) that the overall average marketing age of male and female lambs were 4.125 ± 0.06 and 4.228 ± 0.81 months respectively in Esera District, of Dawro Zone, Southern Ethiopia. According to the respondents, they sold every age category (lambs up to old ewe/rams and castrated rams) of sheep whenever they want cash income. However, the respondents maintain their breeding flock by retaining outstanding males in the ewe/rams rather than selling breeding female from the flock. The meat demand grows much higher during major holidays/festivals. Thus, the density of producers who sale their sheep targeting the particular holidays/festivals was higher. This was to gain maximum benefit from sales. In the study, areas pastoralists were sell their sheep in the local market 71.15% and 28.85% district market. This indicated that, most of the herders were sell their sheep in the local market. This result was similar with the reports of Zewdu Edea (2012), in western and southwestern Ethiopia.

Table 17Marketing of sheep in the study area

| description | Gella'lo | Gewane | overall | $X^2$ |
|---|---|---|---|---|
| sheep market access | | | | |
| yes | 100 | 100 | 100 | |
| Sell sheep in local market? | | | | 52.36* |
| yes | 46.7 | 95.6 | 71.15 | |
| No | 53.3 | 4.4 | 28.85 | |
| Season of mostly sell? | | | | |
| any time | 100 | 100 | 100 | |
| reasons for selling | | | | |
| cash needed | 100 | 100 | 100 | |
| | mean±SD | | | |
| minutes taken to reach market place | 55.5±22.34 | 52.78±13.05 | 55.14±18.4 | |
| average market age in month(male) | $5.22^b$±1.07 | $6.82^a$±1.21 | 6.02±1.39 | |
| Average market age in month(female) | $5.56^b$±0.85 | $7.51^a$±1.52 | 6.53±1.57 | |

$^{a-b}$ Means with different superscript letters with the same row are significantly different(P<0.05),$X^2$=chi-square value,*significant

Table 18Classes of sheep sold when cash is needed

| classes of sheep | Gewane | | | | Gelalo | | | |
|---|---|---|---|---|---|---|---|---|
| | R1 | R2 | R3 | Index | R1 | R2 | R3 | Index |
| Male lambs< 6 months | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ewe lambs b/n 6 month and 1year | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Breeding ewe | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ram lambs b/n 6 months and 1year | 17 | 0 | 30 | **0.23** | 14 | 0 | 28 | **0.27** |
| Female lambs <6 months | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| Breeding rams | 1 | 0 | 0 | **0.005** | 0 | 5 | 7 | **0.04** |
| Castrated | 59 | 0 | 0 | **0.27** | 54 | 0 | 0 | **0.3** |
| Old ewe | 4 | 13 | 39 | **0.18** | 2 | 18 | 31 | **0.17** |
| Old rams | 10 | 57 | 19 | **0.31** | 19 | 45 | 16 | **0.22** |

Index=sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each variable divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all variables. R=rank

## 4.12. Major Sheep Production Constraints

Major constraints challenging sheep production in the study area are presented in Table 19. The HHs reported that the major sheep production constraints were Feed shortage, Disease, Drought and predator across the study areas. In Gellalo district feed shortage, Drought, Disease and predator was constraints with the index of (0.34, 0.31, 0.3 and 0.06) respectively. Whereas in Gewane Drought (0.34), feed shortage (0.32), Disease (0.3) followed by (0.03) predator with the respective index. According to informants, and village elder, the diminishing in size of grazing land was related with the bush encroachments of the areas, investors and conflicts. Occurrence of outbreak disease across the study districts was major constraints for sheep production. The current finding was comparable with the previous review report of Addis Getu (2015), that major constraints of sheep production in the western part of Ethiopia was feed shortage, disease and parasites, drought, inadequate veterinary service and lack of infrastructures and with the report of Alemitu Beyene, *et al* (2018) that disease and parasite, feed shortage and grazing land shortage, water shortage, drought and predators were the most pertinent constraint of small ruminant production in Esera District, of Dawro Zone, Southern Ethiopia.

Table 19Constraints of sheep production ranked top three

| Constraints | Gewane | | | | Gella'alo | | | |
|---|---|---|---|---|---|---|---|---|
| | Rank1 | Rank2 | Rank3 | Index | Rank1 | Rank2 | Rank3 | Index |
| Genotype | 0 | 0 | 0 | **0** | 0 | 0 | 0 | **0** |
| Feed shortage | 51 | 24 | 15 | **0.32** | 34 | 55 | 11 | **0.34** |
| Water shortage | 0 | 0 | 0 | **0** | 0 | 0 | 0 | **0** |
| Disease | 31 | 44 | 15 | **0.3** | 29 | 36 | 25 | **0.3** |
| Drought | 67 | 19 | 4 | **0.34** | 76 | 11 | 1 | **0.31** |
| Market | 0 | 0 | 0 | **0** | 0 | 0 | 0 | **0** |
| Lack of superior genotype | 0 | 0 | 0 | **0** | 0 | 0 | 0 | **0** |
| predator | 0 | 3 | 9 | **0.03** | 0 | 7 | 11 | **0.06** |

Index=sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each variable divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all variables

### 4.13. Reproductive performances of sheep

The overall reproductive performances of sheep in the study area are summarized in table (20). Age at first mating (sexual maturity) for both sexes is not fixed. The overall average age at first service (sexual maturity) for both sexes were 7.3 and 6.0 months for males and females respectively. The age at first service (sexual maturity) in this study seem to be lower than that reported Amelmal Alemayehu, (2011), age at sexual maturity (puberty) was 11.05±1.6, 10.88±1.7 and 9.5±1.4 months for males and 11.13±2.7, 10.8±1.9 and 9.5±1.4 months for females in Tocha, Mareka and Konta, respectively and Mengistie Taye *et al.* (2016) for males (8.00 months) in Doyogena district, Southern Ethiopia. The present result also agreed with result of Zewdu Edea (2008) for Bonga breeds were 7.51 ± 2.14 for males but lower than that of females which reported 9.3 ± 2.2 months and similar for Horro breeds 7.1 ± 3 and 7.8 ± 2.4 months for males and females, respectively. This report also comparable with Amare Berhe *et al* (2019) that age at first service was reported 5.12 and 6.35 months for male and female respectively for Begait Sheep. However, the current result of AFS was in agreement with that of Dhaba Urgessa (2013) who reported 5-8 months for local female sheep in Illu Abba Bora and AFS for male was in line with the report of Solomon Gizaw *et al.* (2013) 7.10 months for Afar ram lambs under pastoral management. In addition, the average age at puberty of male lambs was slightly lower than that of Alemitu Beyene, *et al* (2018) reported which (6.409 ± 0.07) in lowland, (6.682 ± 0.12) highland and midland (6.792 ± 0.06) months but the average age at puberty of female lambs was slightly higher than (7.727 ± 0.16) in highland, (7.278 ± 0.06) midland and lowland (7.091 ± 0.04) months in Esera District, of Dawro Zone, Southern Ethiopia.

According to Ermias Belete *et al.* (2014) funding age at first lambing varied by location and season.The, overall current finding of Age at first lambing (AFL) for females and males were 12.3 and 9.6 months respectively. AFL of males was significantly ($P<0.05$) different across the study districts. The overall current result was lower than the report of Berhanu Belay and Aynalem Haile (2009) who reported that the AFL of south western Ethiopia ewes was 404 days (13.47 months), Mesfin Lakew et *al*. (2014) reported average AFL of 18.10 months at eastern Amhara region, Matawork Milkias Gobena and Mitiku Gebre Tona (2017) reported majority of the age at first lambing for Ethiopian sheep was within the range of 411-475 days (13.7-15.83 months) and Yisehak Kechero *et al*, (2013) reported AFL of 15.90, 15.85, and 15.63 months in Seka, Mana and Dedo districts of South western Ethiopia respectively. However, the overall result of AFL was compatible with the report of Fsahatsion Hailemariam *et al*. (2013) that an average age at first lambing (AFL) was 12.4 months in Gamo gofa Zone, Southern Ethiopia.

According to Amelmal Alemayehu, (2011) the interval between two successive parturitions is called lambing interval and it can be affected by season of lambing or nutritional accessibility, breed and number of parity of ewes and management practice. It is one of the most important Components affecting the lifetime productivity of the ewe. The overall present finding of LI was 9.1 months. This value was comparable with that of Zelalem Abate,

(2016) who reported that the average LI for indigenous sheep breeds was between 6.6 and 13.6 months. The overall current result was also in agreement with that of Tesfaye Getachew (2008) who reported 9 months for Afar sheep and Mengiste Taye (2008) who reported 9.16 months for Washera sheep. It appears that this current value was longer than what had been found 8.9 months for Bonga ewes and 7.8 months for Horro ewes (Zewdu Edea, 2008) and for Gumuz breed 6.64 months (Solomon Gizaw, 2007).

Litter size (LS) or prolificacy is defined as the number of progenies born per parturition. Litter size is a trait that depends on ovulation rate. It is one of the most important reproductive parameters affecting the productivity of a dam and thereby the profitability of a farm. Ermias Belete *et al*. (2014) reported, litter size mainly influenced by breed, level of nutrition, season and age. Extensively management system is the major source of variation in litter size as reported by (Shigdaf Mekuriaw *et al*, 2013). The overall current Litter size of sheep in the study area was estimated to be around 1.16. Tsedeke (2007), Fsahatsion Hailemariam *et al*. (2013), Hundie Demissu (2015), Zewdu Edea (2008) and Getahun (2008) reported that 1.70 for Arsi-Bale sheep, 1.3 in Gamogofa Zone of Southern Ethiopia, 1.57±0.52 in Western Ethiopia Horro Guduru area, 1.36 for horro sheep, 1.42 for adilo sheep respectively, which were higher than obtained in the current study. However, Mengistie aye *et al*.(2010),Yadeta Neme ( 2015) , Solomon Gizaw (2007) reported 1.11 for Menz and Washera sheep, 1.19±0.42 for Local sheep in Ada Barga and Ejere and 1.17 for Gumuz sheep were comparable with the present report. The overall current result was also in agreement with that of Zelalem Abate (2016) who reported that the LS for indigenous Ethiopian sheep was between 1.02 and 1.51.

Early maturing females are known to have a relatively long and fruitful reproductive life. Similarly, total lifetime production (lifetime lamb crop) can be increased by encouraging first lambing at an early age (Amelmal Alemayehu, 2011). The overall current mean reproductive life span in the study area was 8.3 years. Within those years, the ewe could produce about 11.97 lambs in her reproductive lifetime. There was significant difference between districts that ewes in Gela'alo district produce significantly lower number of lambs per lifetime than Gewane district. The overall current finding of RLS in ewe was higher than the report of Zewdu Edea (2008), 7.9 ± 3.1 for bonga and 7.4 ± 2.7 for horro sheep. On the contrary, this report was lower than the report of Fikrte Ferew (2008), 9.12 ± 1.6 for Shinile and Erer local sheep, Yadeta Neme (2015) reported 10.52 ± 1.3 for Ada-Barga and Ejere local sheep and Amelmal Alemayehu (2011) reported 9.17±1.70 for Tocha local sheep, 9.82±1.51 for Mareka local sheep and 9.28±1.62 for Konta local sheep respectively. On the other hand, this finding was in line with that of Solomon Gizaw (2007) who reported 8.5 for gumuz sheep. The finding was also in agreement with Amelmal Alemayehu (2011) and Fikrte Ferew (2008) who reported 8.57±3.7, 8.62±4.1, 8.18 ± 2.27 for Tocha local sheep, Mareka local sheep and Shinile and Erer local sheep respectively. however, the current result of LTLC was lower than Zewdu Edea (2008) reported for Bonga and horro sheep that 12.2 ± 1.80 and15.3 ± 4.3 respectively, Solomon Gizaw (2007) reported for Gumuz sheep 13.5 ± 1.76 and Amelmal Alemayehu (2011), 10.78±4.7 for Konta local sheep.

Table 20Reproductive performance of Afar sheep in the study districts (mean±SD)

| Reproductive traits | Gela'alo | Gewane | Overall |
|---|---|---|---|
| Age at sexual maturity male(month) | 7.28±0.73 | 7.38±0.79 | 7.33±0.76 |
| Age at sexual maturity female(month) | 5.89±0.75 | 6.12±0.82 | 6.00±0.79 |
| Age at first lambing male(month) | 9.10$^{\mathbf{b}}$±1.29 | 10.12$^{\mathbf{a}}$±1.27 | 9.61±1.38 |
| Age at first lambing female(month) | 12.09±1.45 | 12.42±1.09 | 12.25±1.29 |
| Average lambing interval of ewe | 9.41±7.02 | 8.74±1.37 | 9.07±5.06 |
| Litter size(prolificacy) | 1.19±0.39 | 1.13±0.34 | 1.16±0.37 |
| Average reproductive lifetime of ewe ( years) | 7.78$^{\mathbf{b}}$±1.025 | 8.74$^{\mathbf{a}}$±1.79 | 8.26±1.53 |
| Average number of lambing per ewe lifetime | 11.31$^{\mathbf{b}}$±1.96 | 12.62$^{\mathbf{a}}$±1.85 | 11.97±2.01 |
| Occurrence of multiple births per 100 ewes | 6.49$^{\mathbf{b}}$±2.19 | 7.65$^{\mathbf{a}}$±2.82 | 7.07±2.59 |

$^{a\text{-}b}$ Means with different superscript letters with the same row are significantly different(P<0.05)

### 4.14. Diseases and disease control

Sheep diseases were one of the main constraints for sheep production in the area. According to key informants (veterinarian) in the study area internal parasite, sheep pox, pasteurellosis, PPR and fasciolosis (Liver fluke) were the main sheep diseases in the study area. This finding is different from that of Amelaml Alemayehu *et al* (2015) who reported internal and external parasite, Diarrhea and megaga (local name) were the most frequently diseases of sheep across all the studied districts in Dawuro Zone and Konta Special Wereda of South Region of Ethiopia. Zewdu Edea (2012) in western and south-western Ethiopia, that pasteurellosis, coenurosis, diarrhea and lung worm were the most important diseases of sheep at different seasons of the year in Adiyo Kaka district and lung worm, liver fluke (fasciolosis) and coenurosis were also the most significant diseases in Horro. On the other hand, the current report was in line with Bosenu Abera *et al* (2014) who reported Fasciollosis, sheep pox, foot root and Pasteurollosis was major diseases affecting sheep productivity in Selale Area, Central Ethiopia. The majority of the sampled HHs had access to veterinary services in five km distance. Treating animals from private veterinarian was common as the public veterinary clinic was very limit to access services. About 62.2% of the respondents had access to veterinary from private veterinarian and the rest 34.4% and 3.3% had veterinary services from government veterinarian and from shop/market respectively.

Table 21 Major sheep diseases sand their symptoms in the study area

| Common name | local name(afaraf) | symptom of the disease | |
|---|---|---|---|
| Pastuerolosis | tufo | nasal discharge | |
| Sheep pox | korboda | Skin lession | |
| PPR | dahan | Coughing and fever | |
| Fasciolosis | tirro | Diarrhea and reduced appetite | |
| Internal parasites | kirbi | Diarrhea | |
| **Parameters** | **gella'lo (%)** | **Gewane (%)** | **overall** |
| Access to veterinary services | | | |
| Government veterinarian | 67.9 | 1.1 | 34.5 |
| Private veterinarian | 25.4 | 98.9 | 62.2 |
| shop/market | 6.7 | 0.0 | 3.3 |
| $X^2$ | | **102.957*** | |
| Distance to nearest veterinary service | | | |
| < 1 Km | 12.2 | 23.3 | 17.8 |
| 1-5 Km | 87.8 | 76.7 | 82.2 |
| $X^2$ | | **3.801ns** | |

$X^2$=chi-square value,* significant, ns=non significant

## 4.15. Phenotypic Characterization of Indigenous sheep ecotypes

### 4.15.1. Qualitative characteristics

Qualitative traits of indigenous sheep population of the study area are summarized in Table 22. The observed overall coat color pattern for both sexes were plain (50.7%) and patchy (49.3%). The current result indicated that different color with White dominant (38.5%) was the most frequently observed hair coat color followed by Fawn (23.5%) and white coat color (15.2%). The sampled sheep population in the study area had similar coat color pattern. the current finding was similar with that of Hizkel Kenfo (2017) who reported that the coat color pattern of indigenous sheep population in the study area was 47.43% plain, 51.90% patchy and 0.68% spotted coat color in Bensa district of Sidama Zone in Southern Nations Nationalities and Peoples' Region (SNNPR) of Ethiopia. In contrast, Fsahatsion Hailemariam *et al* (2018) reported dominant coat color pattern of plain (67.7%) and patchy (18.5%) in Gamogofa zone. Similarily, Tesfay, H. H *et al* (2017) reported dominant coat color pattern of plain (54.5%) and patchy (18.2%) for Tanqua-Abergelle sheep, plain (59.4%), patchy (15.4%) for Kolla Tembien sheep and plain (67.3%), patchy (10.2%) for Adwa sheep in central zone of Tigray. All of the sheep (100%) in the study area were characterized by possessing Short and coarse hair coat type. The predominant tail type observed in sampled sheep populations were long fat tail (79.1%) in both sexes followed by the Short fat tail (20.7%). The proportion of long fat tail was higher in males as compared to females. The tail shape as observed indicate that both the rams and ewes had tail Cylindrical turned up at end (100%). These current findings were similar with that of Tesfaye Getachew; *et al* (2009) who reported almost all (99.7%) had short and coarse hair and were fat tailed which is curved upward at end for Afar sheep in Amibara District. The majority (93%) of sheep population in the current study areas possessed straight head profile with few frequency of Convex (7%) head profile. The current result was comparable with Hizkel Kenfo (2017) who revealed that most of the sample population sheep had flat face profile (73.4%) followed by convex (13.57%) and concave (13.03%) in Bensa district of Sidama Zone in Southern Nations Nationalities and Peoples' Region (SNNPR) of Ethiopia. Conversely, Wendimu Bireda, *et al* (2016) reported that Black Head Somali Sheep was characterized by flat (57.67%), concave (42.33%) and flat (46%), concave (49.67%) and convex (4.33%) in Gode and Adadile districts respectively which disagrees with the current findings. Tassew Mohammed *et al* (2014) reported that the majority of the female sample sheep population (69.6% for Habru and 64.0% for Gubalafto) exhibited concave head profile but similar with the male sheep indicated straight head profile (63.3% for Habru and 61.3 % for Gubalafto districts in Northern Wollo zone, Amhara National Regional state.

Table 22Qualitative traits of sheep population in the study area (%)

| Qualitative characters | Gela'alo female | Gela'alo male | Gewane female | Gewane male | overall mean for both sexs | $X^2$ |
|---|---|---|---|---|---|---|
| **Coat color pattern** | | | | | | 1.03ns |
| Plain | 48.6 | 71.8 | 43.5 | 52.5 | 50.7 | |
| Patchy | 51.4 | 28.2 | 56.5 | 47.5 | 49.3 | |
| **Coat color type** | | | | | | 9.26* |
| White | 15.1 | 14.1 | 15.8 | 14.7 | 15.2 | |
| Black | 2.7 | 1.2 | 1.9 | 1.6 | 2 | |
| Brown | | 9.4 | 2.9 | 3.3 | 3 | |
| Fawn | 24.9 | 37.6 | 17.7 | 19.7 | 23.5 | |
| Red | 5.9 | 9.4 | 4.3 | 13.1 | 6.7 | |
| White dominant | 41.1 | 20 | 46.4 | 29.5 | 38.5 | |
| Black dominant | 4.9 | 1.2 | 4.8 | 3.3 | 4.1 | |
| Red dominant | 5.4 | 7.1 | 6.2 | 14.8 | 7 | |
| **Hair coat type** | | | | | | |
| Short and coarse hair | 100 | 100 | 100 | 100 | 100 | |
| **Horn** | | | | | | |
| absent | 100 | 100 | 100 | 100 | 100 | |
| **Ear orientation** | | | | | | 0.45ns |
| Semi-pendulous | 85.9 | 85.9 | 86.1 | 91.8 | 86.7 | |
| Pendulous | 7.6 | 4.7 | 6.2 | 3.3 | 6.1 | |
| Carried horizontally | 6.5 | 9.4 | 7.7 | 4.9 | 7.2 | |
| **Wattle** | | | | | | 0.06ns |
| Present | 20.5 | 11.8 | 21.5 | 19.7 | 19.4 | |
| absent | 79.5 | 88.2 | 78.5 | 80.3 | 80.6 | |
| **Ruff** | | | | | | |
| absent | 100 | 100 | 100 | 100 | 100 | |
| **Head profile** | | | | | | 3.02ns |
| Straight | 95.7 | 80 | 98.6 | 83.6 | 93 | |
| Convex | 4.3 | 20 | 1.4 | 16.4 | 7 | |
| **Rump profile** | | | | | | 1.29ns |
| Sloping | 91.9 | 84.7 | 94.7 | 73.8 | 89.8 | |
| roof | 8.1 | 15.3 | 5.3 | 26.2 | 10.2 | |
| **Tail type** | | | | | | 6.78* |
| Short fat | 22.2 | 2.4 | 33 | | 20.7 | |
| Long fat | 77.8 | 97.6 | 66.5 | 100 | 79.1 | |
| Short thin | | | 0.5 | | 0.2 | |
| **Fiber type** | | | | | | |
| Hair | 100 | 100 | 100 | 100 | 100 | |
| **Tail shape** | | | | | | |
| Cylindrical turned up at end | 100 | 100 | 100 | 100 | 100 | |

$X^2$=chi-square value, ns=non significant,*=significant

All of the sampled sheep populations were characterized by the absence of horns (polled) and rudimentary horn shape. In general, the ear length of sampled sheep population was short with the average value of 4.20 cm. About 86.7%, 7.2% and 6.1% of the sampled population were characterized by semi-pendulus, horizontal and pendulous ear orientations, respectively. These findings were similar with that of Seare Tajebe *et al* (2011) that horn was absent in 97.1% of the males and 100% females and all of the animals had short and small ear with average value of 2.93cm in Tanq Abergelle district, central zone of Tigray region. According to Tassew Mohammed *et al. (*2014), the predominant ear forms observed in the sample sheep population were semi-pendulous (60.6% for Habru and 53.6% for Gubalafto) followed by rudimentary (23.2% for Habru and 25.4% for Gubalafto) and carried horizontal ear form (12.6% for Habru and 14.3% for Gubalafto) but different from the finding of horn, that was present in 87.5 % of males and on the contrary it was similar for females with absence of horn in Gubalaafto district sample sheep population. However, it was similar for Habru district sheep that about 100% of female and 90% of male sheep had no horn in Northern Wollo zone, Amhara National Regional state.

The presence of wattle in the study area was less pronounced for both male and female populations. About 19.4% of both male and female sheep populations possessed wattle whereas the majorities (80.6%) were devoid of wattles. Ruff was totally absent in the sampled population sheep of the study area. The current result was similar with that of Hizkel Kenfo *et al* (2017) reported about (94.4%) sheep had no wattle and absence of ruff in all of the sampled population sheep in Bensa District, Southern Ethiopia.

Fiber type of all the sampled population of both sexes were hair. The current finding was in line with the report of Markos Tibbo *et al* (2004) for horro sheep that about 80% of them were hairy and 18% slightly woolly. In the study area majority of the rump profile was observed with Sloping profile that accounted about 89.8% and 10.2% of roof. The resent report was not inagreement with that of Tassew Mohammed *et al* (2014) reported that the majority of the rump profile were observed with roofing profile, which accounted 59.6% in Habru and 62.3% in Gubalafto districts sheep of Northern Wollo zone, Amhara National Regional state.

### 4.15.2. Quantitative characteristics

Although live body weight is an important growth and economic trait, it is not always possible to measure it due to mainly the lack of weighing scales, particularly in rural areas. Body measurement can also be used routinely in weight estimation and selection programs based on its utility in determining breed evolution trends (Riva J, *et al* 2002). In the present study, body weight of indigenous sheep (both sexes) showed an increment with age of the animals with an overall body weight of 33.6 and 36.3 kg for male and 32.2 kg for female, respectively. The current result was similar with Solomon Abegaz *et al*. (2011) who reported male 34.6 Kg and female 31.4 Kg for Gumuz sheep. However, the current result was higher than Abera Melesse *et al*. (2013a) reported 27.5 and 25.8 kg for the respective rams and ewes of Kembata and Tembaro-Hadiya zones. Bosenu Abera *et al*., (2014) reported 27.23 and 27.96 kg of body weight for Selale sheep female and male sheep populations. Tewodros Bimerow *et al*., (2011) recorded 28.0 and 23.6 Kg of body weight for male and female Farta sheep.

The overall mean of BL, HG, HW, RH, RW, ChD and ChW obtained in the current finding was 57.4cm, 68.8cm, 62.1cm, 61.2cm, 14.5cm, 30.5 and 15.4cm respectively. The current finding was comparable with that of Tewodros Bimerow *et al* (2011) reported the overall mean wither height, heart girth, body length and pelvic width obtained for Farta sheep were 63.6±0.31 cm, 70.4±0.38 cm, 55.4±0.30 cm and 12.7±0.11 cm, respectively. Inversly, the report obtained for Doyogena sheep HW, RH and HG was 65.89cm, 67.55cm and 72.03cm respectively (Mengitie Taye *et al*, 2016). Which was higher than the current report. On the other hand, the present finding was higher than that of Alemayehu Tadesse and Tikabo Gebremariam (2010) reported BL (49.59cm), HG (65.03cm) and HW (58.18cm) for Highland Sheep in Tigray Region, North-Ethiopia

**District**

District had a significant effect on body weight and other linear body measurements except EL, RH, RW, CBL and ChD. The current finding was consistent with the findings of Mesfin Asaminew (2016), Belete Asefa *et al* (2017) and Michael Abera *et al* (2016) who reported comparable values in sheep types reared in various parts of Ethiopia.

**Sex effects**

The interaction on body weight and other body measurement are presented in Table 24. Body weight and other linear body measurements showed significant differences between sexes. For traits showing significance difference, males were larger ($p<0.05$) than females. This result is in agreement with that of Hizkel Kenfo (2017) for sheep type in Bensa District, Southern Ethiopia. The present finding was also comparable with that of Jemal Mohammed *et al* (2018) who reported that sex had a highly significant effect on all of linear body measurements except rump width for sheep reared in North Eastern Amhara, Ethiopia. On the contrary, Michael Abera *et al* (2016) revealed that sex of animals had no significant effect ($P<0.05$) on most of the linear body measurements except for BW, RW, RH and CC in sheep reared in East Gojam zone, Ethiopia.

**Age effects**

The variation between the different age classes were found to be significant ($p<0.05$) as detected by pairwise comparisons for both sexes (Table 23). The trend showed that all linear body measurements increased with increase in dentition class except tail circumference and tail length. The present study was similar with that of Belete Asefa *et al* (2017) who reported that all the linear body measurements were increased as the age of the animal increased from the yearling age group 1PPI to the oldest 4PPI and above age group for sheep reared in Bale Zone, Ethiopia. Nurlign Mohammed et al (2017) also reported similar findings for South Wollo sheep, Ethiopia. Jemal Mohammed *et al* (2018) also revealed that body weight and most of body linear measurements showed significant variability in an increasing trend as animal age advances for local Sheep in North Eastern Amhara of Ethiopia.

Table 23Mean body weight (Kg) and LBM (cm) of Gela'alo and Gewane districts, sex and age interactions

| Effect & level | N | BW | BL | HG | HW | EL | RH | TL | CC | RW |
|---|---|---|---|---|---|---|---|---|---|---|
| Overall(Mean± SD) | 540 | 33.64±5.26 | 57.37±3.24 | 68.83±3.81 | 62.05±3.55 | 4.20±1.38 | 61.18±3.31 | 21.19±4.89 | 6.57±0.67 | 14.47±1.06 |
| CV% | | 10.88 | 3.51 | 3.83 | 4.04 | 31.60 | 3.89 | 17.43 | 8.48 | 6.12 |
| $R^2$ | | 0.52 | 0.62 | 0.53 | 0.51 | 0.09 | 0.49 | 0.44 | 0.32 | 0.30 |
| **District** | | * | * | * | * | ns | ns | * | * | ns |
| Gela'alo | 270 | $33.07^{b}$ | $56.86^{b}$ | $69.60^{a}$ | $61.71^{b}$ | 4.10 | 61.00 | $21.96^{a}$ | $6.62^{a}$ | 14.46 |
| Gewane | 270 | $34.20^{a}$ | $57.88^{a}$ | $68.06^{b}$ | $62.38^{a}$ | 4.29 | 61.36 | $20.42^{b}$ | $6.52^{b}$ | 14.49 |
| **Sex** | | * | * | * | * | * | * | * | * | * |
| Male | 146 | $36.30^{a}$ | $58.70^{a}$ | $70.54^{a}$ | $63.61^{a}$ | $3.83^{b}$ | $62.71^{a}$ | $26.17^{a}$ | $6.96^{a}$ | $14.70^{a}$ |
| Female | 394 | $32.65^{b}$ | $56.88^{b}$ | $68.20^{b}$ | $61.47^{b}$ | $4.33^{a}$ | $60.62^{b}$ | $19.34^{b}$ | $6.42^{b}$ | $14.39^{b}$ |
| **Age** | | * | * | * | * | * | * | ns | * | * |
| 1PPI | 99 | $28.52^{d}$ | $54.03^{d}$ | $64.75^{d}$ | $58.29^{d}$ | $3.55^{c}$ | $57.70^{d}$ | $19.41^{b}$ | $6.05^{c}$ | $13.60^{d}$ |
| 2PPI | 137 | $31.72^{c}$ | $55.70^{c}$ | $67.51^{c}$ | $60.95^{c}$ | $4.07^{b}$ | $60.30^{c}$ | $21.86^{a}$ | $6.49^{b}$ | $14.12^{c}$ |
| 3PPI | 150 | $35.29^{b}$ | $58.64^{b}$ | $69.99^{b}$ | $63.24^{b}$ | $4.45^{a}$ | $62.13^{b}$ | $21.49^{a}$ | $6.77^{a}$ | $14.76^{b}$ |
| 4PPI | 154 | $37.02^{a}$ | $59.77^{a}$ | $71.49^{a}$ | $64.28^{a}$ | $4.47^{a}$ | $63.29^{a}$ | $21.43^{a}$ | $6.78^{a}$ | $15.08^{a}$ |

Table:-continued

| Effect and level | N | TC | CL | CD | RL | HL | SC | HW | CW |
|---|---|---|---|---|---|---|---|---|---|
| Overall(Mean± SD) | 540 | 25.94±4.89 | 15.54±0.96 | 30.49±2.09 | 13.85±1.01 | 16.56±1.01 | 7.78±0.85 | 10.68±1.03 | 15.37±1.94 |
| CV% | | 15.16 | 5.39 | 4.62 | 5.74 | 5.05 | 9.06 | 7.86 | 9.22 |
| $R^2$ | | 0.36 | 0.24 | 0.55 | 0.39 | 0.31 | 0.32 | 0.34 | 0.47 |
| **District** | | * | ns | ns | * | * | * | ns | * |
| Gela'alo | 270 | $26.78^{a}$ | 15.49 | 30.45 | $14.03^{a}$ | $16.47^{b}$ | $7.91^{a}$ | 10.69 | $15.07^{b}$ |
| Gewane | 270 | $25.11^{b}$ | 15.58 | 30.52 | $13.66^{b}$ | $16.65^{a}$ | $7.64^{b}$ | 10.67 | $15.67^{a}$ |
| **Sex** | | * | * | * | * | * | * | * | * |
| Male | 146 | $30.21^{a}$ | $15.86^{a}$ | $31.69^{a}$ | $14.37^{a}$ | $16.89^{a}$ | $8.26^{a}$ | $11.16^{a}$ | $16.51^{a}$ |
| Female | 394 | $24.36^{b}$ | $15.42^{b}$ | $30.04^{b}$ | $13.65^{b}$ | $16.44^{b}$ | $7.60^{b}$ | $10.50^{b}$ | $14.95^{b}$ |
| **Age** | | ns | * | * | * | * | * | * | * |
| 1PPI | 99 | $23.66^{b}$ | $14.78^{c}$ | $28.30^{d}$ | $12.98^{c}$ | $15.80^{d}$ | $7.10^{c}$ | $9.83^{c}$ | $13.80^{c}$ |
| 2PPI | 137 | $26.73^{a}$ | $15.42^{b}$ | $29.82^{c}$ | $13.57^{b}$ | $16.22^{c}$ | $7.70^{b}$ | $10.42^{b}$ | $14.71^{b}$ |
| 3PPI | 150 | $26.71^{a}$ | $15.79^{a}$ | $31.13^{b}$ | $14.16^{a}$ | $16.84^{b}$ | $7.99^{a}$ | $11.04^{a}$ | $16.07^{a}$ |
| 4PPI | 154 | $25.97^{a}$ | $15.88^{a}$ | $31.85^{a}$ | $14.34^{a}$ | $17.08^{a}$ | $8.06^{a}$ | $11.10^{a}$ | $16.29^{a}$ |

*significant at ($p<0.05$), ns=non significe; BW=body weight; BL=body length; HG=heart girth;HW=height at wither;EL=ear length;RH=rump height;TL=tail length,CC=cannon bone circumference,RW=rump width,TC=tail circumference,CL=canno bone length,CD=chest depth,RL=rump length,HL=head length,SC=shin circumference,HW=head width,CW=chest width

### 4.15.3. Correlation between body weight and other linear body measurements

The association among body weight and linear body measurements of sheep in the study area is presented in Table 24. The high association of LBMs with body weight would imply that these measurements can be used as indirect selection criteria to improve live weight (Kosgey, I.S et al.,2006; Solomon Gizaw, 2008) or could be used to predict body weight (Attach and Elkhidir,2004; Afolayanet et al.,2006; Fasaeet et al.,2006). Almost all of the parameters considered had positive and significant correlation with live body weight. Among the measured linear quantitative variables, HG (r=0.85), RH (r=0.80), CD (0.79), CW (r=0.78), HW (r=0.76) and BL (r=0.72) showed a positive and strong association for males. In females, RH (r=0.77), HW (r=0.76), HG (r=0.75), CW (r=0.75), CD (r=0.70) and BL (r=0.68) showed strong positive correlation with body weight. Among the body measurements, HG was the most strongly correlated trait with body weight (r = 0.85) for males and RH (r = 0.77) for females. There are different conflicting reports in the literature with regard to the correlation trend of body weight with linear body measuremnent traits. For example Belete Asefa *et al* (2017), Hizkel Kenfo *et al* (2017) and Wendimu Bireda *et al* (2016) reported that HG had the highest association with body weight than other body measurements for both males and females while Seare Tajebe *et al* (2011) reported that HW was positively and strongly correlated to body weight of both sexes and all age groups. The correlation of EL with body weight was not significant and is similar with the observations of (Mengistie Taye *et al*, 2016).

Table 24Coefficient of correlations between body weight and linear body measurements sampled population (above the diagonal for males[146] and below the diagonal for females[394])

| Traits | BW | EL | BL | HG | HW | RH | TL | CC | RW | TC | CL | CD | RL | SC | HL | ShC | HW | CW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BW | | 0.08ns | 0.72** | 0.85** | 0.76** | 0.80** | 0.37** | 0.61** | 0.66** | 0.50** | 0.51** | 0.79** | 0.46** | 0.57** | 0.52** | 0.47** | 0.66** | 0.78** |
| EL | 0.30** | | 0.05ns | 0.07ns | 0.13ns | 0.15ns | 0.03ns | 0.08ns | 0.04ns | 0.06ns | 0.07ns | 0.001ns | 0.11ns | 0.12ns | 0.02ns | 0.10ns | 0.06ns | 0.11ns |
| BL | 0.68** | 0.21** | | 0.65** | 0.76** | 0.75** | 0.28** | 0.44** | 0.73** | 0.21* | 0.52** | 0.74** | 0.43** | 0.43** | 0.70** | 0.20* | 0.55** | 0.64** |
| HG | 0.75** | 0.29** | 0.64** | | 0.72** | 0.77** | 0.39** | 0.63** | 0.68** | 0.51** | 0.49** | 0.79** | 0.51** | 0.58** | 0.49** | 0.44** | 0.64** | 0.68** |
| HW | 0.76** | 0.28** | 0.77** | 0.73** | | 0.90** | 0.26** | 0.59** | 0.63** | 0.43** | 0.65** | 0.73** | 0.42** | 0.53** | 0.60** | 0.38** | 0.60** | 0.78** |
| RH | 0.77** | 0.29** | 0.77** | 0.72** | 0.95** | | 0.35** | 0.62** | 0.58** | 0.49** | 0.59** | 0.73** | 0.39** | 0.56** | 0.59** | 0.39** | 0.62** | 0.74** |
| TL | 0.22** | 0.07ns | 0.22** | 0.37** | 0.25** | 0.27** | | 0.43** | 0.35** | 0.32** | 0.25** | 0.40** | 0.20* | 0.41** | 0.23** | 0.22** | 0.11ns | 0.23** |
| CC | 0.44** | 0.23** | 0.39** | 0.52** | 0.43** | 0.44** | 0.26** | | 0.54** | 0.51** | 0.47** | 0.63** | 0.45** | 0.54** | 0.42** | 0.41** | 0.42** | 0.53** |
| RW | 0.42** | 0.17** | 0.46** | 0.44** | 0.46** | 0.45** | 0.21** | 0.35** | | 0.28** | 0.46** | 0.73** | 0.45** | 0.44** | 0.59** | 0.26** | 0.56** | 0.57** |
| TC | 0.31** | 0.08ns | 0.18** | 0.38** | 0.28** | 0.29** | 0.60** | 0.27** | 0.14** | | 0.37** | 0.46** | 0.19* | 0.47** | 0.23** | 0.50** | 0.38** | 0.45** |
| CL | 0.43** | 0.20** | 0.45** | 0.45** | 0.48** | 0.47** | 0.25** | 0.39** | 0.28** | 0.39** | | 0.57** | 0.23** | 0.37** | 0.55** | 0.21* | 0.49** | 0.47** |
| CD | 0.70** | 0.25** | 0.69** | 0.74** | 0.69** | 0.67** | 0.39** | 0.49** | 0.53** | 0.34** | 0.50** | | 0.47** | 0.47** | 0.56** | 0.36** | 0.66** | 0.70** |
| RL | 0.47** | 0.22** | 0.41** | 0.58** | 0.46** | 0.47** | 0.26** | 0.40** | 0.37** | 0.33** | 0.38** | 0.49** | | 0.31** | 0.25** | 0.20* | 0.31** | 0.36** |
| HL | 0.45** | 0.17** | 0.49** | 0.43** | 0.46** | 0.46** | 0.25** | 0.29** | 0.40** | 0.21** | 0.38** | 0.53** | 0.40** | | 0.26** | 0.40** | 0.34** | 0.45** |
| ShC | 0.51** | 0.32** | 0.40** | 0.58** | 0.51** | 0.52** | 0.32** | 0.43** | 0.30** | 0.37** | 0.39** | 0.49** | 0.47** | 0.34** | | 0.16ns | 0.55** | 0.48** |
| TtL | 0.46** | 0.22** | 0.43** | 0.52** | 0.49** | 0.51** | 0.22** | 0.36** | 0.34** | 0.25** | 0.24** | 0.46** | 0.47** | 0.29** | 0.51** | | 0.27** | 0.34** |
| HW | 0.49** | 0.11* | 0.50** | 0.44** | 0.49** | 0.48** | 0.20** | 0.30** | 0.29** | 0.23** | 0.38** | 0.50** | 0.34** | 0.48** | 0.41** | 0.37** | | 0.68** |
| CW | 0.75** | 0.30** | 0.64** | 0.71** | 0.65** | 0.64** | 0.23** | 0.48** | 0.40** | 0.34** | 0.44** | 0.69** | 0.50** | 0.38** | 0.50** | 0.47** | 0.50** | |

**p<0.01;*p<0.05;ns=non-significant; BW=body weight; EL=earlength; BL=bodylength; HG=chest girth; HW= height at wither; RH= rump height; TL= tail length; CC= cannon bone circumference; RW= rump width; TC= tail circumference; CBL= cannon bone length; Chd= chest depth; RL= rump length; SC= scrotom circumference; HL= head length; ShC= shin circumference; HW= head width; CW= chest width; TtL= teat length

### 4.15.4. Prediction of Body Weight from Linear Body Measurements

Regression analysis is commonly used in animal research to describe quantitative relationships between a response variable and one or more explanatory variables such as body weight and body measurements (heart girth, chest depth, body length and height at wither) especially when there is no access to weighing equipment (Cankaya, 2008). Multiple linear regression models for predicting the body weight of sheep from linear body measurements are presented in Tables 25 and 26. In this study, all the body measurements of indigenous sheep were fitted into the regression model within sex and age group; and the optimum model was identified for predicting body weight from LBMs. Heart girth, HW, CW, RH, CC and HL were the best fitted model for ewes. For rams, HG, BL, RW, RH, CW, CD, TC and shine circumference were the best-fitted model for male sheep. The first variable was different in both female and male for explanation of more variation than other variables. As indicated in Tables 26 and 27, the adjusted $R^2$ was increased as new variable was added to the model while addition of the new variable decreased the Mallows parameter C (P). This indicated that, addition of unnecessary variable to the model might increase the error. The stepwise regression analysis showed that the addition of other LBMs to the first variable in the model resulted in a significant increase in adjusted $R^2$ and improved the accuracy of prediction by decreasing the error. The present finding of stepwise regression revealed that, based on sex and age group can be estimate the body weight by considering RH and HG for females and RH, CW, CD and HG for males. Predictions of body weight from combinations of these multiple variables possess a practical problem under field settings due to the higher labor and time needed for measurements and calculations. Measuring the first variable in the model with tape is easy, cheap, and rapid. Thus, body weight prediction from the first variable alone would be a practical option under field conditions with reasonable accuracy. Belete Asefa *et al* (2017) suggested that HG was the best sole predictors of body weight of sheep (in both sexes) at farmers' condition while Seare Tajebe *et al* (2011) reported that HW was found to be best predictor of body weight in Abergelle sheep.

Table 25Stepwise multiple regression equations for estimation of live body weight of ewes by fitting linear body measurements

| Age group | Model | Intercept | Regression coefficient | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | β0 | β1 | β2 | β3 | β4 | β5 | $R^2$ | $R^2$adj | C(P) | SE |
| 1PPI | RH | -49.36 | 0.73 | | | | | 0.54 | 0.53 | 20.49 | 2.33 |
| | RH, ChW | -37.77 | 0.50 | 0.37 | | | | 0.62 | 0.61 | 8.09 | 2.14 |
| | RH, ChW, EL | -35.94 | 0.47 | 0.34 | 0.18 | | | 0.65 | 0.63 | 4.53 | 2.07 |
| 2PPI | RH | -24.82 | 0.65 | | | | | 0.42 | 0.42 | 24.07 | 2.87 |
| | RH, ChW | -27.82 | 0.52 | 0.32 | | | | 0.51 | 0.50 | 9.08 | 2.67 |
| 3PPI | ChG | -35.93 | 0.62 | | | | | 0.38 | 0.38 | 59.02 | 2.93 |
| | ChG, HW | -55.78 | 0.44 | 0.44 | | | | 0.54 | 0.53 | 16.83 | 2.54 |
| | ChG, HW, ChW | -52.04 | 0.32 | 0.39 | 0.30 | | | 0.61 | 0.60 | 0.44 | 2.35 |
| 4PPI | ChG | -43.4 | 0.64 | | | | | 0.40 | 0.40 | 36.52 | 2.70 |
| | ChG, ChW | -32.87 | 0.42 | 0.37 | | | | 0.50 | 0.49 | 15.32 | 2.49 |
| | ChG, ChW, RH | -47.42 | 0.38 | 0.31 | 0.23 | | | 0.54 | 0.53 | 6.53 | 2.39 |
| | ChG, ChW, RH, CBC | -47.60 | 0.40 | 0.33 | 0.25 | -0.14 | | 0.56 | 0.54 | 3.95 | 2.35 |
| | ChG, ChW, RH, CBC, HdL | -56.83 | 0.40 | 0.32 | 0.25 | -0.15 | 0.13 | 0.57 | 0.56 | 1.94 | 2.32 |

RH=rump height; HG=heart girth; CD=chest depth; CW=chest width; TC=tail circumference; SC=shin circumference; BL=body length;RW=rumpwidth

Table 26Stepwise multiple regression equations for estimation of live body weight of rams by fitting linear body measurements

| Age group | Model | Intercept | Regression coefficient | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | β0 | β1 | β2 | β3 | β4 | $R^2$ | $R^2$adj | C(P) | SE |
| 1PPI | RH | -27.55 | 0.82 | | | | 0.67 | 0.66 | 12.04 | 2.79 |
| | RH, ChG | -40.50 | 0.51 | 0.44 | | | 0.77 | 0.75 | 2.28 | 2.38 |
| | RH, ChG, ChD | -43.54 | 0.36 | 0.34 | 0.30 | | 0.80 | 0.78 | -0.19 | 2.23 |
| | RH, ChG, ChD, EL | -45.88 | 0.27 | 0.40 | 0.32 | 0.18 | 0.83 | 0.81 | -1.72 | 2.09 |
| 2PPI | ChW | 6.73 | 0.75 | | | | 0.57 | 0.56 | 9.67 | 3.06 |
| | ChW, TC | 0.16 | 0.58 | 0.34 | | | 0.67 | 0.64 | 1.97 | 2.77 |
| 3PPI | ChD | -54.43 | 0.79 | | | | 0.62 | 0.60 | 37.57 | 2.96 |
| | ChD, ChG | -68.29 | 0.51 | 0.42 | | | 0.71 | 0.69 | 22.77 | 2.60 |
| | ChD, ChG, ChW | -54.58 | 0.23 | 0.47 | 0.36 | | 0.78 | 0.76 | 13.36 | 2.32 |
| | ChG, ChW | -43.94 | 0.58 | 0.48 | | | 0.76 | 0.75 | 14.41 | 2.37 |
| | ChG, ChW, SHC | -49.26 | 0.52 | 0.45 | 0.22 | | 0.80 | 0.78 | 9.32 | 2.20 |
| | ChG, ChW, SHC, BL | -62.36 | 0.42 | 0.36 | 0.23 | 0.23 | 0.83 | 0.81 | 5.81 | 2.05 |
| 4PPI | ChG | -28.29 | 0.72 | | | | 0.51 | 0.50 | 19.54 | 2.10 |
| | ChG, ChW | -34.80 | 0.658 | 0.339 | | | 0.63 | 0.61 | 9.24 | 1.87 |
| | ChG, ChW, RW | -61.15 | 0.605 | 0.283 | 0.254 | | 0.68 | 0.66 | 4.91 | 1.75 |

RH=rump height; ChG=chest girth; ChD=chest depth; ChW=chest width; TC=tail circumference; SHC=shin circumference; BL=body length;RW=rumpwidth

### 4.15.5. Morphological indices

Morphology indices were calculated based on Salako, A. E., (2006), Alderson, G. L. H. (1999) and Chiemela, P. N *et al* (2016) methods, in order to assess the type and function of the sheep population. The results of average value of morphological indices are presented in Table 27. The result of structural indices in this study indicated that; Height slope was 0.87 which indicated that wither height is longer than rump height and these sheep were longer in front than back ward. The current report was in agreement with Salako AE (2006), Chiemela PN *et al* (2016), Khargharia G *et al* (2015) and Parés-Casanova (2013) who suggested that if the withers are lower than the rump, the animal is low in front and vice versa. Cephalic index of the present study was 64.51. This cephalic index showed that the sheep in the study area were mesocephalic that is medium-headed (Schlueter, C *et al*., 2009). A sheep is said to be brachycephalic or brachycranial (short headed) when its cephalic index is greater than 81.1% ( Marchant *et al*., 2017).The body index of sheep in the study area was 83.43 that classify them as brevigline. Brevigline means that the animal has a tendency to form a rectangular pelvis (Amborlini LC 2001). Pelvic index gives an idea of the structure of the croup; this reason is closely related to reproductive fitness (Israel, H.*et al* 2013). This study revealed pelvic index value of 104.87. Compact index is a useful indicator of the overall value of the animals due to combination of more than one morphological traits used for the calculation; it provides an accurate picture of type and function of ruminant animals (Chiemela PN *et al* 2016). Therefore, the compact index value of the present finding was 5.40, which classified as meat type. Since Compact index indicates how compact the animal is. Meat type animals have values above 3.15, whereas values close to 2.75 indicates dual purpose and close to or below 2.60 indicates that the animals are more suitable for milk purpose (Alderson, G. L. H., 1999, Chiemela, P. N. *et al* 2016, Dauda A, 2018). Proportionality is an important index that correlates with good health and better disease resistance (Chacon E *et al* 2011). It also provides information about the length of the animal. If the value is greater than 100 its shape is square and these sheep had a characteristic of dairy type. The proportionality value reported in this study was 108.22, which classified the studied sheep populations as dairy phenotype. The width slope and length indices are useful parameters for estimating balance, and may serve as important index in assessment of function (Salako AE.2006). This study revealed Width slope of 0.95 and length index of 0.93 respectively. Width slope index value showed that the sampled sheep population had rump width narrower than chest width.The current report width slop and length index was higher than that of Jemal Mohammed, *et al* (2018) who reported width slope and length index 0.85 and 0.89 respectively for local sheep in Ethiopia. The Thoracic development value of 1.11 obtained in this study was less than 1.2 stated by Alderson, G. L. H., (1999) and Chiemela, *et al*. (2016) which is an indication of animal with good thoracic development. If the value of the dactyl thorax index is less than 10 the animal classified as dairy type and greater than 11 the animal is classified as meat type. In the current study a dactyl thorax index of 9.54 was observed, which characterize the sampled sheep population as dairy type.The body ratio (1.01) shown that the sheep in the study area were higher at the withers than the rump. The value of relative body index (0.93) indicated that body length of those animals were less than wither height. The current result of transversal pelvic index was 23.68 which indicated that the pelvic width of the sheep were less than their height at rump suggesting the ewes would had less chance of dystocia (Edilberto, C *et al*., 2011; Sandip Banerjee, 2015). Longitudinal pelvic index serves to estimate the meat capacity of the animal relating the length of rump to the height at withers. Longitudinal pelvic indexs not exceeding 37 are suitable indicators for meat animals (Agraz, 1981; López, J.*et al* 1992; Salako AE, 2006). Longitudinal pelvic index of sheep in the current study was 22.65, which was, classified them as meat animals. Balance was recorded in the current work around 101.47 that showed bigger surface for the chest than for the rump.

The current reports were higher than that of Jemal Mohammed, *et al* (2018) who reported the value of balance was 0.81 and 0.67 for dorper crossbred and dorper sheep respectively However, this present result was in agreement with S. Harkat *et al* (2015) for Ouled-Djellal sheep breed in Djelfa, Biskra, Laghouat, and M'Sila and cradle regions of Algeria. Relative depth of thorax indicates the relationship between chest depth and legs length (Saste, 2003). The current value of Relative depth of thorax was 49.15, which was not intended to meat phenotype, as the value was less than 50.

Table 27Average value of morphological indices, mean and standard deviation of Afar Sheep

| Parameters | Mean | SD | CV |
|---|---|---|---|
| Height slope | 0.87 | 0.05 | 5.75 |
| Cephalic index (%) | 64.5 | 5.21 | 7.94 |
| Body index (%) | 83.4 | 3.74 | 4.48 |
| Pelvic index (%) | 105 | 8.38 | 7.87 |
| Relative depth of thorax (%) | 49.2 | 2.34 | 4.69 |
| Width slope | 0.95 | 0.10 | 10.3 |
| Proportionality (%) | 108 | 3.97 | 3.67 |
| Balance | 102 | 17.51 | 16.4 |
| Transversal pelvic index (%) | 23.7 | 1.55 | 6.52 |
| Longitudinal pelvic index (%) | 22.7 | 1.51 | 6.61 |
| Relative body index or length index | 0.93 | 0.03 | 3.55 |
| Dactyl thorax index (%) | 9.54 | 0.78 | 7.89 |
| Thoracic development | 1.11 | 0.04 | 4.05 |
| Body ratio | 1.01 | 0.02 | 1.90 |
| Relative canon thickness index (%) | 10.6 | 0.91 | 8.41 |
| Compact index | 5.40 | 0.64 | 11.3 |

SD=standard deviation, CV=coefficient of variation

### 4.16. Pre-slaughter weight, dressed carcass weight (kg) and dressing percentage of sheep

Shashie Ayele amd Mengistu Urge, (2019) stated that, dressing percentage (DP) is an important measure of the potential yield of meat from an animal. There was significant difference ($p<0.05$) in pre-slaughter weight, dressed carcass weight and hot carcass weight but no significant diferences ($P<0.05$) in dressed carcass basis dressing percentage and pre-slaughter basis dressing percentage between sexes of the sampled sheep population. Male sheep had higher pre-slaughter weight, dressed carcass weight and hot carcass weight than female sheep. The current overall value of hot carcass weight (kg) and dressing percentage was 8.59±0.41and 37.01±0.61 respectively. The current finding was lower than that of Berhe G, (2010) who reported respectively 42.5% and 10-12 kg of the dressing percentage and carcass weights of Ethiopian sheep. The present result was comparable to that of Sandip Banerjee, (2011) and Shashie Ayele amd Mengistu Urge, (2019). Tesfaye Getachew *et al.* (2011) reported that, the carcass weight of Washera sheep for feedlot growth were 16 kg. Based on Yadete Getahun Kebede, (2014), Ali Ahmed Seid, *et al* (2012), Mohammadi, A.R, *et al* (2011) hot carcass weight for Afar sheep were 9 - 12kg, 7 – 11 kg and 9 - 10 kg respectively when fed various types of basal and supplement feeds. According to the Assefu Gizaw (2012) increased proportion of concentrate from 30 to 50% improved hot carcass weight (HCW) from 7.5 to 9.0 kg and 7.7 to 8.6 kg in Washera and Horro lambs, respectively. In general Dressing percentage values on evscerated carcass weigjht basis were higher than on pre-slaughter weight basis indicated that the influence of digesta (gut fill) on dressing percentage. According to Gibbs, M.J., and E. W. Ivings, (1993) that ingesta constitute a large portion of the body weight even when the animals are fasted for long hours.

Table 28Average values (±SE) for weight (kg) of edible carcass components, dressed carcass, hot carcass and dressing percentage of Afar sheep of male and female in the study area

| | Male(15) | Female(15) | |
|---|---|---|---|
| parameters | mean±SE | mean±SE | overall |
| pre-slaughter | $25.24^{a}$±1.75 | $21.17^{b}$±0.88 | 23.20±1.03 |
| liver | 0.31±0.02 | 0.32±0.02 | 0.31±0.01 |
| heart | 0.10±0.01 | 0.11±0.01 | 0.10±0.01 |
| kidneys | 0.10±0.01 | 0.17±0.06 | 0.14±0.03 |
| neck | $1.07^{a}$±0.12 | $0.83^{b}$±0.03 | 0.95±0.07 |
| shoulder with thorax | 1.37±0.11 | 1.28±0.06 | 1.32±0.06 |
| foreleg | 1.44±0.1 | 1.31±0.06 | 1.38±0.06 |
| hindleg | 1.78±0.15 | 1.65±0.08 | 1.71±0.08 |
| lumbar | $0.43^{a}$±0.03 | $0.31^{b}$±0.03 | 0.37±0.02 |
| spinal cord | $1.14^{a}$±0.08 | $1.01^{b}$±0.06 | 1.07±0.05 |
| tail weight | $0.96^{a}$±0.09 | $0.40^{b}$±0.05 | 0.68±0.07 |
| loin and flank | $0.64^{a}$±0.08 | $0.44^{b}$±0.05 | 0.54±0.05 |
| dressed or evscerated carcass | $22.42^{a}$±1.74 | $17.78^{b}$±0.89 | 20.10±1.05 |
| Hot carcass | $9.58^{a}$±0.73 | $8.08^{b}$±0.34 | 8.59±0.41 |
| dressing percentage* | 43.25±1.45 | 45.91±1.09 | 43.34±0.9 |
| dressing percentage** | 37.89±1.04 | 38.28±0.76 | 37.01±0.61 |

a-b with different super scripts in the same row differ significantly($P<0.05$)
*calculated based on dressed carcass; **calculated based on pre-slaughter weight;
SE= standard error

# 5. SUMMARY AND CONCLUSION

Sheep is the most important livestock species, which have been adapted to a range of environments extending from the cool alpine climate of the mountains to the hot and arid pastoral areas of the lowlands. It play an important economic role and make a significant contribution to both domestic and export markets through provision of food (meat and milk) and non-food (manure, skin and wool) products. However, sheep production is constrained by various factors in Ethiopia that needs to be addressed by systematically describing and characterizing the production and marketing system, demands, and phenotypic attributes, thereby prioritize, and implement appropriate interventions (research and development) through the involvement of stakeholders to address the challenges. The existing knowledge on characterization of sheep genetic resources, husbandry practices and meat characterization in various region of the country shows that the information on breed level characterization is inadequate. The present study was, therefore, conducted in Gela'alo and Gewane districts of Gebiresu zone of Afar region to characterize the physical, their environment, husbandry practices, meat characterization and to identify the sheep population category in the study area. Data were collected from 180 sheep keepers. For assessment of qualitative and quantitative traits, 540 sheep (1PPI to 4PPI) of both sexes were randomly sampled in the study area. Focus group discussions and key informants interview were held to strengthen the findings of the survey.The major production system in the study areas was Livestock production (pastoralist) system.The overall average numbers of sheep holding per household was 24.21±8.65.The primary reason for keeping sheep across the study districts was milk, to derive income followed by meat. The major feed sources in the study area were communal natural pasture in the two-production system while the source of water were rivers and tape water. All of respondents in the study area indicated that sheep flock herded together with goat. Castration of sheep was common in the study area.

The common and economically important diseases in the study area were ovine pastuerolosis, sheep pox, PPR, fasciolosis and internal parasites. The overall average ages of sexual maturity of male and female sheep in the study area were 7.33±0.76 and 6.00±0.79 months, respectively. Age at first lambing, lambing interval, reproductive life time of ewe, average number of lambing per ewe's life time and average number of lambs per lambing of indigenous sheep in the study area were 12.25±1.29 months,9.07±5.06 months,8.26±1.53 years,11.97±2.01and1.16±0.37,respectively. The most important traits of breeding ram selected by the respondent were Age, appearance, libido and color while the preferable traits used for selection of breeding ewes were milk yield, appearance, lamb growth, and lamb Survival across the two study districts. The natural uncontrolled mating was predominant in the study area. Sheep fattening was common in the study area.

The major sheep production constraints were feed shortage, disease and Drought in the study area. In the study area pastoralist marketing their sheep in the district and local markets. The sampled sheep in the study area had plain (50.7%) and patchy (49.3%), short and coarse hair (100%) , flat face profile ((93%) and Convex (7%) , long fat tail (79.1%) and Short fat tail (20.7%). Both sexes of sampled sheep populations were (100%) polled. Sex of the sheep had significant ($p<0.05$) effect on the body weight and linear body measurements. Most dentition classes of sheep contributed significant differences to body weight and the linear body measurements. The correlation coefficient between body weight and other linear body measurements were positive and significant both for male and female sheep. The result of the multiple regression analysis showed that heart girth alone could accurately predict body weight for male and rump height for female. The structural indices results indicated that the sampled sheep population was classified as dairy type and light meat type.

In general, most of the indigenous sheep was long fat tailed type with the major coat color pattern varies from patchy to plain of different colors. The head profile of indigenous sheep was mostly straight, with some possessed of wattles. All of males and females were polled. In conclusion, the current finding may provide preliminary information for further research in molecular characterization or for community-based breeding improvement program in the two study districts (Gela’alo and Gewane).

### 5.1. Recommendations

Based on the current study the following recommendations have been made:

- The present study showed that sheep producers dispose fast growing animals at younger age through sale at the market. Therefore, community based selective breeding program needed to control negative selection and improve the performance and productivity of sheep particularly males.
- Prevalence of disease and parasites, and poor health management negatively influenced productivity of sheep flock in the study area. Hence, the type, seasonal occurrence and economic losses due to the diseases and parasites should be documented and pertinent control measure should be introduced.
- The predominant production system of the area was traditional low-input-low-output with little market orientation. Thus, effort should be made to transform the system into market-oriented system using value chain framework with involvement of stakeholders.
- The study showed that producers have no access for market information. Therefore, it is important to disseminate livestock market information on time to actors and service providers through extension staff, or breeders cooperative.
- The study demonstrated that producers have poor capacity to adopt improved sheep production techniques. Thus, effort should be made to create awareness and develop capacity of producers on the subject.

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# 7. APPENDICES

list of appendix table 1The standard breed descripitor for qualitative traits of sheep developed by FAO(2012)

| Qualitative variables | Description of the traits |
|---|---|
| Sex: | Female, Male, castrate |
| Age | 1PPI,2PPI,3PPI,4PPI |
| hair coat color pattern | Plain, Patchy/Pied, Spotted |
| hair coat color type | Black, Dark Red, Light Red, Fawn, Grey,White , Red, Black, Brown, Dark brown |
| Hair type | hair, coarse wool, wool |
| Fiber type | hair sheep, wool sheep |
| Horn presence | Present, absent |
| Horn shape | Scurs, Straight, Curved, Spiral, Corkscrew |
| Ear orientation | Erect, Semi-Pendulous, Pendulous, Carried Horizontally |
| Horn orientation | Lateral, Obliquely Upward, Backward (Indicate Also if Animal is Polled or if Horns are Loose or Just Stumps) |
| Wattle | Absent, Present |
| Ruff | Present ,Absent |
| Facial (head) profile | Straight, Concave, Convex, markedly convex |
| Rump profile | flat,sloping,roof |
| Tail type | short fat,long fat,short thin,long thin,fat rumped |
| Tail shape | cylindrical + straight, cylindrical + turned up at end, bi-lobbed without appendage, broad without lobe, other |
| Body skin color | Pigmented, Not Pigmented |

list of appendix table 2ANOVA of body weight of indigenous sheep for the effect of sex,age and sex by age

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| age | 3 | 5326.989988 | 1775.663329 | 112.98 | <.0001 |
| sex | 1 | 2143.654978 | 2143.654978 | 136.39 | <.0001 |
| sex*age | 3 | 85.237042 | 28.412347 | 1.81 | 0.1447 |
| Error | 532 | 8361.54489 | 15.71719 | | |

list of appendix table 3ANOVA of chest girth of indigenous sheep for the effect of sex,age and sex by age

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| age | 3 | 2959.748048 | 986.582683 | 133.12 | <.0001 |
| sex | 1 | 867.952869 | 867.952869 | 117.12 | <.0001 |
| sex*age | 3 | 13.905634 | 4.635211 | 0.63 | 0.5988 |
| Error | 532 | 3942.685005 | 7.411062 | | |

list of appendix table 4ANOVA of body length of indigenous sheep for the effect of sex,age and sex by age

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| age | 3 | 2052.14609 | 684.048697 | 61.14 | <.0001 |
| sex | 1 | 392.509892 | 392.509892 | 35.08 | <.0001 |
| sex*age | 3 | 54.661992 | 18.220664 | 1.63 | 0.1817 |
| Error | 532 | 5952.479535 | 11.188871 | | |

list of appendix table 5ANOVA of height at wither of indigenous sheep for the effect of sex,age and sex by age

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| age | 3 | 2296.712966 | 765.570989 | 114.08 | <.0001 |
| sex | 1 | 678.882146 | 678.882146 | 101.16 | <.0001 |
| sex*age | 3 | 37.116609 | 12.372203 | 1.84 | 0.1382 |
| Error | 532 | 3570.213734 | 6.710928 | | |

list of appendix table 6ANOVA of rump height of indigenous sheep for the effect of sex,age and sex by age

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| age | 3 | 1738.901426 | 579.633809 | 64.68 | <.0001 |
| sex | 1 | 554.254601 | 554.254601 | 61.85 | <.0001 |
| sex*age | 3 | 34.132659 | 11.377553 | 1.27 | 0.284 |
| Error | 532 | 4767.683836 | 8.961812 | | |

list of appendix table 7 stepwise multiple Regression equations for estimation of live body weight of Males and females by fitting linear body measurements

| sex | Model | Intercept | Regression coefficient | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| male | | β0 | β1 | β2 | β3 | β4 | β5 | $R^2$ | C(P) | SE |
| | HG | -42.74 | 1.12 | | | | | 0.73 | 75.52 | 4.03 |
| | HG ,CW | -34.68 | 0.79 | 0.92 | | | | 0.80 | 18.58 | 3.63 |
| | HG,CW ,BL | -44.70 | 0.69 | 0.75 | 0.34 | | | 0.82 | 6.22 | 4.37 |
| | HG,CW,BL,SC | -48.66 | 0.62 | 0.70 | 0.38 | 0.89 | | 0.83 | -0.40 | 4.46 |
| female | | | | | | | | | | |
| | RH | -37.96 | 1.17 | | | | | 0.59 | 204.33 | 2.98 |
| | RH ,CW | -31.58 | 0.73 | 1.32 | | | | 0.71 | 32.88 | 2.56 |
| | RH,CW ,HG | -39.11 | 0.58 | 1.05 | 0.30 | | | 0.73 | 9.74 | 2.91 |
| | RH ,CW,HG,CD | -39.77 | 0.55 | 0.97 | 0.25 | 0.26 | | 0.73 | 5.54 | 2.90 |
| | RH ,CW,HG,CD,TL | -40.89 | 0.55 | 0.93 | 0.27 | 0.32 | -0.08 | 0.73 | 2.30 | 2.93 |

HG=hrart girth, CW=chest width, BL=body length, SC=shin circumference, RH=rump height, CD=chest depth, TL=tail length list of appendix table 8the standard breed descriptor for quantitative traits of sheep developed by FAO (2012)

| Traits | Definitions |
|---|---|
| Sex | Female, Male, castrate |
| Age | 1PPI, 2PPI, 3PPI, 4PPI |
| Ear length (cm) | Length of the ear on its exterior side from its root to the tip |
| Body length (cm) | Horizontal length (cm) from the point of shoulder to the hipbone |
| 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 |
| Height at withers (cm) | Height (cm) from the bottom of the foreleg to the highest point of the shoulder when the animal will standing upright |
| Body weight (Kg) | Live body weight (kg) measured early in the morning |
| Scrotum circumference (cm) | Measured from the middle of scrotum |
| Rump height (cm) | Height (cm) from the bottom of the hind leg to the highest point of rump when the animal was standing upright |
| Rump length (cm) | Measured from the back of the rump to the hook bones |
| Rump width (cm) | The horizontal distance b/n the extreme lateral points of the hook bone(tuber coxae)of the pelvis) |
| Horn length (cm) | the distance of horn from the base to the tip (cm) |
| Teat length (cm) | the length of the teat measured from the base of the teat to the end of the teat in centimeters |
| Head length (cm) | the length of the face from the poll of the animal to the end of muzzle in centimeter |
| Head Width (cm) | Maximum distance between zygomatic arches |
| Tail length (cm) | measured from the base of the tail to the end of the coccygeal vertebrae |
| Chest depth (cm) | the dorsal–ventral distance between the most dorsal point of the withers and the ventral surface of the sternum; |
| Chest Width (cm) | Maximum intercostal diameter at the level of the 6th rib, just behind the elbows |

list of appendix table 9overall weight (kg) of non edible carcass

| carcass | N | mean | SE |
|---|---|---|---|
| head weight | 30 | 1.32 | 0.28 |
| skin weight | 30 | 2.08 | 0.44 |
| lungs with trachea weight | 30 | 0.26 | 0.01 |
| tests with penis weight | 30 | 0.32 | 0.11 |
| spleen weight | 30 | 0.05 | 0.01 |

N=number of sheep, SE=standard error

Appendix figure 1:-House hold interviewing

Appendix figure 2:-focal group discusion

Appendix figure 3linear measurments both left and right side

Appendix figure 4:-live body weighting     Appendix figure 5:-separating carcass components

Appendix figure **6:-**dressed carcass weighing

List of figure in the appendix 1Sheep housing