CHARACTERIZATION OF GOAT AND SHEEP PRODUCTION SYSTEM AND PHENOTYPIC CHARACTERIZATION OF INDIGENOUS GOATSIN OROMIA ZONE OF AMHARA REGION, ETHIOPIA

MSc. THESIS

BY:

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Characterization of Goat and Sheep Production System and Phenotypic Characterization of Indigenous Goats in Oromia Zone of Amhara Region, Ethiopia

MSc. Thesis

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DEDICATION

I dedicate this piece of work to all of my family members for their unreserved love, encouragement and partnership in the success of my life.

STATEMENT OF AUTHOR

By my signature below, I declare and confirm that this thesis is my own work and that all sources of materials used for this thesis have been duly acknowledged and I have followed all ethical principles of scholarship in the preparation, data collection, data analysis and completion of this thesis.

This thesis is submitted in partial fulfillment of the requirement for MSc degree from the School of Graduate Studies at Jimma University. The thesis is deposited in the Jimma University Library and is made available to borrowers under the rules of the library. I solemnly declare that this thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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The author Mr. Teshome Mulualem was born on July 19, 1992 at Efratanagidim Woreda, North Shewa Zone, Amhara National Regional State, Ethiopia from his father Mulualem Gizaw and mother Yemarwuha Wesena.

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LIST OF ABBREVIATION

AAFRDO	Artuma Fursi Animal and Fish resource Development office
AnGR	Animal Genetic Resources
CACC	Central Agricultural Census Commission
C (p)	Mallows C parameters
CSA	Central Statistics Agency
DA's	Development Agents
ESGPIP	Ethiopia Sheep and Goat Productivity Improvement Program
FAO	Food and Agricultural Organization of the United Nations
FMD	Foot and Mouth Disease
FPC	Finite Population Correction
GLM	General Linear Model
ILRI	International Livestock Research Institute
JAFRDO	Jile Timuga Animal and Fish resource Development Office
KI	Kidding Intervals
LBMs	Linear Body Measurements
LSM	Least Square Means
MSE	Mean Square Error
OZAFRDO	Oromia Zone Animal and Fish resource Development Office
PPI	Pair of Permanent Incisor
PPR	Pest des Petit, Ruminants
PROC	Procedure
R^2	Coefficient of Determination
RMSE	Root Mean Square Error
SAS	Statistical Analysis System
SD	Standard Deviation
SE	Standard Error
SPSS	Statistical Package for Social Science
X^2	Chi Square

COMPARATIVE CHARACTERIZATION OF GOAT AND SHEEP PRODUCTION SYSTEM AND PHENOTYPIC CHARACTERIZATION OF INDIGENOUS GOATS IN OROMIA ZONE OF AMHARA REGION, ETHIOPIA.

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ABSTRACT

The objectives of this study were to describe sheep and goats production systems comparatively and to phenotypically characterize the goat population in three districts of Oromia zone (Artuma Fursi, Dewachefa and Jile Timuga). The study was performed based on household survey and field measurements. For household survey, 162 households (54 from each district) were involved while body measurements were taken from 600 goats (200 goats from each district). Data collected through questionnaire (survey) were described by descriptive statistics using SPSS. Observations on qualitative traits of goats were analyzed using frequency procedure of SPSS. However, quantitative traits were analyzed using SAS version 9.3, (2014). The overall average number of sheep and goats per household were 7.19±4.34 and 11.90±6.70, respectively in the study area. Agro-pastoral (84.6%) and pastoral (15.4%) were the main production system in the study area. The primary reason of keeping sheep and goats in all districts was for cash income. Goat milk is consumed by respondents particularly in Artuma Fursi and Jile Timuga districts with index value of 0.019 and 0.078, respectively. On the other hand, all respondents in the study area reported that using sheep milk for home consumption is forbidden by their culture. Natural pasture and river water were the major sources of sheep and goats feed and water respectively in both dry and wet seasons in the three districts.Majority (88.3%) of farmers in the study area practiced uncontrolled mating system. Appearance/body size, growth rate and color were the first, second and third selection criteria, respectively, to select breeding ram and buck in the study area. The overall liter size of sheep and goats were 1.27±.49 and 1.73±.82 in the study area, respectively. Diseases were the main production constraints in all of the study districts. The most frequent color patterns observed in the study area were plain (77.7%), patchy (20.2%) and spotted (2.2%). The predominant coat color type was fawn in Artuma-Fursi (30.0%) and (26.5%) in Dewa-chefa districts whereas in Jile-Timuga district (31.5%) red coat color was the most frequently observed color. The presence of horn was common in each of the three districts with a straight shape and backward orientation. District had significant ($P<0.05$) effect on body weight and other linear body measurements except cannon bone length, cannon circumference. Age classes of animals contributed significant ($p<0.05$) differences to body weight and most of the linear body measurements. Heart girth was the first variable to explain more variation than other variables in both female (62%) and male (68%) goats. The prediction of body weight could be based on regression equation BW = -19.55 + 0.63HG for female and BW = -45.72 + 1.0HG for male sample goat population. Goats had better economic importance than sheep with respect to income generation.Most body measurements of goats in Artuma Fursi and Dewachefa district relatively higher than Jile-Timuga district.

Key words: Body Weight, Characterization,Indigenous Goats, Qualitative Traits, Quantitative Trait

1. INTRODUCTION

Ethiopia is believed to have the largest livestock population in Africa (CSA, 2016/17). Small ruminants are preferred by the small holder farmers from the fact that they require small investments; have shorter production cycles, faster growth rates and greater environmental adaptability as compared to large ruminants (Helen *et al.*, 2013; Tatek *et al.*, 2016).

Sheep and goats are among the major economically important livestock species in Ethiopia. They are considered most prolific ruminant among all domesticated ruminant species especially under harsh climatic conditions (Tesfaye, 2004; IBC, 2004; Sebsibe, 2006). According to CSA (2016/17), Ethiopia has about 30.70 million sheep and 30.20 million goat population. Out of total sheep, about 72.14 percent are females, and about 27.86 percent are males. Similarly, out of the total goats, 70.61 percent are females and about 29.39 percent are males. Majority of the national goat population is found in the lowland areas of the country. Nearly all (99.99%) of the goats are indigenous types (CSA, 2016/17) which have become adapted to a wide agro-ecological zones of the country (Workneh, 1992) due to natural selection.

Sheep and goats are reared under diverse agro-ecological zones from very arid to very humid and over a wide range of production systems. Sheep and goats are relatively cheap and are often the first asset acquired, through purchase or customary means, by a young family or by a poor family recovering from a disaster such as drought or war. Sheep and goats, once acquired, become a valuable asset providing security to the family as well as milk and dairy products (ESGPIP, 2008). According to CSA (2016/17) the purpose of both sheep and goats kept for mutton and meat are higher for males. On the other hand, the same report revealed that female sheep and female goats are primarily kept for breeding purposes. Rearing of small ruminants play important socio economic role in many rural areas where they are reared for generating income and as bank on hooves (Belete *et al*., 2015). The purpose of keeping goats in highland systems is mainly meat production for sale. Whereas in the lowland areas, utilization of goat milk is common and meat production is also one of the main purposes for rearing the goat populations (Aschalew *et al*., 2000; Tesfaye, 2009; Mekuriaw *et al*., 2016).

On other hand sheep also play a major role in the food security and social well-being of rural populations living under conditions of extreme poverty (Duguma*et al.*, 2010). Generally, small ruminants account for about 40% of the cash income earned by farm households, 19% of the total value of subsistence food derived from all livestock production, and 25% of total domestic meat consumption (Adane and Girma, 2008). However, sheep and goat production constrained by different factors such as poor nutrition, prevalence of diseases, lack of appropriate breeding strategies and poor understanding of the production system(Tesfaye, 2009; Tsedeke,2007).

Phenotypic characteristics are important in breed identification and classification. Morphometric measurements used to evaluate the characteristics of various breeds of animals, and provide first-hand information on the suitability of animals for selection (Nesamvuni *et al*., 2000; Mwacharo *et al*., 2006; Martins *et al.*, 2009; Yakubu, 2010a) and for further characterization studies using modern molecular methods. Characterization studies are essential for improvement planning, sustainable utilization and conservation strategies of a breed at local, national, regional and global levels (FAO, 2012). Breed characterization is the first step in the crucial task of genetic resource conservation (Baker, 1992; FAO, 2011). In addition, knowledge of the adapted goat genetic resources is a pre-requisite for designing appropriate breeding and utilization programs.

In Ethiopia, based on physical description, goat population has been classified in to 14 goat types (Farm-Africa, 1996). However, these goat populations are re-grouped in to seven goat types (Getnet, 2016). Halima *et al.,* (2012) identified six morphologically distinct indigenous goat populations in Amhara region. Tegegne (2012) also identified two goat ecotypesin southwestern part of Ethiopia. However, genetic/molecular characterization revealed only the presence of eight distinctively different breed types or populations in the country (Tesfaye, 2004). The existence of such a large gene pool in various agro-ecologies is believed to be through the process of natural selection (Abegaz *et al*., 2008). It is important for breed improvement and conservation and for development of a sustainable animal production system (Mahmoudi *et al*., 2011). Even though, these previous studies (Alemayehu, 1993; Nigatu, 1994; Mahilet, 2012; Belete, 2013; Bruh, 2013; Alefe, 2014; Hulunim, 2014; Ahmed,

2013; Alubel, 2015; Tsigabu, 2015; Feki and Berhanu, 2016; Zergaw *et al*., 2016 and Belay, 2017) have identified the management practice of goat owners and phenotypic characterization of indigenous goats in Ethiopia, the diversity of production systems and genetic resources is not well-represented or described.

In Oromia administrative zones of Amhara region, Halima *et al.*, (2012) and Hulunim (2014) conducted goat characterization works only in Bati district. However, these studies were not represented the whole zone goat population. In addition, any casual observer can understand that physical appearance difference between goat population in Bati and the rest districts of Oromia administrative zones goat population. However, there is no empirical evidence to substantiate this hypothesis. Oromia administrative zone of Amhara region is found in lowland parts of the country, where indigenous sheep and goats are found in all districts of the zone. Characterizing these goat populations and comparatively describing rearing environment of sheep and goats is very essential to design management and utilization strategies. The comparative characterization of sheep and goat is very crucial for which type of small ruminant species is more important economically and their performance in the area. The characterization work is also important to implement the appropriate breeding strategies to improve the livelihoods of the small holder farmers and to satisfy the growing demand of meat for domestic consumption and international market. Therefore, the objectives of the study were:

- To assess sheep and goat production systems
- To assess sheep and goat reproductive performance and marketing systems in the study area
- To characterize indigenous goats phenotypically in the study area

2. LITERATURE REVIEW

2.1. Description of Sheep and Goat Production System in Ethiopia

Sheep and goat in Ethiopia and most developing regions are kept under traditional extensive systems. Sheep and goats are largely produced in mixed crop–livestock, specialized pastoral and agro-pastoral systems. Livestock production is of subsistence nature (Solomon *et al*., 2010). Sheep and Goat production in Ethiopia is described under low input production system and is operated by smallholder farmers. The main features of the low input goat production system are its full dependence on natural resources and the limited demand for inputs. This system is characterized by land scarcity, severe resources degradation and recurrent drought (IBC, 2004).

Ethiopian small ruminant production systems are broadly classified into "modern" and "traditional" (Tibbo, 2006; Getahun, 2008). The "modern" system is practiced only in few places such as government ranches and in small scale urban production systems while most of small ruminant production depends on the traditional extensive system of production (Tibbo, 2006; Solomon, *et al*., 2010). The major farming activities in the highland study area were mixed crop-livestock production system, whereas the lowland farmers practiced dominantly (83.1%) mixed crop and livestock farming followed by livestock rearing alone (16.9%) (Mekuriaw *et al*., 2016). In Ethiopia, sheep and goats are maintained under two broad production systems (Tembely, 1998; EARO, 2000; Solomon *et al*., 2010). These are mixed-crop-livestock farming system and agro–pastoral and pastoral production systems.

2.1.1. Mixed Crop-livestock Farming System

Both sheep and goats are raised in mixed crop–livestock systems. In a mixed crop–livestock production system, which is prevalent in humid, sub-humid and highland agro–ecological zones, goats are kept by smallholders and graze together with sheep and/or other livestock such as cattle. In these mixed-species grazing systems, goats complement cattle and sheep rather than compete with them for feed, because of their inherent ability to eat a wider variety of plant species (Yoseph, 2007). These mixed herds usually freely graze on communal pastures and seasonally on fallow cropland with no extra-supplement and receive minimum

health care. However, due to the increasing population pressure in areas with this production system, free grazing is becoming limited and goats are now tethered, reflecting the challenge of procuring sufficient feed in this system (FARM-AFRICA, 1996). Furthermore, in highland agro–ecology, as in central Ethiopia, increased human population has led to decreased farm size and a gradual shift from keeping large to small ruminants, mainly goat and sheep (Peacock, 2005).

Mixed crop-livestock system is commonly practiced in the most crop dominant area of high land and mid-altitude of the country, with altitude ranges of 1500 to 3000 m.a.s.l. The area receives good amount of rainfalls and has moderate temperature. The integration and the importance of small ruminants (goat) in the system vary from place to place. The integration is lower in south part of the country where the perennial crop production is more important and small ruminants are less important. In the dry highland area of the Northern part of the county, goat plays a great role where crop production is unreliable (IBC, 2004; Solomon *et al*., 2010a). The purpose of keeping goats in highland systems is mainly meat production for sale (Mekuriaw *et al*., 2016).

2.1.2. Agro- pastoral and Pastoral System

In pastoral and agro–pastoral production systems, which are found in arid and semi-arid agro–ecological zones, goats are kept by nearly all pastoralists, often in mixed flocks with sheep, freely grazing or browsing in the rangelands. This production system is associated with the purely livestock based nomadic and transhumance pastoral production systems based largely on range, primarily using natural vegetation. In the lowlands of Ethiopia, livestock is comprised of large flocks and herds of sheep and goats, cattle and camels mainly transhumant, where only surplus are sold at local markets or trekked to major consumption centers. Extensive livestock keeping is the backbone of the economies of the lowlands (EARO, 2000).

In the lowlands of Ethiopia, pastoralist production system with no or little farming is practiced and cattle and camels are kept to provide mainly milk. The climate in these areas is characterized by low, unreliable and unevenly distributed rainfall and by year round high

temperatures. Animal production often concentrates around water points and herd size per family is usually large (Azage *et al*., 2009). The system is characterized by high degree of dependency on milk and meat production and 10-50% of the income is derived from livestock production. In this system there is some crop agriculture practice along with the livestock production (IBC, 2004; Solomon *et al*., 2008).

Farmers/pastoralists choice of agricultural enterprises in Ethiopia depends on the production environment (availability of resources, particularly land, water and climate), long-standing tradition of agricultural production in the community, socio-economic circumstances (awareness and skill, access to inputs and markets), and government support (inputs and services) which stems from agricultural policies (Solomon *et al*., 2010).In the lowland goat population, utilization of goat milk is common and meat production is also one of the main purposes for rearing the goat populations (Mekuriaw *et al*., 2016).

2.2. Socio-Economic Importance of Sheep and Goats

Small ruminants have economic importance to small-holder farmers including female-headed households. The total income share from small ruminants tends to be inversely related to size of land-holding, suggesting that small ruminants are of particular importance for landless people especially for rural women (Oluwatayo and Oluwatayo, 2012). Goats in developing countries are considered to be one of the most important farm animals for the small- scale farmers, providing them with meat, milk, skins and manure (Tegegn, 2015). Likewise sheep also provide meat, milk skin and manure (Helen *et al*., 2013). The primary reason of keeping small ruminant is forincome generation (Dhaba *et al.,* 2012*;* Tsedeke, 2007; Belete, 2009; Getahun, 2008). The other reason of keeping small ruminants are saving, meat consumption, risk mitigation and manure production (Dhaba, *et al.,* 2012).

Knowledge of reasons for keeping animals is a prerequisite for deriving operational breeding goals (Rewe *et al*, 2006). Goats are socio–economically important in developing countries, ensuring food and fiber supply and providing income to small households (Lebbie, 2004; Gurmessa *et al*., 2011). The most frequently reported reason for keeping goat is cash income generation followed by milk and meat production for home use (Abraham *et al*., 2017).

Similarly the most frequent reason of keeping sheep is to derive income, saving, mutton and manure (Hizkel, 2017; Tassew *et al*., 2014). In addition Belete (2013) worldwide different goat breeds produce variety of products, including milk, meat and fiber (Galal, 2005).

Sheep and goats contribute a quarter of the domestic meat consumption; about half of the domestic wool requirements; about 40% of fresh skins and 92% of the value of semi-processed skin and hide export trade. At optimum off take rates, Ethiopia can export 700,000 sheep and 2 million goats annually and at the same time supply 1,078,000 sheep and 1,128,000 goats for the domestic market. The annual off take rate of sheep and goats is, however, only 33 and 35%, respectively (Alemu and Merkel, 2008).

2.3. Sheep and Goat Management Practices

2.3.1. Feeds and Feeding Systems

The major feed resources for sheep and goats include grazing on communal natural pasture, private pastures, crop stubble, fallow land, road side grazing, crop residues, browses, grains, improved forages, and non-conventional feeds like household feed left over. Grazing on crop stubble, private pastures, road sides as well as weeds from crop fields are the major feed resources for sheep and goats in Alaba district (Tsedeke, 2007). In addition Belete (2009) report that communal grazing land, roadside grazing, riverside grazing and aftermath grazing are the major types of grazing for sheep and goats in Goma southwest Ethiopia. Grazing is the common feed source for small ruminants throughout the year. Likewise Fikru and Gebeyahu (2015) grazing is the common feed source for small ruminants. Communal grazing land, roadside grazing, private grazing, riverside grazing and indigenous browser are the major types of feed for sheep and goats.

Similarly many reports Hizkel (2017); Mesfin (2015); Shewangzaw and Adis (2016); Tesfaye (2008) indicated that natural pasture is the main feed resource for small ruminants. Likewise Abrham *et al*. (2017) natural pasture, browse species, crop residue and crop aftermath are the major feed resource in 14 Western Tigray. Indigenous browse species are available feed resources for goats mainly in the dry season and the drought periods (March-June). Natural

pasture grazing and browsing on communal grazing lands, road and riverside and aftermath grazing are major sources of feed for small ruminants in Illu Abba Bora zone (Dhaba *et al*., 2012). Riverside grazing is the most important source of feed during the dry period in southwest Ethiopia. In addition crop-residues are used as a feed resource for sheep and goats (Assen and Aklilu, 2012).

2.3.2. Water Sources

Water resource is pertinent and vital for the subsistent life of livestock and livestock owners (Abrham *et al*., 2017). Water sources for livestock include rivers, streams, and ponds, deep well, pipe water and rain water harvest as well as springs. River is the major water sources for small ruminants in the Goma district of Jimma zone (Belete, 2009). Similarly Hizkel (2017) Yadeta (2016); Tsedeke (2007) reported that river water is the major source of water in Bensa, West Shewa and Alaba district respectively. Other water sources include ponds, deep well, pipe water and rain water during rainy season (Belete, 2009; Tsedeke, 2007). In addition Abrham *et al*. (2017) river, pond and borehole form the major source of water for domestic use and livestock watering. River, deep wells and pipe water respectively are the major source of water and also free access to water both during wet and dry seasons in Illu Abba Bora zone (Dhaba *et al*., 2012).

2.3.3. Common Sheep and Goat Diseases

Poor health management is one of the important problems hindering livestock productivity in Ethiopia Zewdu *et al*. (2012). Internal parasitic infestation has the highest incidence limiting small ruminant production in Ilu Abba Bora Zone of Oromia Regional State (Dhaba *et al*., 2012). Gastro-intestinal parasites are the major health problem of goats and sheep. Diseases and parasitic infestations are the cause of mortality and morbidity in South western parts of Ethiopia (Tsedeke, 2007). Similarly Fikru and Gebeyahu (2015) the spread of disease and parasites are the causing serious health problem of small ruminant in Eastern Ethiopia.

According to Desta (2017) the major diseases and parasites of sheep and goats in the Tigray region are pasteurellosis, sheep and goat pox, anthrax, brucella, peste des petits ruminants (PPR), and mange mites/skin diseases. Likewise Dhaba *et al*. (2013) Gastro-intestinal

parasites, Diarrhea, Bottle jaw, nasal, discharges(*furro*), trypanosomosis (*qoqsa*), liver flukes (*balle*) and anthrax are the major diseases and parasites of small ruminant in Southwest Ethiopia. Alubel (2015) reported that sheep and goat pox, Anthrax, PPR and Coenurosis are the major goat diseases in Ziquala district of Amhara National Regional State.

2.4. Reproductive Performance of Sheep and Goats

Reproductive performance is a prerequisite for any successful severely limited as it is often the case in sub-Saharan Africa.Reproduction failure is the first sign of decreased productivity (Mukasa-Mugerwa *et al.*, 2002). Evaluations of the performance of economically important traits of the livestock are very useful inputs for planning a breeding program (Solomon, 2014). Good reproductive performance is a prerequisite for any successful genetic improvement and it determines production efficiency (Zewdu, 2008). It is depends on various factors including age at first lambing, litter size, lambing interval and the life time productivity of the ewe, the last one being related to longevity (Sulieman *et al*., 1990; cited by Amelmal,2011). Yadeta (2016) also reported, productive and reproductive performance depends on various factors including: AFL (age at first lambing), weaning age, slaughter age, age at sexual maturity of male, LI (lambing interval)/ KI (kidding interval), LS (litter size) and reproductive life span, are economically important traits for both sheep and goats. The reproductive performance of Ethiopian sheep and goats shown in Table 1 below.

Reproductive performance is an important criterion when evaluating the structure of the strength and weakness of the breeds in particular production environments (Browing *et al*., 2006). It has high impact on overall flock productivity. Poor reproductive performances of Ethiopian sheep and goats can be associated with genetic factors, poor management, seasonal fluctuations in feed resources and diseases (Mukasa-Mugerwa *et al*., 2002).

Table 1. The reproductive performance of Ethiopian sheep and goats

Goat breed types	Traits			Source
	Age at first kidding /lambing, months	Kidding/lambing interval, months	Litter size	
Central highland	13.59	10.26	1.16	Taye *et al.*,2013
Abergelle	15.5	8.3	-	Solomon,2014
Bati	14.9	7.9	-	Hulunim,2014
Local goats in Jimma	12.5	9.1	1.6	Blete ,2009
Local goat in Tigray	15.01	8.41	-	Assen and Aklilu,2012
Arsi bale	12.1	6.9	1.75	Tsedeke,2007
Keffa	12.5	7.9	1.7	Belete,2009
Local goats in Illu Abba Bora	10-13	9-11	-	Dhaba *et al.*,2013
Local sheep in Ada Barga and Ejere	14.25	8.55	1.25	Yadeta, 2016
Sheep breed types				
Local sheep in Jimma	12.9	7.3	1.4	Belete ,2009
Local sheep in Tigray	13.92	8.41	-	Assen and Aklilu,2012
Begayt	24.38	8.55	-	Ashebir *et al.*,2016
Arsi bale	12.7	12.7	1.70	Tsedeke,2007
Aberasheep in Sidama	12.9	9.6	1.5	Marufa *et al.*,2017
Menz	15.22	7.6-9.1	-	Abebe,1999
Local sheep in Illu Abba Bora	10-13	9-12	-	Dhaba , 2013
Local sheep in Gamogofa Zone	12.4	7.34	1.3	Fsahatsion *et al.*, 2013
Local sheep in Ada Barga and Ejere	14.29	8.83	1.19	Yadeta, 2016

2.5. Sheep and Goat Breeding Practices

Farmers breeding management decision is determined by the merits of livestock species and breeds, farmers breeding objectives and the production environment. Male and female animals run together throughout the year and mating/breeding is uncontrolled, mating and thus lambing/kidding seasons are concentrated in seasons when feed is most available (Solomon *et al.*,2010). Sheep and Goat production in Ethiopia is constrained by many biological, environmental and socio- economic factors. Among them, lack of systematic breeding programs is an important constraint. Therefore, there is a need to design and implement the appropriate breeding strategies to improve the livelihoods of the small holder farmers and to satisfy the growing demand of meat for domestic consumption and international market.

However, there is no systematic goat breeding program is in place and goat is the most neglect livestock species in research and development endeavors (Tsegahun, *et al*., 2000). Several studies have shown that goat keepers have developed their own breeding practices which include selection of bucks (Grum, 2010) or does (Tegegne, 2012) and rams or ewes (Tesfaye,2008) that are used either in controlled (Grum, 2010) or uncontrolled (Tesfaye *et al*., 2012) mating systems. Whereas, only few farmers keep their own breeding ram and buck (Tsedeke, 2007). In most studies the mating system is uncontrolled due to communal grazing land and small flock size. However, in pastoral and agro-pastoral areas where flock sizes are large, rates of inbreeding are comparatively low (Grum, 2010).

A Selection criterion is the main tools to undertake breeding program for all livestock species, the efficacy of selection depends on the heritability of the trait selected for or againstLorato *et al*. (2015). Farmers give more focus to the selection of females (e.g. twinning rate) (Tegegne, 2012).The main selection criteria of female goats in West Tigray zone is: body size, twining ability and milk yield (Abraham *et al*., 2017). Body size/appearance, color and prolificacy are the main selection criteria of does in Nuer zone of Gambella region (Tsigabu, 2015). In Alubel (2015) report milk production, twining ability, body conformation and frequent kidding are the main selection criteria of does. Whereas; Helen *et al*. (2013) reported in ewe selection appearance, coat color and lamb survival in eastern Ethiopia. Similarly,appearance/conformation, liter size and color are the major selection criteria of ewes (Taye *et al*., 2016; Tesfaye, 2008). Large body size, muscling and long large and broad tail are the most desirable physical traits for selection of breeding rams, while for breeding bucks good muscling, large body length and height(Dhaba *et al.,* 2013).

Traditionally livestock are generally selected for their adaptive traits, indicated that survivability and performance during harsh climates. It has been reported that several strains of a single breed may be observed based on the agro ecology where they were developed or even on the cultural and socio economic needs of the reared and in their production system (Gebregzaber, 2016; Lorato *et al*., 2015). One of the important factor associated with the development of the different strains are the vegetation available to the animals or even geographical isolation between the different strains (Solomon *et al.,* 2014).

2.6. Major Constraints of Sheep and Goats Production in Ethiopia

Sheep and goat production and productivity in Ethiopia are generally low. This is mainly a result of low per capital production. Low per capital production is in turn a result of a combination of low reproduction rate, high mortality rate and slow growth rate (Solomon *et al.*, 2010). Sheep and goat production in Ethiopia is constrained by many biological, environmental and socioeconomic factors. Important constraint are, scarcity of feed, lack of infrastructure, high prevalence of diseases and parasites, lack of record, poor market management and inappropriate breeds and high levels of inbreeding, uncontrolled grazing management, lack of superior genotype, lack of labor and extension service, water shortages, and predation have been identified as the major constraints to sheep and goat production (Tsedeke, 2007). Diseases and parasites are the major constraints to improved small ruminant production and productivity in most production systems/agro-ecological zones (Solomon *et al.*, 2010). Similarly Fikru and Gebeyahu (2015) the major constraints of sheep and goat production and productivity are diseases and parasites are the main cause of mortality. In addition Dhaba *et al*. (2012) high prevalence of diseases and parasite infestation, Feed shortage, are the major constraints to small ruminant production in southwest Ethiopia. In many studies occurrence of various diseases is the common and first priority challenge for all goat populations (Mekuriaw *et al*., 2016, Belete, 2013). Feed and grazing land shortage are also the most limiting constraint in small ruminant production (Belete, 2009; Assen and Aklilu, 2012). Feed shortage, disease occurrences and drought are the major problem of goat production (Hulunim, 2014).

2.7. Distribution and Classification of Indigenous Goat Breeds of Ethiopia

Ethiopia has the largest livestock population in Africa and a home land of large number of goat populations which are kept in various production systems and different agro-ecological zones of highlands, sub-humid, semi-arid and arid environments Mekuriaw *et al*. (2016). Indigenous goat breeds/types are widely distributed and are found in all agro-ecologies of Ethiopia and it appears they have evolved through a process of natural selection (Galal, 2005) that favored adaptation and survival rather than production. The majority of the goat population is found in large flocks in the arid and semi-arid lowlands. In pastoral and

agro–pastoral production systems, found in arid and semi-arid agro–ecological zones, goats are kept by nearly all pastoralists, often in mixed flocks with sheep, freely grazing or browsing in the rangelands (Yoseph, 2007).

A comprehensive phenotypic characterization of Ethiopian goats was done by Farm Africa (FARM Africa, 1996) classifying indigenous goats based on their geographic location and the ethnic communities who keep them. Goat breeds found in Ethiopia have been identified and classified based on their differences in physical characteristics and genetic make-up. The physical characteristics include body color, size and shape of body parts, and presence or absence of body parts. Identification and classification of breeds based on physical characteristics can be supported by advanced tools. Advanced classification is based on differences between breeds in their genetic make-up. For this purpose, analysis of the genetic material called DNA is required. Such classification results in identification of genetically distinct breeds (Solomon, 2009).

According to earlier characterization work, indigenous Ethiopian goats have been phenotypically classified into 11 types while physical and genetic characterization showed only eight distinctively different types (Tesfaye, 2004). Based on the goat physical, morphological and functional characteristics descriptors, the Ethiopian goats have been phenotypically and genetic differences at the DNA level, four families and 12 breeds of goats have been identified in Ethiopia (Farm Africa, 1996;Tesfaye, 2004). Tesfaye (2004) has classified these indigenous goat types of Ethiopia in to 8 distinct genetic entities using genetic DNA markers, These are: -Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergalle, Afar, Highland goats (previously separated as Central and North West Highland) and the goats from the previously known Hararghe, South eastern Bale and Southern Sidamo provinces (Hararghe Highland, Short-eared Somali and Long-eared Somali goats).However, Getnet (2016) reported that Ethiopian goat populations are re-grouped in to seven goat types namely the previous (Gonder and Abergelle) grouped as Tekeze-Vally goat type, (Afar, Long eared Somali, Small eared Somali and Woyto-Guji) as dry lowland goat type, (Ambo and Agew) as North-West central highland goat, (Arsi-Bale and Hararghe highland) as mixed goat, Gumuz as Wet-lowland goat, (Nubian and Barka) as Nubian and Keffa goats.

Getnet *et al.* (2005) identified five morphologically different goat types, namely: Felata, Arab, Gumuz, Oromo and Agew. Felata, Arab and Gumuz goats predominate in semi-arid zones while Agew and Oromo goats are found in sub humid zones of the region. In the southwestern part of Ethiopia, Tegegne (2012) defined two goat ecotypes: Meanit and Sheko which are most likely ecotypes of Keffa goats previously characterized in the adjoining area. Likewise, based on their morphological characteristics Halima *et al*. (2012) characterized six goat ecotypes these are:- (Gumuz, Begia-Medir, Agew (West Amhara Region goat population) and Bati, Central Abergelle and Abergelle (east Amhara Region goat population) found in Amhara Region of Ethiopia and clustered in to two main groups. Gumuz, Agew and Begie-Medir the first group and Bati, Abergelle and Central Abergelle grouped as the second.

A family is a group of breeds that are genetically more related and physically more similar than breeds outside the group. The families and breeds are named after their geographical location, the ethnic communities maintaining them, or based on some identifying physical features. Some breeds are known by different local names in different localities. Breeds are also not bounded by political boundaries and the same breed can be present in different countries for example the Barka goat in Eritrea (known as Begayit in Ethiopia) and Nuer sheep in Sudan (Gambela goat type **)** (Tsigabu *et al*., 2015).

2.8. Characterization of Goat Genetic Resource in Ethiopia

Breed characterization includes all activities related with the description of the origin, development, structure, population, quantitative and qualitative characteristics of the breeds in defined management and climatic conditions (Ayalew*et al*., 2004; Rege, *et al*., 2006; Solomon *et al*., 2011). Breeds can be characterized by morphological (phenotypic) and molecular tools. Breed characterization is the first step in the urgent task of genetic resource conservation. In order to make a first attempt at identifying the goat types of Ethiopia, FARM-Africa began a national goat breed survey of Ethiopia and Eritrea in 1990. This document identifies and characterizes the indigenous goat types in Ethiopia and Eritrea. Description of the goat type includes local names, origins, races, distribution, agro climatic

zones, management systems, flock size, flock structure, feeding, housing, major problems, key identifying features, products (milk, meat, skins), productivity (reproduction), research done and reference person (FARM Africa,1996).

2.8.1. Phenotypic Characterization

Phenotypic characterization of AnGR process of identifying distinct breeds or populations by describing their external and production characteristics in a given environment and under given management, taking into account the social and economic factors. The information generated by characterization studies is essential for planning the management of AnGR at local, national, regional and global levels (FAO, 2012).

Phenotypic characterization of animal genetic resources for food and agriculture (AnGR) is the practice of systematically documenting the observed characteristics, geographical distribution, production environments and uses of these resources (FAO, 2011). Phenotypic characterization is essential in mapping out an inventory of characteristics peculiar to a group of animals and sustainable use of its animal genetic resources. Lack of information on characterization of genetic resource may lead to underutilization of that resource, its replacement and dilution through cross breeding despite their local adaptation to prevailing environmental constraints (Manzi *et al*., 2011).

Phenotypic characterization activities are technically and logistically challenging. Ensuring that they are well targeted (collect data that are important to the country's priority AnGR and livestock-development activities) and are carried out in an efficient and cost effective manner requires thorough planning and careful implementation. Valid comparisons among livestock breeds or populations, whether nationally or internationally, require the development and use of standard practices and formats for describing their characteristics. Such standards and protocols are also needed for assessing requests for the recognition of new breeds (FAO, 2012).

Physical description of a breed should focus on characters which, in the view of keepers of the breed and local experts, facilitate identification of animals as being members of the breed or strain. These should include coat color (common and/or special colors and color

combinations); horn shape and size; and presence or absence of horn, rump height, and other specific visible characteristics physical or morphological characteristics can be particularly useful in the classification of populations/strains/breeds within a species (Farm Africa, 1996). FAO (2012) also reported that, breed characterization through phenotype, is based on the description of qualitative and quantitative traits.

In addition to physical characteristics, phenotypic characterization of livestock breeds also includes information on population size, flock size and composition, production estimates and information on the production environment and husbandry conditions, which are known to play vital roles in trait expression. This method provides basic evidence for the variation between and within livestock populations, which could be utilized for selection purposes (Okpeku *et al.*, 2011).

2.9. Quantitative and Qualitative Trait Characteristics

2.9.1. Qualitative Characteristics

This category of traits covers the external physical form, shape, color and appearance of animals which are recorded as discrete or categorical (FAO, 2012). Qualitative are those that can be categorized like coat color, presence/absence of horns, beard, ruff, muzzle, toggle, facial profile, ear form, horn orientation, ear orientation hair length *etc*. The physical descriptions of different Ethiopian goat breeds were reported by many autors such as: Alubel (2015); Tsigabu (2015); Yaekob *et al*. (2015); Hulunim (2014); Alefe (2014); Ahmed (2013); Belete (2013) Dereje (2013); Halima *et al.* (2012); FARM Africa, (1996) etc. Qualitative characteristics of goats describe in table 2 below.

Table 2.Qualitative characteristics of goat of Ethiopian

Breed/Type	facial profile	Horns type	Coat color	Ear orientation	
Nubian	63% convex, 37% straight	63% curved backwards	72% black	long ears	Farm Africa(1996)
Afar	Concave narrow face	Thin long up ward-pointing	white 48% with Patch coat	Pick eared	Farm Africa(1996)
Bati	83.33% Straight and 14.2% Slightly concave	96.7% Straight	29.63%Dark red/brown and 22.2%light red	59.88% lateral and 35.8% Hanged down	Hulunim(2014)
Abergele	98.77Straight	70.1% Curved backward	30.98% Red/brown,30% White and red	98.1% carried horizontal orientation	Alubel, 2015
Arsi –Bale	90.32% flat	59.52% straight forward,	45.71%White and 20.63%black+white	57.4% lateral and 36.5 Dropped	Belete (2013)
Woito-Goji	80.6% Straight to concave	71.4% straight and 18.8% spiral	45.7%Brown, 20.1% Black and 19.9% white with 91.2% plain	69.8% Semi pendulous and 30.3% horizontal	Yaekob *et al*,2015
Harerghe Highland	98.2% Straight	45.2%Straight and 41% are polled	34.5%Brown and 26.2% white coat, 15.6% Black and 14%grey with 70.3% plain color pattern	81.9%horizontal orientation	Dereje (2013)
Short eared Somali	77.78%Straight facial	54.4% straight with 61.54% backward orientation Upward pointing	36.27% White in color with 45.08% plain pattern	84.9% Forward Erected	Hulunim(2014)

Table 2. (*Continued)*

Long eared Somali	43.75% Straight and 32.3concave	51.3%Curved and 48.9 straight	70.83%White with 72.4% plain pattern	76.04% Semi pendulous	Alefe(2014)
Central highland	84.39% straight facial	74.3% Curved	34.71% White and red, 21.66 White	54.1% carried horizontal	Alubel, 2015
Western highland	100%Concave facial	76%Straight pointing backward	42%white and 42% fawn	Long eared	Farm Africa(1996)
Western low land	52.1%Concave facial	64.3% Straight pointing backward	23.2% White	60.5% Pendulous orientation	Tsigabu (2015)
Keffa	92%.Straight facial	83% straight Pointing backwards	Black (30%) or brown (31%).	Small ears	Farm Africa(1996)

2.9.2. Quantitative Trait Characteristics

Knowledge of these quantitative characteristics is important to implement genetic improvement (selection), appreciate variations among goat populations so as to facilitate their sustainable use and estimate live body weight from simple and more easily measurable variable as well as market value in terms of cost of the animals (Hulunim,2014). This category of traits covers the size and dimensions of animals' bodies or body parts, which are more directly correlated to production traits than qualitative traits and have continuous expression because of numerous genes that determine their expression (FAO, 2012). These traits include different body measurements viz. heights (rump, withers), lengths (diagonal, head, ear, horn, neck, muzzle, tail, legs) and girths, (belly, chest) depths as reported by some other previous researchers. Body size is found to be a key classifying physical characteristic of Ethiopian goat families. Body size refers to the height, length and width of the animal. Such measures of body size are called linear body measurements and include height at withers and chest girth. Linear body measurements are taken using a measuring tape (Solomon, 2009). The physical descriptions of different some Ethiopian goat breeds is shown in Table 3 below.

Table 3.Linear body measurements in adult of indigenous goat breeds.

Breed	Parameters (Mean + SD)					
	WH (cm)	BW (kg)	CG (cm)	EL(cm)	HL(cm)	Reference
Nubian	70.1 ± 3.4	34.1± 5.4	74.3 ± 3.8	20.1 ± 3.6	14.6 ± 2.9	Farm Africa(1996)
Barka	69.73±0.02	34.05±0.3	-	23.63±0.1	19.52±0.1	Gebrekiros (2014)
Afar	60.9 ± 3.3	33.8 ± 5.3	67.4 ± 3.8	12.3 ± 1.8	17.4± 3.9	Farm Africa(1996)
Gumuz	65.09	34.65	75.03±0.77	13.23	-	Halima *et al*.(2012)
Bati	66.36	29.87	70.02±0.56	13.72	-	Halima *et al*.(2012)
Begia-Medir	71.35	32.54	73.93±0.74	14.44	-	Halima *et al*.(2012)
Abergelle	65.31±0.3	27.52±0.3	70.21±0.3	12.81±0.1	23.3±0.3	Alubel (2015)
Arsi-Bale	66.66±0.16	29.52±0.2	71.95±0.17	14.0±0.04	9±0.03	Belete (2013)
Woyto-Guji	66.4±3.5	28.8±5.0	72.5±4.2	12.5±1.0	10.8±3.7	Farm Africa(1996)
H. Highland	59.6±0.21	23.7±0.21	66.6±0.23	13.04±0.1	8.47±0.15	Dereje (2013)
C. Highland	71.02±0.3	33.95±0.4	74.90±0.3	15.04±0.1	15.74±0.3	Alubel (2015)
W. Highland	66.2±0.1	26.8±0.2	69.2±0.2	14.9±0.1	12.8±0.4	Ahmed(2013)
W. Lowland	56.5±0.06	19.8±0.1	62.8±0.1	13.0±0.1	-	Tsigabu (2015)
S.E. Somali	62.88±0.25	24.67±0.3	67.27±0.3	12.99±0.1	17.51±0.3	Hulunim(2014)
L.E. Somali	66.2±0.2	31.09±0.1	73.0±0.1	14.3±0.0	8.6±0.0	Alefe(2014)
Keffa	66.7±4.0	28.2±5.2	72.2±4.5	13.0±1.0	11.6±3.6	Farm Africa(1996)

3. MATERIALS AND METHODS

3.1.Description of the Study Areas

The study was conducted in three districts namely, Artuma Fursi,Dewachgefa and Jile Timuga districts of Oromia zone which is located in Amhara Regional state in north eastern Ethiopia. The geographical area of these three districts is shown as shaded area in figure1.

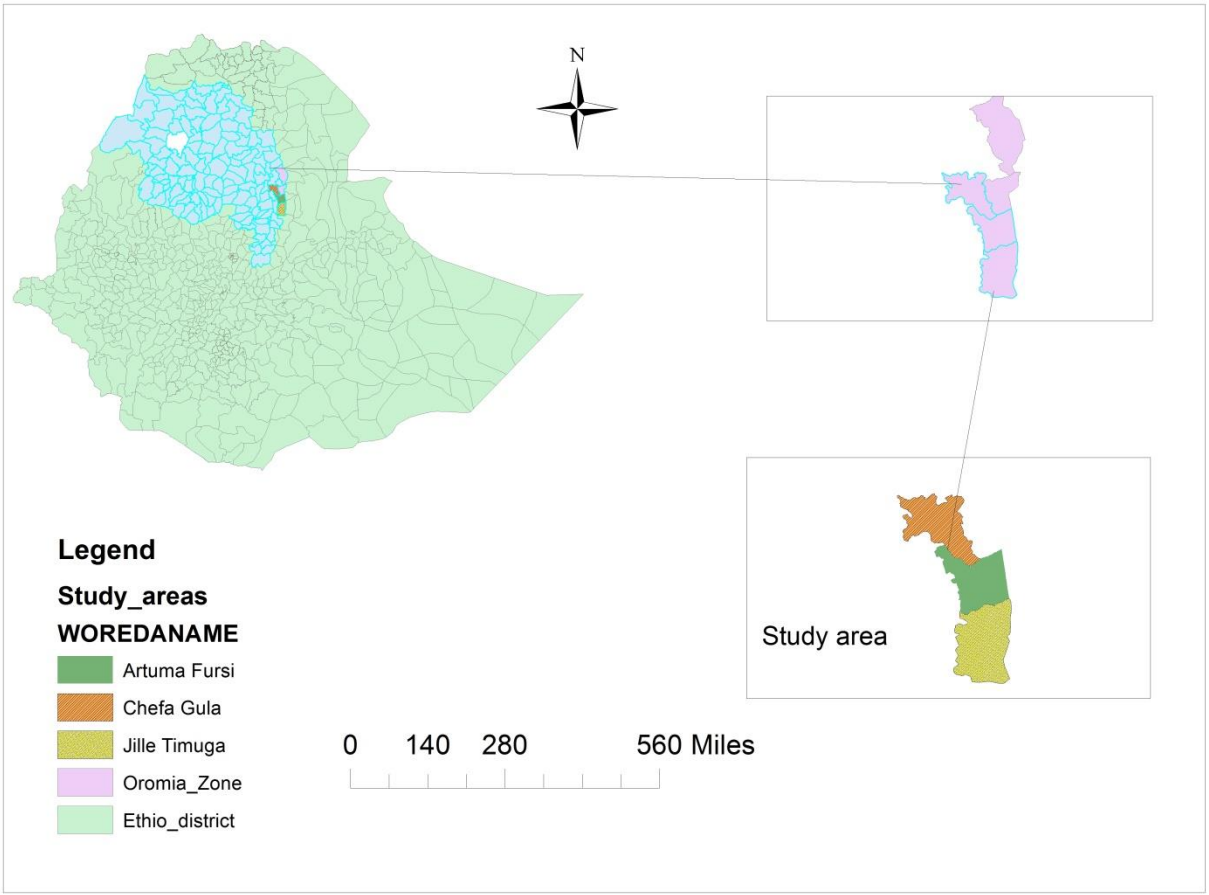

Figure 1. Map of the study area

3.1.1. Artuma Fursi districts

Artuma Fursi is one of the districts in the Oromia Zone of Amhara regional state bordered on the south Jile Timuga, on the west by the north Shewa zone, on the northwest by Dewachefa, on the north by the Afar Region. The area is located at 10° 18′ 45”N, latitude and 5°18′ 44’’ E longitude.

The total land area of the district is about 1,078.09 km^2, from these 38% % plains (Plateau), 28.5% mountains, 6.6% valley, 22.5% on intermediate level, 4.4% swamp. The altitude of the area ranges from 1000 to 2500 m above sea level. The climatic condition of Artuma Furs district80% lowland (Kola) and 20% midland (Weyna Dega). The maximum temperature is 33 °C and the minimum temperature is about 15 °C and the mean annual rainfall ranges from 600-900mm.

According to AAFRDO (2017) report Artuma Fursi district have 24 rural kebeles and 2 urban kebeles. The estimated human population of the district is 109,681 from which 54, 204 are males and 55477 are females. The total livestock population of the Artuma Fursi district is consists of 63, 6264 cattle, 18,821 sheep, 29,535 goats, 10,938 donkeysand 53,776 poultry.

3.1.2. Dawa Chefa districts

Dawa Chefa is one of the district in the Oromia Zone of Amhara regional state bordered on the south by Artuma Fursi, on the southwest by the North Shewa Zone, on the northwest by the Debub Wollo Zone, on the northeast by the Argobba special woreda, and on the east by Dawa Harewa. Dawa Chefe was part of former Chefe Golana Dewerahmedo district. The town of Kemise is surrounded by Dawa Chefa district.

The area is located at 10°43′N, latitude and 39°52′E longitude. The total land area of the districtis about 568.92 km^2. Dawa Chefa districtfalls within 89% Kolla (lowland), 10% Weyna Dega (midland) and 1% Dega Highland) agro-climatic condition.The altitude of the area ranges from 1500 to 2600 m above sea level. The mean annual rainfall of the woreda ranges from 660 mm to 1100 mm and the mean annual temperature ranges from12-33 ^{0}C. The rainfall distribution of the study area has highly seasonal and temporal variations. According to the OZAFRDO (2017) report, the total livestock population consists of 94,460 cattle, 34,224 goats, 33,395 sheep, 8,274 donkey, 4,114 camel and 65,193 poultry.

3.1.3. Jile Timuga districts

Jile Timuga is one of the districts in the Oromia Zone of Amhara regional state which is bordered on the east and south by the Afar Region, on the west by the North Shewa Zone, and on the north by Artuma Fursi. Senbeta is the center of the district. The area is located at 10^0 02′ -10^0 25’ N, latitude and 39°55′ -40^0 24’E longitude.

According to the information from the Jile Timuga agricultural and rural development office (2017/18),the total land area of the districtis about 882.56 km^2, from these 39.7% % plains (Plateau), 22.3% mountains, 31.% valley and 7% on intermediate level. District is divided into 94.07% kola (lowland) 5.93% weynadega (midland) agro-ecological zones. The mean annual rainfall ranges from 605-900mm and the maximum and minimum temperature is 33 °C and 12°C respectively. The altitude ranges between 1000-2000 m.a.s.l.

The total human population of the districtis 82,124 out of which 40,225 are males and 41, 598 are females. From the total population above 92.51% live in rural kebeles and livestock rearing and crop production is the main activities of the farmers. Jile Timuga district have high livestock population from those 119216 cattle, 54,575, goats, 30,154 sheep, 6992 camels, 7722 donkeys and 44030 poultry (JAFRDO, 2017/18).

3.2. Sampling Technique and Sample size Determination

Purposive sampling was applied to select the study districts. The survey was conducted in three sample districts (Artuma Fursi, Dawa Chefa and Jile Timuga) which were selected based on the presence of a relatively large proportion of sheep and goats. From three districts totally nine kebeles (three from each) namly Chereti, Chaka and Kechecho from Artuma Fursi Dodo,Teref and Tucha from Dawachefa and Fugnadenbi, Beta and Werelencha from Jile Timuga were purposively selected again based on relatively large sheep and goat population. From each kebele, households which had at least two sheep and two goats were randomly selected and interviewed.

For body measurements and qualitative trait descriptions of goats, castrated goats, pregnant doe and kids were avoided from the sample goat population for body measurement and description trait in orderto enhance accuracy and to represent the adult goat population. Then, sample goats were taken by using simple random sampling method. Dentition was used to determine the estimated age class of goats and goats which had one and above pair of permanent incisor (1PPI) was used for body measurements and qualitative trait descriptions.

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

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

n = sample size
Z = standard normal deviation (1.96 for 95% confidence level)
P = 0.12 (estimated population variability proportion, 12%)
q = 1-Pi.e. (0.88)
e = level of precision (0.05)
Based on the formula,

$$\mathbf{n = \frac{Z^2 \times p(q)}{e^2} = \frac{[(1.96)^2 \times 0.12(1 - 0.12)]}{(0.05 \times 0.05)} = \frac{3.8416 \times 0.1056}{0.0025} = 162}$$

Based on this 162 sheep and goat owner households (54 from each districtand 18 from each kebele) were interviewed about production systems from all the study districts.

For body measurements and qualitative trait descriptions, dentition was used to determine the age and goats which had one and above pair of permanent incisor (≥1PPI) was used for body measurements and qualitative trait descriptions. Pregnant female and castrated male was not included to avoid inaccuracy for body weight and linear body measurements (LBMs). Based on FAO (2012), from the total sample size, 10% of goats were male whereas the other 90% were females. The sample size was determined by the formula given by Cochran's (1977) as FAO (2012) recommended for phenotypic characterization of livestock for simple random sampling.

$$n = \left(\frac{Z^2 * (p)(q)}{e^2}\right.$$

n =sample size for infinite population

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

p= the estimated value for the variability proportion of the population, 50% conservative population variability

q=1-p

e=level of precision (0.05)

Based on the formula,

$$\boldsymbol{n = \frac{Z^2 \times p(q)}{e^2} = \frac{[(1.96)^2 \times 0.154(0.846)]}{(0.05 \times 0.05)} = \frac{3.8416 \times 0.130284}{0.0025}} = 200$$

This is for one district, for three districts 3*200=600. Therefore totally 600 (200 from each district)indigenous goats used for collecting data of quantitative and qualitative traits descriptions.

Table 4. Summary of the total number of samples

Districts	Study kebeles	Liner body measurement			Household	Group Discussion
		Adult females	Adult males	Total		
Artuma Fursi	Chereti,	60	7	67	18	1
	Chaka	60	7	67	18	1
	Kechecho	60	6	66	18	1
Dewachefa	Dodo	60	7	67	18	1
	Teref	60	6	66	18	1
	Tucha	60	7	67	18	1
Jile Timuga	Fugnadenbi	60	7	67	18	1
	Beta	60	7	67	18	1
	Werelencha	60	6	66	18	1
Total	9	540	60	600	162	9

3.3. Data Types and Method of Data Collection

3.3.1. Comparative Characterization of Sheep and Goats Production System

The questionnaire covered various aspects of livestock species with more details on sheep and goats production and marketing systems. A semi-structured questionnaire was used in designing the questionnaire prepared by International Livestock Research Institute (ILRI) (Workneh and Rowlands, 2004). Based on the questionnaire, socio economic characters like sex, age, education level, marital status, household size, composition of livestock species, flock size, flock structure, economic importance, management practices like feed and water resource utilization and availability, breeding practices, health conditions, reproductive performance and problems, production constraints and market price of sheep and goats were collected.

In addition, information was collected from group discussions and the group included extension workers, DAs, model farmers, village leaders, elders, women and socially respected individuals. The focus of the discussions was reason of keeping sheep and goats, major selection criteria of male and female animals (sheep and goats), major constraints, and economic importance of sheep and goats, special distinguishing features of the indigenous sheep and goat production system.

Secondary data like: climatic data (temperature and rainfall), geographical location, and livestock population demography was collected from Zone administrative office, the district, office of agriculture Rural Development and other written documents.

3.3.2 Morphometric Data Collection

Morphometric data was collected based on breed morphological characteristics descriptor list of FAO (2012). Qualitative traits such as coat color pattern, coat color type, hair type, horn presence, horn shape, horn orientation, ear orientation, back profile, head profile, rump profile, toggle presence, beard presence, and ruff presence was recorded through visual observations. Quantitative traits such as Body Length (BL), Height at Withers (HW), Heart

Girth (HG), Chest depth(CD), Shoulder Width (SW), Pelvic Width (PW), Ear Length (EL), Rump Length (RL), Rump width(RW), Canon Bone Height(CBH), Canon Bone Width (CBW), Horn Length (HL), and Scrotum Circumference (SC) for males was collected using tailors measuring tape while body weight (BW) was measured using spring balance.The data from questioner and quantitative and physical observation was collected from February 4, 2018 to May 6, 2018.

3.4 Data Management and Statistical Analysis

All data gathered during the study period was coded and recorded in Microsoft Excel. Preliminary data analysis like homogeneity test, normality test was employed for quantitative data before conducting the main data analysis. Different types of statistical analysis were used depending upon the nature of the data. All data was analyzed by SAS version 9.3 (2014) and SPSS Version 20.

Data generated from questioners was described and summarized using descriptive statistics. Chi-square (x^2) test was carried out to assess the statistical significance among categorical variables using district as fixed effect. Index was calculated for data that needs ranking like reasons for keeping sheep and goats, feed resources during the dry and wet seasons, selection criteria associated with breeding females and males, reproductive problem of sheep and goats, disease observed and production constraints of sheep and goats.$$I = \sum \frac{3 \text{ x I st} + 2 \text{ x I nd} + 1 \text{ x I rd given for an individual reason}}{3 \text{ x I st} + 2 \text{ x I nd} + 1 \text{ xI rd for all reasons}}$$

For adult animals, sex and age group and study area (district) of the goat were fitted as independent variables while body weight and linear body measurements except scrotal circumference were fitted as dependent variables. General linear model procedure (PROC GLM) of SAS was used for quantitative variables using district as fixed effect. Least square means (LSM) with their corresponding standard errors were calculated for each body trait over sex, age, location and age by sex interaction. When analysis of variance declared significant difference, least square means was compared using Tukey- Kramer test.

The model employed for analyses of the least square mean in body weight and other linear body measurements of male and except scrotum circumference for female goats was:

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

Where:

y_{ijk} = the observation of body weight and LBMs excluding scrotum circumference in the i^{th}age group j^{th} sex and k^{th} district

μ = overall mean

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

S_j= the effect of j^{th}sex (j =male, female)

D_k= the effect of k^{th} district [K = Artuma Fursi, Dewachefa, Jile Timuga]

$(AS)_{ij}$=the interaction effect of i^{th} age group and j^{th}sex

e_{ijk} = random residual error

All of the measurements (BL, HW, CD, SW, PW, EL, RL, RW, CBL, CBC, HL and SC) were entered in to SAS and then Correlations (Pearson's correlation coefficients) between body weight and other linear body measurements were computed within each sex. To estimate body weight from linear body measurements, all body measurements for males and except scrotum circumference (SC) for females was together entered into the model below, and then body weight was regressed on those body measurements for all age groups of males and females using maximum adjusted R^2 method (SAS, 9.3) to determine the best fitted regression equation for the prediction of body weight from LBMs. Best fitted model was selected based on coefficient of determination (adjusted R^2), the mallow's parameters C (P) and mean square error (MSE). Stepwise regression procedure of SAS was used to estimate regression coefficient of BW on various LBMs in order to develop best fitted regression equation for the prediction of live BW. In step one, all the above independent variables were together entered into the model for males and excluding SC for females, and a group of variables having maximum adjusted R^2 and minimum MSE was selected for each sex. Then, in step two, the variables which were selected based on maximum adjusted R^2 and minimum MSE was

entered together into the model to find the best fitted regression equation. The following model was used for the estimation of body weight from linear body measurements.

For male:

$Y = \beta0 + \beta1X1 + \beta2X2 + \beta3X3 + \beta4X4 + \beta5X5 + ej$

Where,

Y = the dependent variable; body weight

β_0 = the intercept

X1, X2, X3, X4, X5 were the independent variables (BL, HW, CD, SW, PW, EL, RL, RW, CBL, CBC, HL and SC) respectively.

β1, β2, β3, β4 and β5 were regression coefficients of the variables X1, X2, X3, X4 and X5

ej = the residual random error

For female:

$Y = \beta0 + \beta1X1 + \beta2X2 + \beta3X3 + \beta4X4 + \beta5X5 + \beta6X6 + \beta7X7 + ej$ Where:

Y = the dependent variable; body weight

β_0 = the intercept, X1, X2 , X3 , X4 , X5, X6, and X7 were the independent variables (BL, HW, CD,SW,PW,EL,RL,RW,CBL,CBC and HL) respectively.

β1, β2, β3, β4,β5, β6 and β7were regression coefficients of the variables X1, X2, X3, X4, X5,X6 and X7

e_j = the residual random error

4. RESULT AND DISCUSSION

4.1. General Household Information

The characteristics ofhouseholds in the study area are presented in Table 5.The majority (80.2%) of households in the study area were male headed while the remaining proportion was headed by females. There was no significant difference (P>0.05) in sex of the household heads among districts. The occurrence of less percentage of women respondents in the study areas could be due to the culture of the community that females do not lead the family.

Half (50.0%) of the respondents in the study area were within the age class of 31-40 years while 22.2% of households were found in the age class of 41-50 years. This revealed that most farmers in the study area are found within productive age class. There was no significant difference (p>0.05) across districts in household age structures. With regard to marital status, majority (88.9%) of the respondents were married while 6.8 and 4.3 % of respondents were, divorced and widowed, respectively.

In the study area, the small ruminant owners had different educational background. Above half (53.1%) of the respondents were illiterate. This could be difficult to sustainably improve and expand small ruminant production. This result was relatively higher as compared to the result of Hulunim (2014) who reported that 43.88% of respondents in Bati district were illiterate. The remaining 46.9% of the respondents in the study area were literate in different educational category. This would be a good chance for adoption of new technologies and to implement control breeding and management practice improvement strategies. The overall average family size of the respondents in the study area was 6.3 which are almost comparable with the report of the national average family size of 6.5 (CACC, 2011).

Table 5. General household information in the study area

Variables	District						Overall		
	Artuma Fursi		Dewachefa		Jile timuga				
	N	%	N	%	N	%	N	%	X^2 value
Sex structure of household									
Male	42	77.8	43	79.6	45	83.3	130	80.2	0.545^{ns}
Female	12	22.2	11	20.4	9	16.7	32	19.8	
Age structure									
20-30	4	7.4	3	5.6	8	14.8	15	9.3	12.096^{ns}
31-40	32	59.3	28	51.9	21	38.9	81	50	
41-50	7	13	12	22.2	17	31.5	36	22.2	
51-60	8	14.8	7	13	3	5.6	18	11.1	
>60	3	5.6	4	7.4	5	9.3	12	7.4	
Marital status									
Married	47	87	46	85.2	51	94.4	144	88.9	4.655^{ns}
Divorced	3	5.6	6	11.1	2	3.7	11	6.8	
Widowed	4	7.4	2	3.7	1	1.9	7	4.3	
Educational status									
Illiterate	27	50.0	28	51.9	31	57.4	86	53.1	12.690^{ns}
Read and write	26	48.1	20	37.1	18	33.4	64	39.5	
Primary	0	0	4	7.4	5	9.3	9	5.6	
Secondary high school	1	1.9	2	3.7	0	0	3	1.9	
Household size Mean ±SD	6.6±1.46		5.7±2.1		6.5±2.0		6.3±1.9		

SD=Standard deviation

4.2. Livestock Holding per Household

Average numbers of various livestock species per household in the study area are summarized in Table 6. The overall average number of goats per household (11.9) in the study area was higher than all livestock species and followed by cattle (10.3). There was significant difference between districts in sheep, goat, cattle and chicken population per household ($p<0.05$). The average number of goats per household in Jile Timuga district (14.44) was significantly ($P<0.05$) higher than the two districts (10.29 in Artuma Fursi and 10.96 in Dewachefa). This was due to farmers in this district depends on livestock rearing and use goat production as source of income generation. However, there was no significant difference between Artuma Fursi and Dewachefa districts. The overall flock size of goats per house

hold(11.90) in the study area was comparable with the result of Alubel (2015) who reported that the average flock size per household in Lay Armachiho district of North Gondar zone was 10.5. On the contrary, the present result was higher than the report of Hulunim (2014) who reported that the average flock size of goats per house hold in Bati districts was 8.99.

On the other hand, the average flock size of sheep in Dewachefa (9.79) and in Artuma Fursi (6.87) was significantly higher than average flock size of sheep (4.92) in Jile Timuga district. This could be due to high available wet grazing land in Dewachefa and Artuma Fursi districts as observed during data collection and group discussion. The overall mean number of sheep per households in the study area (7.19) was comparable with the report of Hulunim (2014) who reported that the average flock size of sheep per house hold in Borena district was 7.82. The average number of cattle per household in Artuma Fursi (13.16) was significantly ($P<0.05$) higher than the average number of cattle per household in Dewachefa district (8.72). Respondents in Artuma Fursi districts had significantly higher number of chicken (6.28) than respondents in Jile-Timuga district (3.21). This could be due to female respondents in Artuma Fursi districts relatively higher (22.2%) and chicken is easily managed by females.

Table 6. The Mean of Livestock of species holding per house hold

Livestock	ArtumaFursi	Dewachefa	Jiletimuga	Overall
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Goat	10.29±4.49^{b}	10.96±4.59^{b}	14.44 ±9.23^{a}	11.90±6.70
Sheep	6.87±3.70 ^{a}	9.79±4.60 ^{a}	4.92±3.19 ^{b}	7.19±4.34
Cattle	13.16±4.9^{a}	8.72±3.84 ^{b}	9.12 ±5.26^{ab}	10.30±5.11
Chicken	6.28±4.00 ^{a}	3.94±2.17^{ab}	3.21±1.47 ^{b}	4.61±3.15
Donkey	1.17±0.39	1.04±0.20	1.45±0.88	1.22±0.57

^{abc}: means with different superscript in the same row are significantly different ($p<0.05$).

4.3. Flock size and Structure of Sheep and Goats and Production System in the Study area

Flock size and structure of sheep and goats in the study area presented in Table 7. The mean number of ewes, male kids<6 month and bucks had significant differences ($P<0.05$) between districts. The mean number of ewes was 2.89, 3.21 and 2.22 for Artuma Fursi, Dewachefa,

and Jile Timuga districts. The mean number of ewes in Artuma Fursi and Dewachefa was higher than that of Jile Timuga district. Whereas the overall mean number of does (>1 year) was 4.18 in the study area. The mean number of does was higher than the overall mean of ewes; this could be due to higher flock size of goat as presented Table 6 above. The current results were lower in ewes but higher in does from the reports of Yadeta (2016) who reported 3.12 and 1.98 for breeding ewes and does respectively in west Shewa zone. In addition the current result is comparable with the report of Hulunim (2014) who reported 3.51 breeding doe in Bati district.

On the other hand, the overall mean number of rams (>1 year) and bucks have almost similar size 1.62 for sheep and 1.63 for goats. However, the number of castrated males goats was higher (2.53) than castrated sheep (1.56). The overall mean of lambs in male aged 6 months to 1 year per household were lower (1.30)than female aged 6 months to 1 year (1.43) compared to other groups. Similarly overall mean of goats in male aged 6 months to 1 year were lower (1.70) than female aged 6 months to 1 year (1.91) as compared to other groups. This lower mean may be due to sale of these animals at age 6 month to 1 year. The present result was higher as compare to Dhaba *et al*. (2012) in all age groups numbers of both species. In the study area the mean of kids (<6 month) were relatively higher than mean of lambs (<6 month) this is because of high number of does as compare to ewes across all the districts. Based on total number of breeding rams and total number of breeding ewes the breeding ratio of sheep were 1.62 to 2.82 (Ram: Ewes). On other hand the breeding ratio of goats was 1.63: 4.18 for buck and does, respectively.

Production System of sheep and goats in the study area is presented in (Table 7). Sheep and goats production in all study districts was characterized by low input subsistence, multiple production objectives in marginal environments. The Agro-pastoralist (mixed) production system is the predominant system (83.3%, 96.3% and 74.1%) for Artuma Fursi, Dewachefa, and Jile Timuga districts respectively. Similar to current study Hulunim (2014) reported that mixed crop-livestock production system was the predominant system (96.94%) in Bati area. While the remaining 16.7%, 3.7%, and 25.9% household in Artuma Fursi, Dewachefa, and Jile Timuga districts respectively were involved in livestock rearing. The proportion of

pastoralist was relatively higher in Artuma Fursi and Jile Timuga districts of the respondents which were relying on livestock production as source of cash income and food for home consumption. The major crops such as sorghum, maize, teff, *masho*, onion, cabbage and tomatoes were the main cultivating crop and vegetables in the study area.

Table 7. Flock structure over sexes and ages and Production System in the study area

Sheep Flock structure	ArtumaFursi	Dewachefa	JileTimuga	Overall
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Male lamb<6 month	1.44±0.50	1.69±0.94	1.25±0.44	1.51±0.76
Female lamb<6 month	1.64±0.59	1.76±0.82	1.30±0.47	1.62±0.69
Weaned Male lamb 6-12 month	1.23±0.43	1.36±0.56	1.30±0.47	1.30±0.49
Weaned female lamb 6-12 month	1.40±0.59	1.54±0.72	1.27±0.46	1.43±0.62
Ram(>1year)	1.47±0.56	1.84±1.00	1.53±0.67	1.62±0.79
Ewes(>1year)	2.89±1.73[a]	3.21±1.77[a]	2.22±1.14[b]	2.82±1.64
Castrated	1.45±0.72	1.62±0.70	1.55±0.98	1.56±0.77
Goat flock structure				
Male kids<6 month	1.57±0.87[b]	1.76±0.78[b]	2.31±1.50[a]	1.90±1.16
Female kids<6 month	1.72±0.78	1.71±0.98	2.08±1.70	1.85±1.26
Weaned Male kids 6-12 month	1.57±0.56	1.82±0.61	1.69±0.98	1.70±0.77
Weaned female kids 6-12 month	2.00±0.97	1.76±0.90	1.97±1.08	1.91±0.99
Buck (>1year)	1.63±0.65[ab]	1.78±0.69[a]	1.47±0.66[b]	1.63±0.67
Does (>1year)	3.86±1.56	3.75±1.41	4.90±2.85	4.18±2.11
Castrated	2.31±1.13	2.09±1.10	3.03±1.53	2.53±1.35

Production System	ArtumaFursi		Dewachefa		JileTimuga		Overall		X^2 value
	N	%	N	%	N	%	N	%	
Agro-pastoralist(Mixed)	45	83.3	52	96.3	40	74.1	137	84.6	10.311[a]
Pastoralists	9	16.7	2	3.7	14	25.9	25	15.4	

SD=standard deviation

4.4. Purpose of keeping sheep and goats in the study area

The purpose of keeping sheep and goats in the study area is presented in Table 8. The primary reason for sheep and goats rearing in all three districts was income generations with an index value of 0.468, 0.39 and 0.435 for sheep and 0.404, 0.443 and 0.431 for goats in Artuma Fursi, Dewachefa and Jile Timuga districts, respectively. The money earned from sheep and goat sale is used to buy cloth and food items, pay taxes, purchase fertilizers and other household goods. This finding was in agreement with reports of earlier workers (Yadeta, 2016; Tegegn, 2012; Solomon *et al*., 2010).

The other reasons of keeping sheep mentioned by the respondents were saving (0.198), meat consumption (0.207), ceremony (0.073), breeding (0.053), gift (0.020) and skin (0.017), respectively. Similarly, saving (0.210), meat consumption (0.180), breeding (0.068), milk (0.032), gift (0.018) and skin, (0.016) were the other reasons of keeping goats in the study area. Goat milk was consumed by respondents particularly in Artuma Fursi and Jile Timuga districts. Similarly, Hulunim (2014) reported that goat owners in Borena, Bati and Siti districts used goat milk for home consumption. On the other hand, all respondents in the study area reported that using sheep milk for home consumption is forbidden by their culture. The study was in agreement with the result of Tesfaye (2008) who reported that farmers in Menz district was not utilized sheep milk for home consumption.

Table 8.The purpose of keeping sheep and goat in the study areas

	Artuma Fursi				Dewachefa				JileTimuga				Overall index
purpose of keeping Sheep													
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index	
Meat	10	4	12	0.169	20	6	7	0.271	4	18	8	0.182	0.207
Income	30	21	6	0.468	22	23	2	0.390	40	6	2	0.435	0.431
Saving	14	7	6	0.210	3	14	10	0.161	8	12	21	0.224	0.198
Milk	0	0	0	0.000	0	0	0	0.000	0	0	0	0.000	0.000
Skin	0	3	4	0.034	0	1	1	0.010	0	0	2	0.006	0.017
Breeding	0	4	6	0.047	1	5	2	0.051	0	3	13	0.062	0.053
Gift	0	1	2	0.014	2	0	2	0.027	0	3	0	0.019	0.020
Ceremony	0	8	1	0.058	6	3	2	0.089	2	5	6	0.071	0.073
purpose of keeping Goats													
Meat	8	6	12	0.151	16	8	7	0.246	4	12	44	0.144	0.180
Income	34	6	14	0.404	28	21	2	0.443	40	4	132	0.431	0.426
Saving	12	16	6	0.233	4	14	10	0.173	8	12	69	0.225	0.210
Milk	0	0	6	0.019	0	0	0	0.000	2	6	24	0.078	0.032
Skin	0	3	4	0.032	0	1	1	0.010	0	0	2	0.007	0.016
Breeding	0	9	2	0.063	1	5	2	0.052	0	8	27	0.088	0.068
Gift	0	0	2	0.006	2	0	2	0.028	0	3	6	0.020	0.018
Ceremony	0	14	1	0.091	2	3	2	0.048	0	0	2	0.007	0.046

R1=first rank, R2=second rank, R3=third rank, I=index

4.5. Source of Feed for Sheep and Goats during Dry and Wet Season in the Study area

Sources of feed for sheep and goat during dry and wet season in the study area are presented in Table 9. The different feed resources reported in all study districts were natural pasture, established pasture, hay, crop residues, fallow land and concentrates. In the study area, availability of feed resources of sheep and goats in the study area depends on season. However, natural pasture was the major feed resources of sheep and goats both in wet and dry seasons in all study districts. The current result was in agreement with Shewangzaw and Adis (2016) in North Gondar district, Yadeta (2016) in west Shoa zone of Oromia Regional State, Mesfin (2015) in Wolaita zone of southern region, Alubel (2015) around Amhara and Tigray National Regional States and Hulumin (2014) in Bati districts. They reported that natural pasture was the major feed resources of sheep and goats both in wet and dry seasons.

Even if sheep are grazer and goats are browser, the feed resources available in the study area mostly natural pasture. Sheep mostly graze different grass types and foliage on pastureland whereas; goats browse on plant sharps like: *Acacia spp.*, Sesbania, *Lantana camara*and other shrubswithin the same pasture. The feed resource of sheep and goats hadn't big difference in the study area. The natural pasture was ranked as first feed source for sheep and goats in both wet (with index value 0.43, 0.47 and 0.46) and dry season (with index value of 0.49, 0.50 and 0.41) for Artuma Fursi, Dewachefa, and Jile Timuga districts,respectively. However, respondents ranked established pasture, fallow land, hay, crop residue and concentrates as the other feed resource of sheep and goats in study area in both wet and dry season.

The availability of feed resources in the study area was different in wet and dry season especially in Artuma Fursi and Jile Timuga districts there was the scarcity of feed occurred in dry season. The coping mechanisms of farmers as respond during group discussion was providing different supplements such as: leaves of trees, bushes, crop residues, sorghum and maize stover, and some farmers feed wheat bran "furishika"during feed shortage in all districts of study area. The major crop residues used in the study area were: sorghum and maize stover and "*masho geleba*".

Table 9.Ranking of available feed resources during the dry and wet seasons in the study area

Feed resources	Artuma Fursi				Dewachefa				Jile Timuga				Overall Index
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index	
Wet season													
Natural pasture	42	4	1	0.43	48	2	4	0.47	36	4	14	0.46	0.45
Established pasture	2	12	14	0.14	0	6	10	0.07	6	14	11	0.21	0.14
Hay	0	0	2	0.01	1	2	0	0.02	0	2	6	0.04	0.02
Crop residues	4	16	21	0.21	2	12	24	0.17	8	12	4	0.19	0.19
Fallow land	4	18	6	0.17	0	18	20	0.17	2	2	7	0.06	0.13
Concentrates	2	1	4	0.04	3	12	2	0.11	1	3	4	0.05	0.07
Dry season													
Natural pasture	44	2	4	0.49	46	0	0	0.50	40	3	4	0.41	0.47
Established pasture	1	15	12	0.16	2	4	16	0.11	4	8	11	0.12	0.13
Hay	0	0	2	0.01	0	0	6	0.02	0	4	2	0.03	0.02
Crop residues	9	21	6	0.26	2	16	15	0.19	6	21	14	0.23	0.23
Fallow land	0	0	4	0.01	0	0	12	0.04	0	15	9	0.12	0.06
Concentrates	0	2	14	0.06	2	15	0	0.13	4	3	5	0.07	0.09

R1=first rank, R2=second rank, R3=third rank, I=index

4.5.1. Grazing method practiced in the study area

The grazing/ browsing practices reported on households in the study areas are summarized in Table 10. The grazing managements of the respondents were different for dry and wet seasons in the study area. Nearly half (55.6%, and 48.1%) of sheep and goat owners in Artuma Fursi and Jile Timuga districts practiced free grazing /browsing method whereas the remaining percentage of sheep and goat owners practiced herding and rotational grazing method during the dry season. The majority of sheep and goat owners in Dewachefa district practiced herding in both in dry season (66.7%) and wetseason (72.2%). Thereason was due to most of the land covered by crop or vegetable in both dry and wet season. The current result wasin agreement with report of Bekalu (2014) who reported that in west Gojjam zone most farmers herding their animals due to cultivation of grazing land for crops production.

Table 10. Grazing/ browsing practices reported on households in the study area

Grazing/ browsing method	Artuma Fursi				Dewachefa				JileTimuga			
	DS		WS		DS		WS		DS		WS	
	N	%		%	N	%	N	%	N	%	N	%
Free grazing	30	55.6	12	22.2	17	31.5	11	20.4	26	48.1	26	48.1
Herding	19	35.2	39	72.2	36	66.7	39	72.2	28	51.9	23	42.6
Rotational grazing	5	9.3	3	5.6	1	1.9	4	7.4	0	0.0	5	9.3

DS= Dry Season, WS= Wet Season

4.5.2. Herding Practices by Households in the Study area

Herding practices of sheep and goat keepers in the study area are presented in Table 11. The main objectives of herding were to prevent sheep and goat from damaging crops, theft and predators. In the study area, all categories of sheep and goats were herded together except new born lambs/kids which were separately managed for about 1 month during the day time. Nearly half (46.3%) of sheep and goat owners in the study area herd this animals together. This type of herding practice was important in order to avoid the shortage of labor resource of the farmers; however it may increase inbreeding. About, 24.1%, 15.4%, 13.0% and 1.2% of respondents in the study area herded sheep and goats separately, all species together, with cattle and equines, respectively. The current study was comparable with report of Hulunim (2014) who reported that about 45% of households in Bati area practiced mixed-species stocking (herding goats with sheep, cattle, equine and camel).

Table 11.Way of sheep and goats herding practice in the study area

Way of herding practice		Artuma Fursi		Dewachefa		Jile Timuga		Overall	
		N	%	N	%	N	%	N	%
Sheep and Goat flock is herded	With cattle	4	7.4	10	18.5	7	13.0	21	13.0
	Both are together	28	51.9	25	46.3	22	40.7	75	46.3
	With equines	1	1.9	1	1.9	0	0.0	2	1.2
	All herded together	8	14.8	7	13.0	10	18.5	25	15.4
	Herded Separately	13	24.1	11	20.4	15	27.8	39	24.1

4.6. Common Source of Water, Frequency and Distances to Watering point

4.6.1. Common Source of Water in the study area

Different water sources in both seasons in the study area are presented in Table 12. The common water sources for livestock include rivers, pipe water, spring, and deep well as well as rain water harvest. Majority (66.7%, 64.8% and 75.9%) of respondents in dry season and almost similar proportion of respondents (70.4%, 64.8% and 63.0%) in wet season in Artuma Fursi, Dewachefa and Jile Timuga districts, respectively,watered their sheep and goats from river. The current finding was similar with the report of Dhaba *et al*. (2012), Ahmed (2013) and Hulumin (2014) who indicated that 61.8%, 42.3% and 76.5%in Illu Abba Bora zone, Horro Gudru Wollega zone and Bati districts;rivers are the most important sources of water for goats in wet and dry season.

Table 12.Common source of water for Sheep and Goats in the study area

Source of water		ArtumaFursi		Dewachefa		JileTimuga		Overall	
		N	%	N	%	N	%	N	%
Dry season	River	36	66.7	35	64.8	41	75.9	112	69.3
	Pipe water	4	7.4	2	3.7	1	1.9	7	4.3
	Deep well	8	14.8	3	5.6	12	22.2	23	14.1
	Spring	6	11.1	14	25.9	0	0.0	20	12.3
Wet season	River	38	70.4	35	64.8	34	63.0	107	66.0
	Pipe water	5	9.3	5	9.3	2	3.7	12	7.4
	Rain water	10	18.5	2	3.7	6	11.1	18	11.1
	Spring	1	1.9	12	22.2	0	0.0	13	8.1
	Deep well	0	0.0	0	0.0	12	22.2	9	7.4

4.6.2. Watering Frequency and Distance to Watering Point during Dry and Wet season

Watering frequency and distance of water during dry and wet season in the study area are presented in Table 13. Majority (66.7% in dry season and 61.1% in wet seasons) of respondents watered their sheep and goats once a day. The rest (33.3% in dry and 38.9% in wet season) of respondents watered their sheep and goats freely. In addition, water shortage was not a problem of sheep and goat in the study area. The current finding is in agreement

with Alubele (2015) who reported that 65.3% of respondents in Lay Armachiho district watered their sheep and goats once a day while 34.7% of respondents watered their goats freely in dry season.

Majority (60.5%) of respondents in dry season watered their sheep and goat between one and five kilometers distance. On the other hand, less than half (45.7%) of respondents in wet season watered their sheep and goats at home in the study area. About,22.2% of respondents in the study districts watered their sheep and goats less than one kilometers distance during dry seasonswhereasduring wet season 42.6% of respondents in the study districts watered their sheep and goats less than one kilometers distance.

Table 13. Watering frequency and distance of watering point during dry and wet season in the study area

Watering frequency		ArtumaFursi		DewaChefa		JileTimuga		Overall	
		N	%	N	%	N	%	N	%
Dry season	Freely available	28	51.9	26	48.1	0	0.0	54	33.3
	Once a day	26	48.1	28	51.9	54	100.0	108	66.7
Wet season	Freely available	17	31.5	24	44.4	22	40.7	63	38.9
	Once a day	37	68.5	30	55.6	32	59.3	99	61.1
Distance of watering point									
Dry season	Watered at home	9	16.7	10	18.5	9	16.7	28	17.3
	Less than 1 km.	15	27.8	13	24.1	8	14.8	36	22.2
	1km to 5 km	30	55.6	31	57.4	37	68.5	98	60.5
Wet season	Watered at home	24	44.4	31	57.4	19	35.2	74	45.7
	<1km	19	35.2	20	37.0	30	55.6	69	42.6
	1km-5km	11	20.4	3	5.6	3	9.3	19	11.7

4.7. Housing of Sheep and Goat in the Study area

Type of house and materials used by the respondents to construct sheep and goats house is presented in Table 14. House protects animals from extreme temperature, rain, wind, predators and theft. Different types of houses, housing materials and housing systems were identified in the study area. However, housing systems of sheep and goats were similar across

districts. Nearly half (52.5%) of respondents in all districts housed their sheep and goats in separate house with roof. This result is comparable with the result of Hulunim (2014) who reported that all of the respondents in Bati area used roofed house for their goats in both dry and wet seasons. However, 13.0%, 16.7% and 20.4% of respondents in Artuma Fursi, Dewachefa and Jile Timuga districts respectively used kraal (fenced) sheep and goat house without roof. This type of house did not protect sheep and goats from rain during wet season, so poor housing system should be improved to roof type of house for better productivity.

The survey result indicated that, 70.4% of respondents in the study area used grasses or bushes for construction of roof while the remaining 20.34% and 9.4% of respondents used corrugated iron sheet and plastic canvas for construction of roof, respectively. This study was comparable with Hizkel (2017) who reported that, 88.2% of households used grasses or bushes for construction of roof while the remaining 11.75% used corrugated iron sheet in Bensa district of southern Region. About 94.4% of respondents in the study area reported that sheep and goats were housed together. This result was similar with the result of Belete (2013) who reported that majority (94.7%) of respondents in Bale Zone housed their goats with sheep. Almost all (98.1%) of in Artuma Fursi, 96.3% in Dewachefa and 79.6% in Jile Timuga) of the respondents housed kids together with the adult flock except newly born lambs or kids. The report was in agreement with the result of Ahmed (2013) who reported that all sex and age groups of goats in Horro Guduru Wollega zone were housed together at night except new born kids.

Table 14.Type of house and housing material in the study area

		Artumafursi		Dewachefa		JileTimuga		Overall	
		N	%	N	%	N	%	N	%
Type of house									
	Family house with roof	6	11.1	8	14.4	6	11.1	20	12.3
	Separate house with roof	28	51.9	29	53.7	28	51.9	85	52.5
	Verenda	8	14.8	4	7.4	6	11.1	18	11.1
	Kraal	7	13.0	9	16.7	11	20.4	27	16.7
	Gatta	5	9.3	4	7.4	3	5.6	12	7.4
Type of housing material									
	Iron sheet	12	22.2	11	20.35	10	18.5	33	20.34
	Grass /bushs	38	70.4	37	68.55	39	72.2	114	70.4
	Plastic canvas	4	7.4	6	11.1	5	9.3	15	9.3
Sheep and Goats are housed									
	With together	51	94.4	52	96.3	50	92.6	153	94.4
	With Cattle	3	5.6	2	3.7	4	7.4	9	5.6
Kids are housed With adults	Yes	53	98.1	52	96.3	43	79.6	148	91.4
	No	1	1.9	2	3.7	11	20.4	14	8.6

4.8. Breeding Practices in the Study Area

4.8.1. Ram and Buck Ownership, Sources, its Selection Practices and Mating System

The sources of breeding ram and buck, mating system and its selection practices of farmers in the study area are summarized in Table 15. About 81.5% and 80.2% of respondents in the study area had their own ram and their own buck, respectively. The current results were in disagreement with Yadeta (2016) who reported that only 23.9% and 21.1% of farmers had their own breeding ram and buck, respectively. However, most farmers did not use their breeding ram or buck for mating purpose due to the fact that most of ram and buck sale or castrated at early age. This finding was in agreement with the report of Helen *et al.* (2013) who reported that 98%, 89% and 71% of respondents in Jijiga and Shinile and in Eastern Harerghe zone kept their own indigenous breeding rams, and Alubel (2015) who reported that 97.1% of respondents in Ziquala, 98.7% of respondents in Tanqua Abergelle had their own indigenous breeding buck. In the study area, 88.3% of respondents practiced uncontrolled mating system. From them, 50.0% of respondents in Artuma Fursi, 57.4% in Dewachefa and

46.3% in Jile Timuga districts didn't know the effect of uncontrolled mating on the future generation of the flock. This finding was in agreement with the report of Hulunim (2014) who reported that 88.78% of respondents in Bati district practiced uncontrolled mating system. The remaining overall percentage of respondents (33.3% and 15.4%) in the study area reported that, grazing/browsing together with opposite sexes and insufficient number of ram and buck in their flock respectively were the main reasons to practice uncontrolled mating.

About 90.7%, 88.9% and 92.6% of respondents in Artuma Fursi, Dewachefa and Jile Timuga districts, respectively, practiced selection of their breeding male and female for the future production purpose. The current results were in agreement with Belete (2013) who reported that 85% of respondents in Bale zone practice selection of males and females goats.

Table 15.The sources of breeding ram and buck, mating system and its selection practices in the study area

Parameter		Artuma Fursi		Dewachefa		Jile Timuga		Overall	
		N	%	N	%	N	%	N	%
Do you have breeding ram	Yes	46	85.2	48	88.9	38	70.4	132	81.5
	No	8	14.8	6	11.1	16	29.6	30	18.5
Do you have breeding buck	Yes	40	74.1	42	77.8	48	88.9	130	80.2
	No	14	25.9	12	22.2	16	11.1	32	19.8
Source of breeding ram	Own born	46	85.2	48	88.9	38	70.4	132	81.5
	Neighbors	8	14.8	6	11.1	16	29.6	30	18.5
Source of breeding buck	Own born	40	74.1	42	77.8	48	88.9	130	80.2
	Neighbors	14	25.9	12	22.2	16	11.1	32	19.8
Breeding/mating system	Control led	4	7.4	7	13.0	8	14.8	19	11.7
	Uncontrolled	50	92.6	47	87.0	46	85.2	143	88.3
Reason of uncontrolled mating	Graze/browse together	20	37.0	15	27.8	19	35.2	54	33.3
	Lack of awareness	27	50.0	31	57.4	25	46.3	83	51.2
	Insufficient no of ram/buck	7	13.0	8	14.8	10	18.5	25	15.4
Do you select breeding male and female	Yes	49	90.7	48	88.9	50	92.6	147	90.7
	No	5	9.3	6	11.1	4	7.4	15	9.3

4.8.2. Selection Criteria for Breeding Ram and Buck in the Study area

The selection criteria of breeding rams and bucks in the study area are summarized in Table 16. Selection of parents of the next generation in both the rams and bucks was based on the performance and preference of farmers. Appearance/Body size, growth rate and color were the first, second and third (index value 0.33, 0.19 and 0.19) selection criteria of breeding ram, respectively, in all of the study areas. Similarly, appearance/body size, growth rate and color were the first, second and third (index value 0.39, 0.23 and 0.23) selection criteria for breeding buck in all of the study area. This finding was in agreement with the report of Yadeta (2016), Hulunim (2014) who reported that body size/conformation was the primary selection criteria of farmers to select both ram and buck as parents of next generation.

On the other hand, tail size was 4th selection criteria for ram while family history was the 4th selection criteria for buck. Fawn coat color was the most preferred color of breeding rams while red, fawn, and white were most preferred color of bucks in all study areas.

Table 16. Selection criteria for selecting breeding ram and buck in the study area

Selection Criteria	Artuma Fursi				Dewachefa				Jile Timuga				Overall
Ram	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index	Index
Color	8	12	9	0.19	12	11	4	0.21	7	12	5	0.17	0.19
Body Size	21	11	9	0.31	19	15	7	0.33	24	11	7	0.35	0.33
Tail Size	10	5	7	0.16	9	8	5	0.17	7	8	4	0.14	0.15
Family History	2	3	4	0.05	2	6	4	0.08	3	4	6	0.08	0.07
Growth Rate	11	12	8	0.22	10	7	4	0.17	11	7	10	0.20	0.19
Adaptability	1	4	3	0.04	1	0	7	0.03	1	2	5	0.04	0.04
Libido	0	2	4	0.03	1	0	2	0.02	0	1	2	0.01	0.02
Selection Criteria of Buck													
Color	11	9	3	0.21	15	13	6	0.28	7	14	9	0.20	0.23
Body Size	20	14	12	0.40	21	15	8	0.35	25	15	10	0.41	0.39
Family History	5	4	4	0.11	1	4	12	0.08	0	6	8	0.07	0.09
Growth Rate	13	8	7	0.24	10	6	14	0.20	16	10	6	0.25	0.23
Adaptability	0	2	2	0.02	1	4	7	0.06	2	3	4	0.05	0.04
Libido	0	0	3	0.01	0	3	2	0.03	0	1	4	0.02	0.02

R1=first rank, R2=second rank, R3=third rank, I=index

4.8.3. Selection Criterion for Breeding Ewes and Does in the Study area

The selection criteria for breeding ewes and does in the study area are presented in Table 17. Appearance/body sizewas the first criteria to select breeding ewes with the overall index value of 0.41 across study districts. Color was the second criteria for selection of breeding ewes in Artuma Fursi and Jile timuga districts, whereas lambing interval the second criteria for selection of breeding ewes in Dewachefa. Likewise appearance/body size, color and litter size were the first, second and third selection criteria, respectively, for breeding does in all the study area. Lambing interval was the 3rd selection criteria for breeding ewes especially in Dewachefa and Jile Timuga districts while litter size was the 3rd selection criteria for breeding does in all the study area. Lamb/kid survival, family history and age at sexual maturity were also mentioned as selection criteria with lower proportion for both species. The current finding was in agreement with Yadeta (2016) who reported that body size and coat color were ranked first and second selection criteria of breeding ewes and does in west Shewa zone.

Table 17. The selection criteria for breeding ewes and does in the study area

Selection Criteria	Artuma Fursi				Dewachefa				JileTimuga				Overal
ewes	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index	l index
Color	10	12	5	0.21	6	14	0	0.16	8	15	0	0.20	0.19
Body Size	22	19	8	0.41	29	8	11	0.43	26	14	0	0.39	0.41
Lamb Survival	2	2	4	0.06	0	0	1	0.00	0	6	4	0.06	0.04
Family History	2	6	5	0.08	3	12	0	0.12	0	3	4	0.04	0.08
Lambing Interval	6	3	7	0.10	7	14	5	0.20	9	5	11	0.18	0.16
Litter Size	7	5	6	0.13	3	2	4	0.06	7	2	6	0.11	0.10
Age of Sexual maturity	0	0	5	0.02	0	0	8	0.03	0	1	4	0.02	0.02
Selection Criteria for of does													
Color	12	12	8	0.23	14	9	6	0.26	11	12	4	0.22	0.24
Body Size	26	18	4	0.41	19	12	5	0.34	30	15	5	0.45	0.40
Kid survival	0	0	5	0.02	0	0	1	0.00	0	0	4	0.01	0.01
Family History	0	4	4	0.04	1	4	0	0.05	0	8	4	0.07	0.05
Kidding Interval	3	7	3	0.09	5	1	0	0.08	4	4	6	0.10	0.09
Litter Size	8	12	6	0.19	8	11	6	0.21	5	7	2	0.12	0.17
Age of Sexual Maturity	0	0	8	0.03	1	4	3	0.06	0	1	6	0.03	0.04

R1=firstrank, R2=secondrank, R3=thirdrank, I=index

4.9. Major Sheep and Goat Diseases in the Study Area

The major common sheep and goat diseases in the study area are presented in Table 18. Diseases have numerous negative impacts on productivity of herds i.e. death of animals, loss of weight, slow down growth, poor fertility performance, decrease in physical power etc. (CSA, 2017).

Pasteurellosis, sheep/goat pox, fascioliasis, PPR (Peste des Petits Ruminants), diarrhea, anthrax, mange mite and foot and mouth diseases were reported as major diseases affecting sheep production in thestudy area. This study was comparable with the report of Solomon *et al*. (2010) Paste des petites ruminants (PPR), foot and mouth disease, pasteurellosis and anthrax are the most important diseases prevalent in Ethiopia. Among those diseases, pasteurellosis and sheep pox (index value 0.33 and 0.23) were the most common disease in sheep across the study districts. Similarly, pasteurellosis and goat pox (index value 0.35 and 0.21) were common disease by affecting production of goats in the study area whereas fascioliasis was the common disease (index value 0.15 and 0.26) of sheep especially in Artuma fursi and Dewachefa district, respectively. This could be due to relatively the grazing land of this district was wet land so favorable for liver fluke prevalence which is important for cause offascioliasis. On the other hand PPR (index value 0.17) was more serious disease in goats than sheep in the study area.

There was great production loss of sheep and goats caused by disease problems due to inadequate health management by farmers and inefficient veterinary service in the study area. Most of the farmers were using modern drugs for treating the sick animals and also some of the farmers treat their animal with locally available medicine. Government animal health centers are the major source of veterinary services in all the study districts however, there was limitation of delivery of health center in all districts.

Table 18. The major sheep and goat diseases inOromia zone of Amhara region

		Artuma Fursi				Dewachefa				Jile Timuga				Overall Index
Major diseases of Sheep														
Local name	Common name	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index	
Fentata	Sheep pox	6	10	8	0.21	8	11	8	0.24	13	6	8	0.25	0.23
Kentir	PPR	3	8	0	0.11	0	1	3	0.02	6	8	4	0.16	0.10
Neft	Pasteurellosis	19	6	0	0.32	17	10	0	0.31	20	12	4	0.37	0.33
Tekimati	Diarrhea	2	4	4	0.08	0	5	4	0.06	4	6	4	0.12	0.09
Afemeyaz	FMD	0	1	3	0.01	0	1	2	0.02	0	0	3	0.01	0.01
Yegubet til	Fascioliasis	8	2	4	0.15	12	9	6	0.26	0	1	3	0.02	0.14
Dingetegna	Anthrax	1	3	5	0.06	1	0	8	0.05	1	1	2	0.03	0.05
Ekeki	Mange Mites	0	2	4	0.04	1	0	4	0.03	2	1	2	0.04	0.04
Major diseases of Goat														
Local name	Common name													
Fentata	Goat pox	16	4	2	0.25	7	4	8	0.14	10	8	11	0.25	0.21
Kentir	PPR	4	8	6	0.15	10	9	5	0.20	4	7	12	0.17	0.17
Neft	Pasteurellosis	21	12	0	0.37	25	9	0	0.36	20	6	0	0.31	0.35
Tekimati	Diarrhea	2	4	1	0.06	0	5	2	0.05	2	4	2	0.07	0.06
Afemeyaz	FMD	0	2	5	0.04	4	2	5	0.08	0	2	3	0.03	0.05
Yegubet til	Fascioliasis	0	1	3	0.02	0	2	4	0.03	0	2	1	0.02	0.02
Dingetegna	Anthrax	0	3	4	0.04	1	3	8	0.06	1	4	8	0.08	0.06
Ekeki	Mange Mites	0	5	6	0.07	2	6	2	0.08	2	3	4	0.07	0.07

R1=first rank, R2=second rank, R3=third rank, I=index

4.9.1. Veterinary Service in the Study area

The distance and type of veterinary service in the study area is presented in Table 19. All of the farmers in Artuma Fursi and Dewachefa, and96.3% Jile Timuga district of farmers have accesse to only government veterinary clinics. Nearly half (54.9%) of sheep and goats owners in the study area had access to veterinary services by traveling up to1 km whereas, 30.9% of them had access to veterinary services from 1 -5 km. The remaining (14.2%) of the sheep and goats owners travelled 5-10 km to get veterinary services. However there was the limitation of veterinary service to address vaccination for all kebeles of the study area due to this there is production loss of sheep and goats. The government should establish more animal health infrastructure not addressed kebeles especially in Dewachefa and Artuma Fursi districts.

Table 19.Percent of farmers accessing public and private veterinary services and distance to veterinary services in Oromia zone of Amhara region

Parameters		Artuma Fursi		Dewachefa		Jile Timuga		Overall	
		N	%	N	%	N	%	N	%
Type of veterinary services	Government	54	100.0	54	100.0	52	96.3	160	98.8
	Private	0	0.0	0	0.0	2	3.7	2	1.2
Distance									
<1 km		28	51.9	32	59.3	29	53.7	89	54.9
1-5 km		17	31.5	12	22.2	21	38.9	50	30.9
5-10 km		9	16.7	10	18.5	4	7.4	23	14.2

4.10. Castration Practices of Sheep and Goats in the Study area

Castration practices, reason of castration and age of castration of sheep and goats in the study area are presented in Table 20. Majority (93.8%) of the respondents saidthattheypracticecastrationoftheirsheepand goats. The current result was comparable with the report of Tesfaye (2008) who reported that 96.7% and 97.2% sheep owners practiced castration in Menz and Afar districts, respectively. The result indicated that 40.0% of sheep owners and 51% of goatownersin the study area mainly practiced castration for reason of improve the fattening potential. The remaining percentage of respondents reason of castration of their ram and buck were to get higher price, make the buck docile or and to control mating to some extent.Inbreedingwas probablycommonasactiveramsorbucksareoftenthe main source ofreplacementmales due to this breeding in both species was uncontrolled.

Majority (72.2%) of farmers in the study area practiced castration by modern method and the remaining (27.8.6%) of farmers used traditional castration method. All sheep and goats were castrated by selected farmers that use traditional material "*allolo*" and modern by burdizo in all districts of the study area. About 66.7% and 33.3% of the respondents in the study area reported that they castrate their sheep at the age of 1.5-2 years and 1-1.5 years respectively. On the other hand, majority (69.1%) of the respondents in the study area reported that they castrate their goats at the age of 2-3 years, while the remaining 30.9% of the respondents in the study area reported that they castrate their goats at the age of 1-2 years. The current result was comparable with Tesfaye (2008) who reported that rams

were castrated at age of 1.7 and 1.5 years, respectively for Menz and Afar sheep whereas; Hulunim (2014) reported that average castration age of buck was 1.72±0.11 years in Bati area. According to the focus group discussion of the respondents the main castration season were September and October while some respondents castrate their ram and buck at any time that the animals perform age of castration across all the study districts.

Table 20.Castration practices of sheep and goats in the study area

Parameters		Artuma Fursi		Dewachefa		Jile Timuga		Overall		X^2value
		N	%	N	%	N	%	N	%	
Do you castrate Your Sheep and Goats	Yes	52	96.3	51	94.4	49	90.5	152	93.8	1.492[a]
	No	2	3.7	3	5.6	5	9.5	10	6.2	
Reason Castration for sheep	Control breeding	6	12.2	3	6.1	5	10.6	14	9.7	3.835[a]
	Better fattening	15	30.6	23	46.9	20	42.6	58	40.0	
	Better income	22	44.9	17	34.7	18	38.3	57	39.3	
	Better temperament	6	12.2	6	12.2	4	8.5	16	11.0	
Reason Castration for goats	Control breeding	3	6.1	3	6.1	6	12.8	12	8.3	2.119[a]
	Better fattening	25	51.0	27	55.1	22	46.8	74	51.0	
	Better income	10	20.4	9	18.4	9	19.1	28	19.3	
	Better temperament	11	22.4	10	20.4	10	21.3	31	21.4	
Castration method for both species										
	Traditional	16	29.6	15	27.8	14	25.9	45	27.8	0.185[a]
	Modern	38	70.4	39	72.2	40	74.1	117	72.2	
Age of castration for sheep	1-1.5 years	17	31.5	18	33.3	19	35.2	54	33.3	0.167[a]
	1.5-2 years	37	68.5	36	66.7	35	64.8	108	66.7	
Age of castration for goats	1-2 years	22	40.7	18	33.3	10	18.5	50	30.9	6.480[a]
	2-3 years	32	59.3	36	66.7	44	81.5	112	69.1	

4.10.1. Mean Marketing and Culling age of Sheep and Goat in the Study area

Average marketing and culling age of sheep and goats in the study area are presented in Table 21. The mean marketing and culling age of sheep and goats were had significant difference across the districts except market age of male sheep, market age of female goat and culling age of male sheep. The mean marketing age for sheep in the study area was 11.68±1.53 month for male and 11.75±1.02 month for female sheep while, the mean marketing age for goats in the study area was 11.76±1.01 month for male and 11.66±1.06 month for female

goats. This indicates that male sheep reach marketing age earlier than female sheep; however, female goats reach marketing age earlier than male goats. The current finding was comparable with Alefe (2014) who reported that the overall, the mean market age of goats in Shebelle Zone was 11.01 and 11.69 month for male and female goats, respectively.

Culling was used to improve the overall productivity of the flock. Farmers in the study area cull their sheep at mean age of 5.09 years for males and 7.19 years for female sheep. On the other hand the mean culling age of goats 4.93 years for male and 7.28 years for female goats. The culling age of male sheep and goats was lower than female sheep and goats the possible reason of this male sheep and goats used for only mating and meat due to this male sheep sale at earlier age than female. This study was comparable with the report of Belete (2013),who reported that, farmers in the Bale zone culled their goats at average age of 8.17±0.16 years for male and 8.5±0.16 years for female goat.

Table 21. Average marketing and culling age of sheep and goats in the study area

Parameter		Artuma Fursi	Dewachefa	Jile Timuga	Overall
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Market age of sheep in month	Male	11.87±0.91	11.74±1.03	11.44±2.27	11.68±1.53
	Female	11.48±1.14^{b}	11.74±1.02^{ab}	12.05±0.68^{a}	11.75±1.02
Market age of Goats in month	Male	11.55±1.17^{b}	11.72±1.08^{ab}	12.01±0.68^{a}	11.76±1.01
	Female	11.79±0.93	11.50±1.17	11.68±1.06	11.66±1.06
Culling age in Sheep years	Male	5.24±0.95	4.90±0.99	5.12±0.75	5.09±0.91
	Female	7.27±0.83^{a}	6.87±0.97^{b}	7.42±0.74^{a}	7.19±0.88
Culling age in Goats years	Male	5.16±0.81^{a}	5.01±0.81^{a}	4.62±0.87^{b}	4.93±0.86
	Female	7.57±1.10^{a}	7.07±1.02^{b}	7.20±0.91^{ab}	7.28±1.03

SD=Standard deviation;^{abc}: means with different superscript in the same row are significantly different ($p<0.05$).

4.11. Average Reproductive performance of sheep and goats in the in three districts

Average reproductive performance of sheep and goats in the study area are summarized in Table 22. Evaluations of the performance of economically important traits of the livestock are very useful inputs for planning a breeding program (Solomon, 2014). Good reproductive performance is a prerequisite for any successful genetic improvement and it determines production efficiency (Zewdu, 2008).

The average age at sexual maturity of male goats but not in sheep across the three districts had significant differences (P<0.05) between districts. The average age at sexual maturity of male sheep was 7.12±1.07 months and average age at sexual maturity of female sheep was 6.44±0.57 in the study area. The result indicated that female sheep reach sexual maturity at early age as compare to male in sexual maturity. The current finding was in agreement with Tesfaye (2008) who reported that an average age of 7.1 months was reported for Afar sheep. On the other hand the average age at sexual maturity of male goat was 7.61, 7.12 and 7.48 months, whereas age at sexual maturity of female goat was 6.51, 6.66 and 6.51 for Artuma Fursi, Dewachefa and Jile Timuga districts respectively. The current finding was lower as compare with Hulunim (2014) who reported that the age at sexual maturity was 8.21±0.28 for male and female goats at Bati district.

The age at fist lambing and age at first kidding was 12.53±.94, 12.55±.96 and 12.61±1.10 months for sheep and 12.37±1.13, 12.74±1.10 and 12.55±1.05 months for goats in Artuma Fursi, Dewachefa and Jile Timuga districts, respectively. The current finding was comparable with Hizkel (2017) and Yadeta (2016) who reported that the first age lambing was 12.84 ±0.24 months while age at first kidding was 13.85±0.12 in Bensa and West shewa zone districts, respectively. The present results in respect of both species had similarity this could be due the districts found in same agro climatic zone. The mean overall lambing interval and kidding interval of the study area was 7.12±.91 and 6.90±1.05 months respectively. The lambing/kidding interval in the present study were lower than the earlier reports in Tesfaye(2008) who reported 9.01 months for Afar sheep and Hulunim (2014) reported 7.95±0.19 months for goats in Bati district.

There was significant difference (p<0.05) between districts in average lambs and kids produce per life time of sheep and goats. The ability of ewes to produce in life time was 8.50, 8.37 and 9.01 lambs whereas; the ability of does produce in life time was 12.25, 12.62 and 12.14 kids for Artuma Fursi, Dewachefa and Jile Timuga districts, respectively. The difference of producing ability in across the districts may be due to management difference and the producing ability difference in both species. In present result goats have higher producing

ability than sheep the possible reason of this due to breed and species difference. The current result was comparable with Tesfaye (2008) who reported that Menz sheep produce 9.3 lambs in life time and Hulunim (2014) reported that goats produce 11.08 kids per life time of does in Bati districts.

There was no significance difference ($p>0.05$) across the districts in average reproductive life span of both species. The overall mean reproductive life span was 8.16±.88 years for sheep and 8.23±1.04 years for goats in the study area. The current result was comparable with Hizkel (2017) who reported that 8.1 ±0.11 years for sheep while, Hulunim (2014) reported 8.02±0.23 years for goats in Bensa and Bati district respectively. There was no significant difference ($P>0.05$) between the districts in average weaning age of sheep however, there was significant difference ($P<0.05$) in goats across the districts. The weaning age of lambs was 3.68±.50, 3.70±.53and 3.74±.48 months whereas; the weaning age of kids was 3.81±.39, 3.88±.41 and 3.57±.49 months in Artuma Fursi, Dewachefa and Jile Timuga districts respectively. The result in the three districts for weaning age of lambs and kids were lower than Yadeta (2016) in Ada Barga and Ejere districts of west Shoa zone, who reported that the overall average weaning ages of lambs and kids were 3.92and 3.77 months respectively.

The result indicated that overall liter size of sheep was 1.27±.49 and 1.73±.82 was for goats in the study area. In the study area, the liter size of goats was higher than sheep,this is important for farmers to select species which produce more animals. High litter size is economically important trait that enhances sheep and goat productivity in terms of producing more number of lambs and kids. These finding were higher than report of Yadeta (2016) who reported that liter size 1.19±0.42for sheep and 1.28±0.33 for goats in Ada Barga and Ejere districts of west Shoa zone.

Table 22. Average reproductive performance of sheep and goats in the study area

Reproductive Traits in sheep	Artuma Fursi	Dewachefa	JileTimuga	Overall
	Means ±SD	Means ±SD	Means ±SD	Mean ±SD
Age of males at sexual maturity (m)	6.79±.83	7.29±1.07	7.27±1.21	7.12±1.07
Age of females at sexual maturity (m)	6.35±.48	6.46±.60	6.51±.63	6.44±.57
Age at first lambing (m)	12.53±.94	12.55±.96	12.61±1.10	12.56±1.0
Lambing interval(m)	7.00±0.91	7.29±.86	7.07±.94	7.12±.91
Average number of lambs per ewe life	8.50±.1.16^{ab}	8.37±1.24^{b}	9.01±1.09^{a}	8.62±.1.19
Reproductive life span of ewes (y)	8.31±.84	8.09±.83	8.07±.96	8.16±.88
Average weaning age (m)	3.68±.50	3.70±.53	3.74±.48	3.70±.50
Liter size	1.25±.48	1.22±.46	1.33±.54	1.27±.49
Reproductive Traits in goats				
Age of males at sexual maturity (m)	7.61±.91^{a}	7.12±.86^{b}	7.48±1.31^{ab}	7.40±1.0
Age of females at sexual maturity (m)	6.51±.86	6.66±.54	6.51±.50	6.56±.65
Age at first kidding (m)	12.37±1.13	12.74±1.10	12.55±1.05	12.55±1.10
Kidding interval(m)	7.14±1.17^{a}	7.03±1.02^{a}	6.53±.84^{b}	6.90±1.05
Average number of kids per doe life	12.25±1.03^{ab}	12.620±.97^{a}	12.14±.73^{b}	12.34±.94
Reproductive life span of does (y)	8.35±.91	8.12±.91	8.22±1.2	8.23±1.04
Average weaning age (m)	3.81±.39^{a}	3.88±.41^{a}	3.57±.49^{b}	3.75±.45
Liter size	1.72±.73	1.90±.93	1.57±.76	1.73±.82

SD=Standard deviation;^{abc}: means with different superscript in the same row are significantly different ($p<0.05$).

4.11.1. Reproductive problems of sheep and goats in the study area

The major reproductive problems of sheep and goat in the study area are summarized in Table 23. Abortion,dystocia; lamb mortality and low growth rate were major reproductive problems of sheep and goat for across in all the study area. From those abortion was the major (index value 0.47, 0.56 and 0.42) reproductive problems of sheep in Artuma Fursi, Dewachefa and Jile Timuga districts, respectively. Similarly, abortion was the major (index value 0.47, 0.49 and 0.46) reproductive problems of goats in Artuma Fursi, Dewachefa and Jile Timuga districts, respectively. Lamb/kid mortality was ranked as second reproductive problem for both sheep and goats in all the study area. High mortality of sheep and goats in abortion and at early age of lamb and kid this might be due to poor management of health condition, and high prevalence of diseases. Farmers in the study area should be give attention for management of pregnant animals and small kids and lambs. The remaining other rank were dystocia and low growth rate ranked orderly for both species across in study area.

Table 23. Reproductive problems of sheep and goats in the study area

Reproductive problem in Sheep	Artuma Fursi				Dewachefa				JileTimuga				Overall index
	R1	R2	R3	Index	R 1	R2	R3	Index	R 1	R2	R3	Index	
Abortion	30	22	2	0.47	35	11	6	0.56	24	21	4	0.42	0.48
Dystocia	1	5	6	0.07	3	1	3	0.06	3	5	10	0.09	0.07
Lamb mortality	20	23	4	0.38	12	18	12	0.35	22	16	12	0.39	0.37
Low growth rate	1	4	14	0.09	1	2	0	0.03	4	3	7	0.8	0.06
Reproductive problem in Goats													
Abortion	28	22	4	0.47	32	20	2	0.49	26	16	8	0.46	0.47
Dystocia	2	3	6	0.06	1	5	3	0.06	4	2	6	0.09	0.07
Kid mortality	24	20	8	0.43	21	24	8	0.43	17	12	14	0.34	0.40
Slow growth rate	0	2	8	0.04	0	3	0	0.02	6	3	5	0.11	0.06

R1=firstrank, R2=secondrank,R3=thirdrank, I=index

4.12. Marketing

4.12.1. Market place

According to the group discussionin Artuma fursi district there are three permanent market places namely Chefa Robit, Chereti and Karakori on Wednesday, Friday and Tuesday respectively. Whereas Dewachefa district there are three permanent market places namely Kemise, Tucha and Mekoy on Thursday, Sunday and Tuesday respectively, in addition in Jile Timuga district there are four permanent market places namely Senbeta, Beta, Jwuha, and Ataye on Sunday, Wednesday, Thursday and Saturday respectively. All of the market places are functional at one day per week; however, consumers in all districts and restaurant owners can buy sheep and goats throughout the week from Kemisse and Shewarobit Town at temporary marketing places (*Gulit*). The market places of all the districts were fenced and contain taxation shade except temporary marketing places (*Gulit*).

4.12.2. Number of animals sold and sale price of sheep and goats

Average number animals sold and average sold price of adult sheep and goats in the study area presented in Table 24. The average sale price of adult sheep in both sex during planting time, female sheep after harvesting time and adult female goats after harvesting crop had significant ($p<0.05$) difference across the districts of the study area. All age group of sheep and goats in both sex were marketed in the study area; however the present study concerned on price information of sold adult sheep and goats in different season of marketing. The average sale prices of adult male sheep during festival were 1437.0, 1412.9, and 1418.5 birr whereas; the average sale prices of adult male goats during festival were 3140.7, 3200.0 and 3011.1 birr for Artuma Fursi, Dewachefa, and Jile Timuga districts respectively. On the other hand the overall average sale price for adult female sheep was 730.2 and 1505.5 birr for adult female goats during festival in the study area. The present result was much higher than the report of Tsedeke (2007) who reported that the sale price of fattened sheep and goats were 378.1 birr and 334.4 birr respectively. This indicated that higher demand of sheep and goats rather than higher supply, the possible reason of this may be lower production of sheep and goats as compare to the human population growth. The productivity and production of sheep and goats should be improved in order to compensate this advent of high price.

The sale price of sheep and goats in both sexes were higher during festival and after crop harvests time than sale price of planting season. The possible reason of these could be during festivals (New Year, Easter, Christmas, Epiphany, Id Al Fetir and Id Al Adha) were high demand of sheep and goats marketing and also farmers bought the breeding sheep and goats rather than sale during crop harvests season in all the study districts. The present result was in agreement with Hulunim (2014) who reported that the meat demand grows much higher during major holidays/festivals. In addition the sale price of goats in both sexes was much higher than sale price of sheep in both sexes across all the study districts. This indicated that goats are economically important than sheep in earning high amount of income generation for farmers in Oromia zone of Amhara region.

The average number of sheep and goat sold per household was significantly ($p<0.05$) different for both species across the three study sites. The variation might be due to the

purpose of keeping, flock size, presence of high price breed and demands of sheep and goats. The overall average number of sheep and goat sold per household in a year was 4.2 and 6.3 respectively, presented in study area (Table 24). In the present study higher (5.5) number of sheep sold in Dewachefa district where as higher (7.5) number of goats sold in Jile Timuga districts; the possible reason of this may be higher flock size of sheep and goats in these districts respectively. The current result was higher than Yadeta (2016) in Ada Barga and Ejere districts of west Shoa zone, who reported that one household sold on average 4.4 heads of sheep and 2.2 goats per year per household.

Table 24. Average number of animalssold and average sale priceof adult sheep and goats in the study area

Sale price of sheep in Birr		Artuma Fursi	Dewachefa	Jile Timuga	Overall
		Mean±SD	Mean±SD	Mean±SD	Mean±SD
During festivals	Male	1437.0±274.2	1412.9±155.4	1418.51±218.1	1422.8±220.2
	Female	729.6±130.5	727.7±126.1	733.3±133.8	730.2±129.0
During planting	Male	1066.6±250.1^{b}	1206.5±216.7^{a}	1164.8±237.0^{ab}	1145.9±240.8
	Female	678.7±129.0^{b}	699.0±122.6^{ab}	756.4±129.6^{a}	711.4±130.6
After Harvesting crop	Male	1153.7±223.5	1202.7±218.5	1144.4±198.5	1166.9±214.0
	Female	731.4±122.2^{b}	779.6±129.4^{ab}	798.1±123.6^{a}	769.7±127.4
Sale price of goats in Birr					
During festivals	Male	3140.7±680.04	3200.0±684.6	3011.11±706.2	3117.3±690.6
	Female	1494.4±301.2	1525. 9±299.1	1505.5±320.6	1508.6±305.5
During planting	Male	2825.9±669.3	2922.2±711.0	2812.9±676.2	2853.7±683.2
	Female	1309.2±153.2	1383.3±188.0	1309.2±189.6	1333..9±180.1
After Harvesting crop	Male	3042.6±69.0	2972.2±796.0	2931.5±734.8	2982.1±738.7
	Female	1459.2±198.6^{b}	1505.5±189.7^{a}	1500.0±181.1^{a}	1488.2±189.9
Average number of sheep sold per household in a year		4.0±1.0^{b}	5.5±1.7^{a}	3.0±0.9^{c}	4.2±1.6
Average number of goats sold per household in a year		5.5±1.2^{b}	5.8±0.9^{b}	7.5±2.6^{a}	6.3±1.9

SD=Standard deviation; ^{abc}: means with different superscript in the same row are significantly different ($p<0.05$).

4.12.3. Marketing participants of sheep and goats in the study area

The result of marketing participants of sheep and goats in the study area presented in Table 25. In the study area the results showed that respondents sold their sheep and goats to traders (54.3%), hotels (22.8), farmers (13.0%) and civil servants (9.9%). The result showed that traders were the major marketing participants whereas; farmers and civil servants were less

marketing participants in the study area. The current result was disagreement with Yadeta (2016) who reported that farmers were the major marketing participants of sheep and goats in west Shoa zone. This difference might be due to the in season of collecting data, bought season of farmers and high demand of meat by farmers.

Table 25.Major participants in sheep and goat marketing in Oromia zone, Amhara region, Ethiopia

Participants	Artuma Fursi		Dewachefa		Jile Timuga		Overall	
	N	%	N	%	N	%	N	%
Farmers	8	14.8	6	11.1	7	13.0	21	13.0
Traders	29	53.7	27	50.0	32	59.3	88	54.3
Hotels	12	22.2	14	25.9	11	20.4	37	22.8
Civil servants	5	29.3	7	13.0	4	7.4	16	9.9

4.12.4. Marketing Constraints

Major marketing constraints of sheep and goat in study area are presented in Table 26. According to the respondents, prices determine by visual, lack of public market information, long transportation and price determine by brokers were the major marketing constraints of sheep and goats in the study area. About (35.2%, 31.5% and 44.4%) of the respondents in Artuma fursi, Dewachefa, and Jile Timuga districts respectively; responded that sheep and goats price determine by visual in negotiation between farmers and buyers as primary marketing constraint. The remaining overall percentage 27.2%, 19.1% and 16.7% of the respondents were recognized that brokers, lack of public market information and long transportation, respectively,were the other constraints of marketing in the study area. The current result was comparable with Tsedeke (2007) who reported that brokers (30.8%), lack of price information (24.1%) and lack of access to markets (17.0%) were the constraints of sheep and goats marketing in southern Ethiopia.

Table 26. Major marketing Constraints of sheep and goat in study area

Major constraints	Artuma Fursi		Dewachefa		Jile Timuga		Overall	
	N	%	N	%	N	%	N	%
Price determine by visual	19	35.2	17	31.5	24	44.4	60	37.0
Lack of public market information	10	18.5	9	16.7	12	22.2	31	19.1
Long transportation	10	18.5	6	11.1	11	20.4	27	16.7
Price determine by brokers	15	27.8	22	40.7	7	13.0	44	27.2

4.13. Major constraints of sheep and goats production in the study area

The major constraints of sheep and goat production in the study area are presented in Table 27. Disease, feed shortage, predator, lack of improved breed, and drought and water shortage were major constraints of sheep and goats production across the study areas. Among those disease and feed shortage were the primary and secondary constraints of sheep in Artuma Fursi and Dewachefa districts whereas, feed shortage and disease was the primary and secondary constraints of sheep in Jile Timuga districts, respectively. On the other hand feed shortage and disease were the primary and secondary constraints of goats in Artuma Fursi and Jile Timuga district whereas, disease and feed shortage were the primary and secondary respectively constraints of goats in Dewachefa districts. In the study area, feed shortage was one of the problems rearing sheep and goats especially in Artuma Fursi and Jile Timuga district might be due to high Parthenium weed encroachment to the natural grazing land. Farmers should remove this Parthenium weed from the grazing land for avoiding feed shortage and favourable feed availability. The current result was in agreement with result of Hulunim (2014) who indicated that feed shortage and disease occurrences ranked 1^{st} and 2^{nd} as major goat rearing constraints in Bati area, and Assen and Aklilu (2012) to which shortage of feed, disease, are the major constraints of sheep and goats in Tigray region.

Table 27. The major constraints of sheep and goat production in the study area

Major Constraint of Sheep	Artuma Fursi				Dewachefa				Jile Timuga				Overall index
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index	
Drought	3	4	2	0.06	0	0	4	0.01	6	12	8	0.17	0.08
Feed Shortage	15	22	12	0.34	4	8	12	0.14	24	18	12	0.41	0.30
Water Shortage	6	6	4	0.11	0	0	1	0.004	6	8	4	0.13	0.08
Disease	24	12	10	0.36	33	20	1	0.50	13	8	4	0.20	0.35
Predator	2	0	3	0.03	1	5	5	0.06	0	2	7	0.04	0.04
Lack of Labor	2	3	6	0.06	6	2	4	0.09	0	1	6	0.03	0.06
Lack of improved breed	2	2	0	0.034	5	12	12	0.18	0	1	2	0.01	0.08
Major Constraint of Goats													
Drought	3	4	2	0.06	0	0	4	0.02	6	12	8	0.16	0.08
Feed Shortage	21	21	9	0.37	9	8	12	0.21	28	13	8	0.38	0.32
Water Shortage	6	6	4	0.11	0	0	1	0.004	6	8	4	0.12	0.08
Disease	20	15	10	0.33	29	16	1	0.47	14	17	8	0.27	0.35
Predator	0	0	3	0.01	2	1	5	0.05	0	0	4	0.01	0.02
Lack of labor	2	3	6	0.06	6	2	4	0.10	0	1	6	0.03	0.06
Lack of Improved breed	2	3	5	0.05	6	8	5	0.15	0	3	4	0.03	0.08

R1=firstrank, R2=secondrank, R3=thirdrank, I=index

4.14. Phenotypic characterization of goat population

4.14.1. Qualitative traits of goats

Qualitative traits of indigenous goats are presented in Table 28. There was no significant ($P>0.05$) difference in coat color patterns of indigenous goats among districts. The coat color patterns observed in the study area were plain (77.7%), patchy (20.2%) and spotted (2.2%).In the study area, twelve coat color types were recorded. The chi-square test indicated that there was significant ($P<0.05$) difference between goat population in the three districts (Artuma-Fursi, Dewa-chefa and Jile-Timuga districts) for coat color types. The predominant coat color type was fawn in Artuma-Fursi (30.0%) and (26.5%) in Dewa-chefa districts whereas in Jile-Timuga district red coat color (31.5%) was most frequently observed color. In studied sample goat populations, white with different colors (red, black, fawn and brown), uniform white, black, roan and gray color goats were also present with small and varied frequencies across the study districts.

In contrary to the current study, FARM Africa (1996) described this goat types as reddish-brown coat color type and included with in central Highland breed. The possible reason may be FARM Africa (1996) covered very wide areafor Central Highland goat there may be heterogeneity within the breed. Similarly Hulumin (2014) reported that dark and light red were the predominant coat colors in Bati goats. In the study area very small proportion of black coat color indicates that the farmers have high preference on coat color due to the effect of market and cultural taboo. The representative coat color type of sampled goat population of Artuma Fursi, DewachefaJile-Timuga districts presented in Figure 2,3,and 4, respectively.

The majority of goat population in Artuma Fursi (83.0%), in Dewachefa, (84.5%) and in Jile-Timuga (85.0) had smooth hair coat type and small proportion of long straight (3.5%), curly rough (2.5%), glossy (5.0%) and dull (3.3%) hair type were observed. With respect to hair length the majority of goats in Artuma Fursi (92.5%), in Dewachefa, (92.0%) and in Jile-Timuga (97.7%) had medium sized and small proportion (6.0%) ofthem had long hair across the study area. In the study area, the majority (98.0%) of goats had horn and only 2.0% had not horn. The majority of goat population in Artuma Fursi (76.5%), in Dewachefa, (70.5%) and in Jile-Timuga (921.5%) had straight horn shape and back ward horn orientation (77.3%) were dominant among the sampled goat population. The occurrences of polled goats in the study area, were very rare which is in line with the previous studies by FARM Africa (1996), Ahmed (2013), Solomon (2014) and Alubel (2015) on Ethiopian indigenous goats, goats in Horro Guduru Wollega zone, and Abergelle goats, respectively. The most frequently observed ear orientation of goats in the study districts were erect/forward (61.5%), carried horizontally (31.8%), pendulous (4.7%) and semi-pendulous (2.0%).

The majority (89.3%) of goat population in the study area had straight head profile and the remaining (10.7%) of goats had slightly concave head profile. Straight back profile was predominant (83.5%) in the study sampled goat populations, other back profiles such as slops up towards the rump, slops down from the wither and dipped or curved were also noted rarely. In the study area sloping rump profile was the most frequently observed rump profile with (64.6%), roofy rump profile (34.2%) whereas flat rump profiles only 1.2% of the sampled goat population. Only 13.7% of the sampled goats population have beard. Beard was

mostly observed in male goat population than females. The presence of toggle and ruff in the study area was less pronounced for both male and female populations. A total of only 2.3% toggle and 0.3% ruff in both male and female goat population in the study area possessed.

Figure 2.Buck (left-side) and doe (right-side) in Artuma Fursi district

Figure 3.Buck (left-side) and doe (right-side) in Dewachefa districts

Figure 4.Buck (left-side) and doe (right-side) in Jile Timuga district

Table 28. Qualitative traits of indigenous goat types found in the study area

Qualitative trait	Levels	ArtumaFursi						Dewachefa						JileTimuga						Overall	
		Female		Male		Total		Female		Male		Total		Female		Male		Total			
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Coat color pattern	Plain	143	79.4	17	85.0	160	80.0	131	72.8	14	70.0	145	72.5	147	81.7	14	70.0	161	80.5	466	77.7
	Patch	33	18.3	3	15.0	36	18.0	45	25.0	6	30.0	51	25.5	29	16.1	5	25.0	34	17.0	121	20.2
	Spotted	4	2.2	0	0.0	4	2.0	4	2.2	0	0.0	4	2.0	4	2.2	1	5.0	5	2.5	13	2.2
	X^2value	5.469ns																			
Coat color type	White	28	15.6	4	20.0	32	16.0	31	17.2	6	30.0	37	18.5	14	7.8	2	10.0	16	8.0	85	14.2
	Black	4	2.2	1	5.0	5	2.5	7	3.9	1	5.0	8	4.0	8	4.4	0	0.0	8	4.0	21	3.5
	Brown	32	17.8	4	20.0	36	18.0	11	6.1	0	0.0	11	5.5	19	10.6	2	10.0	21	10.5	68	11.3
	Fawn	54	30.0	6	30.0	60	30.0	48	26.7	5	25.0	53	26.5	26	14.4	1	5.0	27	13.5	140	23.3
	Gray	1	0.6	1	5.0	2	1.0	5	2.8	1	5.0	6	3.0	3	1.7	0	0.0	3	1.5	11	1.8
	Red	24	13.3	2	10.0	26	13.0	28	15.6	1	5.0	29	14.5	56	31.1	7	35.0	63	31.5	118	19.7
	Roan	11	6.1	0	0.0	11	5.5	10	5.6	3	15.0	13	6.5	1	0.6	0	0.0	1	0.5	25	4.2
	Brown+ white	7	3.9	0	0.0	7	3.5	14	7.8	0	0.0	14	7.0	2	1.1	0	0.0	2	1.0	23	3.8
	Black +white	5	2.8	0	0.0	5	2.5	3	1.7	2	10.0	5	2.5	0	0	0	0.0	0	0.0	10	1.7
	Fawn+white	6	3.3	0	0.0	6	3.0	5	2.8	0	0.0	5	2.5	3	1.7	1	5.0	4	2.0	15	2.5
	Light red	3	1.7	2	10.0	5	2.5	9	5.0	1	5.0	10	5.0	22	12.2	2	10.0	24	12.0	39	6.5
	Red+white	5	2.8	0	0.0	5	2.5	9	5.0	0	0.0	9	4.5	26	14.4	5	25.0	31	15.5	45	7.5
	X^2value	125.972***																			
Hair color type	Smooth hair	161	89.4	5	25.0	166	83.0	158	87.8	11	55.0	169	84.5	162	90.0	17	85.0	179	89.5	514	85.7
	Long straight hair	3	1.7	11	55.0	14	7.0	2	1.1	5	25.0	7	3.5	0	0.0	0	0.0	0	0.0	21	3.5
	Curly rough hair	4	2.2	3	15.0	7	3.5	5	2.8	1	5.0	6	3.0	1	0.6	1	5.0	2	1.0	15	2.5
	Glossy	8	4.4	1	5.0	9	4.5	8	4.4	3	15.0	11	5.5	8	4.4	2	10.0	10	5.0	30	5.0
	Dull	4	2.2	0	0.0	4	2.0	7	3.9	0	0.0	7	3.5	9	5.0	0	0.0	9	4.5	20	3.3
	X^2 value	19.441*																			
Hair length	Medium	173	96.1	12	60.0	185	92.5	171	95.0	13	65.0	184	92.0	175	97.2	20	100	195	97.5	564	94.0
	Long	7	3.9	8	40.0	15	7.5	9	5.0	7	35.0	16	8.0	5	2.8	0	0.0	5	2.5	36	6.0
	X^2 value	6.560*																			

Table 28 (*Continued*)

Qualitative trait	Levels	ArtumaFursi						Dewachefa						JileTimuga						Overall	
		Female		Male		Total		Female		Male		Total		Female		Male		Total			
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Horn	Present	178	98.9	20	100	198	99.0	176	97.8	20	100	196	98.0	176	97.8	18	90.0	194	97.0	588	98.0
	Absent	2	1.1	0	0.0	2	1.0	4	2.2	0	0.0	4	2.0	4	2.2	2	10.0	6	3.0	12	2.0
	X^2 value	2.041ns																			
Horn shape	Straight	142	78.9	11	55.0	153	76.5	128	71.1	13	65.0	141	70.5	169	93.9	16	80.0	185	92.5	479	79.8
	Curved	30	16.7	9	45.0	39	19.5	44	24.4	5	25.0	49	24.5	7	3.9	2	10.0	9	4.5	97	16.2
	Spiral	6	3.3	0	0.0	6	3.0	4	2.2	2	10.0	6	3.0	0	0.0	0	0.0	0	0.0	12	2.0
	Polled	2	1.1	0	0.0	2	1.0	4	2.2	0	0.0	4	2.0	4	2.2	2	10.0	6	3.0	12	2.0
	X^2 value	41.405***																			
Horn orientation	Back ward	142	78.9	16	80.0	158	79.0	128	71.1	17	85.0	145	72.5	146	81.1	15	75.0	161	80.5	464	77.3
	Upward	36	20.0	4	20.0	40	20.0	48	26.7	3	15.0	51	25.5	30	16.7	3	15.0	33	16.5	124	20.7
	Polled	2	1.1	0	0.0	2	1.0	4	2.2	0	0.0	4	2	4	2.2	2	10.0	6	3.0	12	2.0
	X^2value	7.160ns																			
Ear orientation	Erect	109	60.6	15	75.0	124	62.0	112	62.2	12	60.0	124	62.0	106	58.9	15	75.0	121	60.5	369	61.5
	Carried horizontally	54	30.0	4	20.0	58	29.0	56	31.1	7	35.0	63	31.5	66	36.7	4	20.0	70	35.0	191	31.8
	Pendulous	12	6.7	1	5.0	13	6.5	9	5.0	1	5.0	10	5.0	5	2.8	1	5.0	5	2.5	28	4.7
	Semi-pendulous	5	2.8	0	0.0	5	2.5	3	1.7	0	0.0	3	1.5	3	1.7	0	0.0	4	2.0	12	2.0
	X^2 value	5.190ns																			
Head profile	Straight	161	89.4	17	85.0	178	89.0	160	88.9	12	60.0	172	86.0	168	93.3	18	90.0	186	93.0	536	89.3
	Slightly Concave	19	10.6	3	15.0	22	11.0	20	11.1	8	40.0	28	14.0	12	6.7	2	10.0	14	7.0	64	10.7
	X^2 value	5.177ns																			

Table 28 (*continued*)

Qualitative trait	Levels	Artuma Fursi						Dewachefa						Jile Timuga						Overall	
		Female		Male		Total		Female		Male		Total		Female		Male		Total			
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Back profile	Straight	145	80.6	17	85.0	162	81.0	152	84.4	16	80.0	168	84.0	158	87.8	13	65.0	171	85.5	501	83.5
	Slops up to rump	6	3.3	1	5.0	7	3.5	7	3.9	1	5.0	8	4.0	5	2.8	1	5.0	6	3.0	21	3.5
	Slop down from withers	24	13.3	1	5.0	25	12.5	14	7.8	2	10.0	16	8.0	16	8.9	6	30.0	22	11.0	63	10.5
	Curved/dipped	5	2.8	1	5.0	6	3.0	7	3.9	1	5.0	8	4.0	1	0.6	0	0.0	1	0.5	15	2.5
	X^2 value	7.737ns																			
Rump profile	Roofy	69	38.3	7	35.0	76	38.0	56	31.1	6	30.0	62	31.0	61	33.9	6	30.0	67	33.5	205	34.2
	Sloping	108	60.0	12	6.0	120	60.0	121	67.2	14	70.0	135	67.5	119	66.1	14	70.0	133	66.5	388	64.6
	Flat	3	1.7	1	5.0	4	2.0	3	1.7	0	0.0	3	1.5	0	0.0	0	0.0	0	0.0	7	1.2
	X^2 value	6.213ns																			
Toggle	Present	2	1.1	1	5.0	3	1.5	5	2.8	1	5.0	6	3.0	4	2.2	1	5.0	5	2.5	14	2.3
	Absent	178	98.9	19	95.0	197	98.5	175	97.2	19	95.0	194	97.0	176	97.8	19	95.0	195	97.5	586	97.7
	X^2 value	1.024ns																			
Ruff	Present	1	0.6	1	5.0	2	1.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.3
	Absent	179	99.4	19	95.0	198	99.0	180	100	20	100	200	100	180	100	20	100	200	100	598	99.7
	X^2 value	4.01ns																			
Beard	Present	21	11.7	10	50.0	31	15.5	19	10.6	9	45.0	28	14.0	15	8.3	8	40.0	23	11.5	82	13.7
	Absent	159	88.3	10	50.0	169	84.5	161	89.4	11	55.0	172	86.0	165	91.7	12	60.0	177	88.5	518	86.3
	X^2 value	1.384ns																			

4.14. 2. Quantitative traits of goats in the study area

Body weight and other linear body measurements of indigenous goats are presented in Table 29 and 30. In the study area, overall mean of body weight, body length, height at wither, heart girth, chest depth, shoulder width, pelvic width, ear length, rump length, rump width, canon bone length, canon bone circumference, horn length and scrotal circumference were 26.10 kg, 61.7 cm, 63.4cm, 71.5 cm, 29.0cm, 11.4 cm, 12.2cm, 13.3 cm, 12.9 cm, 13.5cm, 13.0 cm, 10.0 cm, 11.5 cm, 23.2 cm, respectively.

Sex effect

Sex had significant ($p<0.05$) effect on only body weight (BW),Height at wither (WH) and heart girth (HG). The mean of all the body measurements in male goats were consistently higher than females for all variables. In the study area, male have higher body weight than female. This was in agreement with the report of Belete (2013) in Bale Zone of Oromia Region,that males have higher body weight than females. This condition was expected since there is hormonal difference between males and females. The sex related differences might be partly a function of the sex differential hormonal effect growth (Semakula *et al.*, 2010).

Age effect

The linear body measurements increased as animal advances with age. Body weight and all body measurements were significantly affected ($p<0.05$) by age except cannon bone length, cannon circumference and rump length. Body weight and all body measurements were increased as the age increased from the youngest (1PPI) to the older (4PPI) age group. The average body weight of goats in the study area was 23.7, 25.6, 28.3 and 29.9 for 1PPI, 2PPI, 3PPI and 4PPI, respectively. This result was in agreement with the finding of Tsigabu (2015) who reported that body weight and these linear body measurements increases when the animal gets older (increase in age).

Location Effect

District had significant ($P<0.05$) effect on body weight and other linear body measurements except cannon bone length, cannon circumference and scrotal circumference. The present result was in agreement with earlier study results that showed district had significant effect on

body measurements of indigenous goat breeds of Ethiopia (Yaekob *et al.* 2015, Solomon, 2014; Belete, 2013). The variation in body weight between goats of different location could be explained by the different management system or the presence of genetic difference within breed.In most body measurements, goats in Artuma Fursi and Dewachefa district had relatively higher than Jile-Timuga. This could be due to management practice, productive grazing land and there was crossbreeding with Afar goats as observed in Jile-Timuga district.

Sex by age interaction

The interaction of sex and age group was significant ($p<0.05$) for body weight and all other body measurements, except rump length, canon bone length and cannon bone circumference. In each age group males were having higher values in height at wither, rump height, rump width, rump length and chest width than females. The value of body weight and other linear body measurements for goats of both sexes increased as age class increased from 1PPI to 4PPI. The mean body weight of males in age group were 1PPI (23.21Kg), 2PPI (25.78Kg), 3PPI (33.7Kg) and 4PPI (36.62Kg) whereas the mean body weight of females in age group were 1PPI (22.49Kg), 2PPI (24.55Kg), 3PPI (26.24Kg) and 4PPI (27.99Kg) in the study area. Similarly, Tsigabu (2015) reported in Nuer zone, bucks in each age category are higher in body weight than does in the respective age category and body weight increases with age in both sexes.

Table 29. Least square mean (± SE) body weight (kg) and other linear body measurements by location, sex, ageand sex by age

Effect and levels	BL	HW	HG	CD	SW	PW	EL	RL
	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE
Overall	61.7±0.1	63.4±0.1	71.5±0.1	29.0±0.1	11.4±0.07	12.2±0.03	13.3±0.04	12.9±0.05
CV%	4.94	4.18	4.49	7.05	13.59	6.11	7.04	10.16
R^2	0.25	0.18	0.26	0.28	0.25	0.12	0.24	0.12
Location	*	*	*	*	*	*	*	*
ArtumaFursi	62.1±0.2^{a}	63.6±0.2 ^{b}	72.0±0.3 ^{a}	28.5±0.2^{b}	12.0±0.1^{a}	12.2±0.06^{a}	13.4±0.08^{a}	12.9±0.1^{b}
Dewachefa	62.6±0.2^{a}	64.6±0.2^{a}	72.3±0.3^{a}	29.5±0.18^{a}	11.7±0.1^{a}	12.3±0.06^{a}	13.4±0.08^{a}	13.2±0.1^{a}
Jile Timuga	60.8±0.2^{b}	63.0±0.2^{b}	70.6±0.3^{b}	29.4±0.18^{a}	10.3±0.1^{b}	11.9±0.0^{b}	13.1±0.1^{b}	12.5±0.1^{b}
Sex	Ns	*	*	Ns	Ns	Ns	Ns	Ns
Male	62.0±0.4	64.4±0.3^{a}	72.42±0.4	29.6±0.26	11.5±0.2	12.2±0.09	13.4±0.1	13.02±0.1
Female	61.7±0.1	63.0±0.1^{b}	70.93±0.1	28.6±0.1	11.2±0.1	12.1±0.03	13.2±0.04	12.8±0.05
Age group	*	*	*	*	*	*	*	Ns
1PPI	59.4±0.3^{b}	62.3±0.2^{c}	69.4±0.3^{d}	27.6±0.2^{b}	10.5±0.1^{b}	11.8±0. ^{b}	12.5±0.1^{b}	12.5±0.13
2PPI	61.1±0.3^{b}	63.3±0.2^{bc}	70.6±0.3^{c}	28.5±0.2^{b}	10.9±0.2^{ab}	12.1±0.0^{ab}	13.1±0.1^{a}	12.5±0.12
3PPI	62.7±0.3^{a}	64.2±0.3 ^{a}	72.3±0.3^{b}	29.5±0.2^{a}	11.8±0.2^{a}	12.2±0.1^{ab}	13.6±0.1^{a}	13.0±0.13
4PPI	64.3±0.3^{a}	65.2±0.2^{a}	74.2±0.3^{a}	30.7±0.2^{a}	12.1±0.1^{a}	12.5±0.0 ^{a}	13.9±0.1^{a}	13.5±0.12

a,b,c ,d means on the same column with different superscripts within the specified district, sex and dentition group are significantly different (P<0.05); BL=Body Length; HW= height at Wither; HG= Heart Girth; CD=Chest Depth; SW= Shoulder Width; PW= Pelvic Width; EL= Ear Length; RL= Rump Length; 1PPI = 1 Pair of Permanent Incisors; 2PPI = 2 Pair of Permanent Incisors; 3PPI = 3 Pairs of Permanent Incisors; 4PPI = 4 Pairs of Permanent Incisors.

Table29. (*Continued)*

Effect and levels	RW	CBL	CBC	HL	SC	BW
	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE
Overall	13.54±0.04	13.01±0.03	10.05±0.02	11.50±0.13	23.25±0.16	26.10±0.16
CV%	6.69	6.56	5.47	23.65		11.83
R^2	0.22	0.09	0.07	0.34		0.41
Location	*	Ns	Ns	*	Ns	*
ArtumaFursi	13.6±0.0 [a]	13.08±0.07	10.12±0.04	12.1±0.24[a]	24.15±0.20	28.3±0.28 [a]
Dewachefa	13.5±0.1[ab]	12.97±0.07	10.07±0.04	11.4±024[ab]	23.11±0.21	26.9±0.27 [b]
Jile Timuga	13.2±0.0 [b]	13.07±0.07	9.99±0.04	10.8±0.2[b]	23.30±0.20	25.4±0.27 [c]
Sex	Ns	Ns	Ns	Ns		*
Male	13.50±0.11	13.15±0.11	10.11±0.07	11.94±0.35	23.52±0.12	28.5±0.40 [a]
Female	13.42±0.04	12.92±0.03	10.0±0.02	10.96±0.12	Na	25.2±0.13 [b]
Age	*	Ns	Ns	*	*	*
1PPI	12.8±0.1 [c]	12.65±0.08	9.88±0.05	8.6±0.2[b]	22.2±0.2[c]	23.7±0.3[c]
2PPI	13.2±0.0 [b]	12.93±0.08	9.98±0.05	10.8±0.2[a]	23.2±0.1 [b]	25.6±0.3[b]
3PPI	13.7±0.1 [a]	13.22±0.09	10.12±0.05	12.4±0.3[a]	24.4±0.2[ab]	28.3±0.3[a]
4PPI	14.0±0.1 [a]	13.36±0.7	10.26±0.5	13.9±0.2[a]	24.2±0.3[a]	29.9±0.2[a]

a,b,c ,d means on the same column with different superscripts within the specified district,sex and dentition group are significantly different (P<0.05); RW = Rump Width; CBL=Cannon Bone Length; CBC= Cannon Bone circumference; HL=Horn Length; SC = Scrotal Circumference; BW = Body weight; 1PPI = 1Pair of Permanent Incisors; 2PPI = 2 Pair of Permanent Incisors; 3PPI = 3Pairs of Permanent Incisors;4PPI = 4Pairs of Permanent Incisors; ns=non-significant; na=not applicable

Table 29. (*Continued)*

Effect and levels	N	BL	HW	HG	CD	SW	PW	EL
		LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE
Sex by age group		*	*	*	*	*	*	*
Male,1PPI	19	57.9±0.69^{c}	62.4±0.6^{c}	68.47±0.7^{d}	27.52±0.4^{d}	10.52±0.4^{b}	11.84±0.1^{ab}	12.47±0.2^{c}
Female,1PPI	93	59.2±0.32^{c}	61.8±0.2^{bc}	69.13±0.3^{d}	27.29±0.2^{cd}	10.47±0.1^{ab}	11.86±0.0^{b}	12.44±0.1^{bc}
Male,2PPI	23	61.8±0.62^{c}	63.6±0.5^{bc}	70.52±0.6^{cd}	28.47±0.4^{d}	11.13±0.3^{ab}	12.17±0.1^{ab}	13.34±0.2^{ab}
Female,2PPI	116	60.5±0.28^{bc}	62.7±0.2^{bc}	70.19±0.3^{cd}	28.04±0.2^{cd}	10.96±0.1^{ab}	12.12±0.0^{ab}	13.06±0.1^{ab}
Male,3PPI	10	65.0±0.95^{b}	65.2±0.8^{bc}	75.00±1.0^{c}	31.30±0.6^{c}	12.30±0.5^{ab}	12.70±0.2^{ab}	14.00±0.3^{a}
Female,3PPI	116	61.9±0.28^{ab}	63.5±0.2^{b}	71.42±0.3^{b}	29.04±0.2^{b}	11.66±0.1^{ab}	12.15±0.0^{ab}	13.54±0.1^{a}
Male,4PPI	8	66.8±1.0^{ab}	68.1±0.9^{ab}	79.25±1.1^{ab}	32.62±0.7^{ab}	12.25±0.6^{ab}	12.50±0.2^{ab}	13.87±0.3^{a}
Female,4PPI	213	63.3±0.21^{a}	64.3±0.18^{a}	73.26±0.2^{a}	30.29±0.1^{a}	11.86±0.1^{a}	12.46±0.0^{a}	13.80±0.0^{a}

a,b,c ,d means on the same column with different superscripts within the specified sex and dentition group are significantly different (P<0.05); BL=Body Length; HW= height at Wither; HG= Heart Girth; CD=Chest Depth; SW= Shoulder Width; PW= Pelvic Width; EL= Ear Length; 1PPI = 1 Pair of Permanent Incisors; 2PPI = 2 Pair of Permanent Incisors; 3PPI = 3 Pairs of Permanent Incisors; 4PPI = 4 Pairs of Permanent Incisors.

Table 29. (*Continued)*

Effect and levels	N	RL	RW	CBL	CBC	HL	BW
		LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE	LSM ±SE
		Ns	*	Ns	Ns	*	*
Male,1PPI	19	12.52±0.30	12.52±0.2^{c}	12.73±0.19	9.84±0.12	8.47±0.6^{d}	23.21±0.7^{e}
Female,1PPI	93	12.49±0.13	12.86±0.1^{c}	12.54±0.08	9.84±0.05	8.31±0.2^{cd}	22.49±0.3^{de}
Male,2PPI	23	12.52±0.27	13.26±0.2^{abc}	13.13±0.17	10.13±0.11	11.52±0.5^{bc}	25.78±0.6^{d}
Female,2PPI	116	12.44±0.12	13.27±0.0^{b}	12.80±0.07	9.92±0.05	10.40±0.2^{ab}	24.55±0.3^{cd}
Male,3PPI	10	13.60±0.42	14.30±0.3^{ab}	13.20±0.27	10.20±0.17	13.40±0.8^{a}	33.70±1.0^{c}
Female,3PPI	116	12.85±0.12	13.60±0.0^{a}	13.11±0.07	10.06±0.05	11.86±0.2^{a}	26.24±0.3^{b}
Male,4PPI	8	13.75±0.47	14.37±0.3^{a}	13.50±0.30	10.25±0.19	14.75±0.9^{a}	36.62±1.1^{a}
Female,4PPI	213	13.40±0.09	14.00±0.6^{a}	13.24±0.05	10.20±0.03	13.35±0.2^{a}	27.99±0.2^{a}

a,b,c ,d means on the same column with different superscripts within the specified sex and dentition group are significantly different (P<0.05); RL=Rump Length; RW = Rump Width; CBL=Cannon Bone Length; CBC= Cannon Bone circumference; HL=Horn Length; BW = Body weight; 1PPI = 1Pair of Permanent Incisors; 2PPI = 2 Pair of Permanent Incisors; 3PPI = 3Pairs of Permanent Incisors;4PPI = 4Pairs of Permanent Incisors; ns=non-significant

4.14.3. Correlation between body weight and other body measurements

Coefficients of correlation between body weight and other linear body measurements for male and female goats are presented in Table 31. In this study all linear body measurements showed significant ($p<0.05$) associations with body weight. In males positive and strong association were found between body weight and heart girth (r=0.68), wither height (r=0.63), chest depth (r=0.54), scrotal circumference (r=0.49), shoulder width (r=0.48) and rump width (r=0.49). These linear body measurements were highly affected by the change in body weight; for this reason they are more important in prediction of live body weight of the animal. Pelvic width (r=0.45), rump length (r=0.35), ear length (r=0.39) and body length (r=0.51) had moderate and positive correlation with body weight. Horn length (r=0.34), cannon bone length (r=0.33) and cannon bone circumference (r= -0.01) showed weak and positive correlation except cannon bone circumference which have negative correlation.

In females heart girth (r=0.62), body length (r=0.52), height at wither (r=0.48) and chest depth (r=0.52) showed strong positive correlation with body weight. Rump width (r=0.45), pelvic width (r=0.43), shoulder width (r=0.48), and rump length (r=0.37) had moderate and positive correlation with body weight. Cannon bone length (r=0.37), horn length (r=0.30), ear length (r=0.27) and cannon bone circumference (r= 0.18) had weak and positive correlation with body weight. Heart girth was the most strongly correlated trait with body weight (r= 0.68 for males; r= 0.62 for females) than other traits.

Table 30.Correlation coefficients among body weight and linear measurements goat (values above the diagonal are for males and below the diagonal are for females) (N=60 for male; N=540 for female

	BL	HW	HG	CD	SW	PW	EL	RL	RW	CBL	CBC	HL	SC	BW
BL		0.63*	0.68*	0.54*	0.48*	0.45*	0.39*	0.35*	0.49*	0.33*	-0.01*	0.34*	0.49*	0.51*
HW	0.48*		0.67*	0.58*	0.46*	0.39*	0.39*	0.47*	0.59*	0.21*	0.193*	0.36*	0.44*	0.37*
HG	0.62*	0.51*		0.63*	0.58*	0.49*	0.52*	0.41*	0.65*	0.31*	0.29*	0.47*	0.58*	0.50*
CD	0.52*	0.48*	0.59*		0.36*	0.47*	0.49*	0.37*	0.58*	0.36*	0.22ns	0.32*	0.44*	0.43*
SW	0.42*	0.32*	0.34*	0.17*		0.40*	0.61*	0.39*	0.56*	0.24ns	0.40*	0.33*	0.45*	0.25ns
PW	0.43*	0.30*	0.46*	0.29*	0.26*		0.44*	0.46*	0.67*	0.31*	0.19ns	0.18ns	0.39*	0.25ns
EL	0.27*	0.35*	0.30*	0.28*	0.27*	0.16*		0.24*	0.59*	0.27*	0.34*	0.37*	0.46*	0.17ns
RL	0.37*	0.38*	0.50*	0.36*	0.26*	0.30*	0.09*		0.50*	0.21ns	0.15*	0.13ns	0.29*	0.16ns
RW	0.45*	0.34*	0.50*	0.37*	0.32*	0.54*	0.24*	0.41*		0.31*	0.39*	0.41*	0.56*	0.32*
CBL	0.37*	0.29*	0.33*	0.31*	0.23*	0.13*	0.16*	0.23*	0.23*		0.19*	0.11ns	0.17ns	0.12ns
CBC	0.18*	0.13*	0.20*	0.17*	0.15*	0.20*	0.19*	0.11*	0.27*	0.14*		0.27*	0.33*	0.24ns
HL	0.30*	0.31*	0.36*	0.35*	0.24*	0.15*	0.33*	0.17*	0.27*	0.21*	0.13*		0.58*	0.68*
BW	0.52*	0.41*	0.55*	0.38*	0.39*	0.33*	0.40*	0.23*	0.42*	0.19*	0.23*	0.49*		0.54*

ns= non-significant (P>0.05); * significant at (0.05) level; BL=Body Length; WH= Wither Height;HG= Heart Girth; CD=Chest Depth; SW=Shoulder Width; PW=Pelvic Width; EL= Ear Length; RL= Rump Length; RW = Rump Width; CBL=Cannon Bone Length; CBC=Cannon Bone Circumference; HL=Horn Length; SC = Scrotal Circumference ; BW=Body Weight

4.14.4. Prediction of body weight from different linear body measurements

Multiple linear regression models for predicting the body weight of goats from linear body measurements are presented in Table 32. The knowledge of live weight of animals is important in livestock production and marketing practices (Birteeb *et al*., 2012). To predict the live weight of animals without weighing scales, mathematical equations can be developed based on actual weight-linear body measurement data (Solomon and Kassahun, 2008). Multiple linear regression analysis was carried out to generate models (equations) for prediction of live body weight of male and female goats separately. Regression of body weight over independent variables, which have higher correlation with body weight, was done to set adequate model for the prediction of body weight separately for each sex.

In this study in order to develop the prediction equation, only eight quantitative traits were selected in the prediction equation for does (HG, HW, SW, RL, RW, BL, CBL and CBC) and only six linear body measurements were taken to be incorporated in to the model for bucks (HG, BL, CD, SW, RW and SC) were selected. The fitted prediction model was selected with smaller C (p), RMSE and higher R^2 values. However, according to Grum (2010) and Tesfaye (2008), considering more variables under extensive management conditions will be unpractical due to cost and accuracy problems. So that heart girth was the first variable to explain more variation than other variables in both female (62%) and male (68%) goats.This shows that heart girth might be the best trait to estimate live body weight for goats in the study area. This was in agreement with the results of Ahmed (2013), Belete (2013), and Hulunim (2014) who reported that chest girth was selected first for prediction of live body weight of goats. Although the use of conventional weighing scales is the best way of determining live weight of an animal however, proper weight measurements are often difficult in villages due to lack of weighing balancein this case body weight could predict using only heart girth.The prediction of body weight from different linear body measurements was indicated as follows.Thus, prediction of body weight could be based on regression equation BW = -19.55 + 0.63HG for female sample population and BW = -45.72 + 1.0HG for male sample goat population where, BW and HG are body weight and chest girth, respectively.

Table 31. Multiple regression analysis of live body weight on different body measurements of female and male goats in the study area

Model	Intercept	B1	B2	B3	B4	B5	B6	B7	B8	R^2	Adj.R^2	C (P)	MSE
For male goats													
HG	-45.72	1.0								0.63	0.637	25.96	11.62
HG+ CD	-46.06	0.70	0.78							0.71	0.077	10.35	9.28
HG+CD+SC	-55.97	0.54	0.74	0.96						0.74	0.031	5.35	8.42
HG+CD+ RW+SC	-55.45	0.49	0.68	0.74	0.75					0.75	0.009	5.11	8.24
HG+CD+SW+ RW+SC	-57.96	0.57	0.64	-0.51	0.96	0.81				0.76	0.010	4.65	8.02
BL+HG+CD+SW+RW+SC	-63.38	0.25	0.48	0.58	-0.58	1.01	0.73			0.77	0.010	4.27	7.80
For females goats													
HG	-19.55	0.63								0.37	0.37	184.4	8.91
HG+SW	-18.82	0.52	0.62							0.45	0.078	95.71	7.80
BL+HG+SW	-23.92	0.26	0.38	0.49						0.49	0.034	57.34	7.31
BL+HG+SW+RW	-25.42	0.23	0.33	0.45	0.59					0.50	0.017	38.94	7.07
BL+HG+SW +RL+RW	-26.31	0.24	0.38	0.48	-0.39	0.70				0.52	0.015	23.13	6.86
BL+HG+SW+RL+RW+CBC	-31.57	0.23	0.37	0.46	-0.38	0.61	0.72			0.53	0.001	13.36	6.73
BL+HW+HG+SW+RL+RW+CBC	-35.15	0.21	0.11	0.35	0.44	-0.41	0.61	0.71		0.54	0.005	8.95	6.66
BL+HW+HG+SW+RL+RW+CBL+ CBC	-34.01	0.22	0.12	0.35	0.45	-0.41	0.61	-0.24	0.7	0.54	0.002	7.89	6.64

HG = Heart girth; CD = Chest Depth; SC = Scrotal Circumference; RW= Rump Width; BL = Body length; SW= Shoulder Width; PW=Pelvic Width; CBL=Canon Bone Length; CBC = Canon Bone Circumference; RL=Rump Length; WH = Wither Height; R2 = coefficient of determination, C (P) = the mallow's parameters, MSE = Mean square error.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusion

The overall mean goat flock size was (11.90) which is higher than all livestock species and followed by cattle recorded per household in the study area. The flock size of sheep was (7.19) which is lower as compare to goats flock size. The overall mean flock structure of does was higher (4.18) than overall mean flock structure of ewes (2.82) in the study area. In general flock structure size of goats was higher than sheep at all age group across all the study districts. The Agro-pastoralist (mixed) production system was the predominant system in the study area. The main reason for keeping small ruminant was for income generation, saving, meat consumption, Ceremony and Breeding purpose. Natural pasture was the major feed resources of sheep and goats both in wet and dry seasons in all study districts.

Appearance/Body size, growth rate and color were the first, second and third selection criteria of breeding ram and buck in all of the study area.There was selection and breeding practice was uncontrolled in the study area. The age at fist lambing and age at first kidding was 12.53±.94, 12.55±.96 and 12.61±1.10 months for sheep and 12.37±1.13, 12.74±1.10 and 12.55±1.05 months for goats in Artuma Fursi, Dewachefa and Jile Timuga districts respectively. The overall liter size of sheep was 1.27±.49 and 1.73±.82 was for goats in the study area. The result indicated that goats have higher litter size than sheep this show that goats had better reproductive rate than sheep. The sale price of goats in both sexes was much higher than sale price of sheep in both sexes across all the study districts. This indicated that goats are economically important than sheep in earning high income generation of farmers. The overall average number of goats sold per household in a year also higher (6.3) than sheep which was 4.2 animals per year per household. Traders were the major (54.3%) marketing participants of sheep and goats in the study area. Disease andfeed shortages were 1st and 2ndproduction constraints of sheep and goatsin the study area.

The most frequent color patterns observed in the study area were plain. The predominant coat color type was fawn in Artuma-Fursi (30.0%) and (26.5%) in Dewa-chefa districts whereas in Jile-Timuga district (31.5%) red coat color were most frequently observed color respectively.

The presence of horn was common in each of the three districts with a straight shape and backward orientation. The present study shown that body weight and linear body measurements influenced by sex and age. All the body measurements in male goats were consistently higher than females for all variables.

Sheep and goats production in all study districts was characterized by low input subsistence, multiple production objectives in marginal environments. Goats have better economically importance than sheep inprolific and income generation. In all the study districts sheep and goat marketing was traditional i.e. they did not use weighing balance, they did not have market information and the price determined by the involvement of brokers rather than seller and buyers.In all the study districts there is a high encroachment of Parthenium weed on the natural grazing lands.The major production constraints of small ruminant production in the study area were disease, feed shortages water scarcity, lack of improved breeds; uncontrolled mating system and market linked problems. Most body measurements of goats in Artuma Fursi and Dewachefa district had relatively higher than Jile-Timuga. The existing of variation in body size and other linear body measurements of indigenous goats would be useful for future genetic improvement through selection and breed conservation.

5.2. Recommendations

- In the study area, sheep and goats are very important livestock species for income generation of farmers due to shorter production cycles, faster growth rates and greater environmental adaptability than other livestock species so the government should give more emphasis for better improvement and change of the livelihood of the community as well as the country economy through better inputs.
- It is better to improving the utilization of available crop residues and forage development by allotting part of their crop land or cultivation in order to avoid overcome the feed scarcity of sheep and goats during dry seasons.
- Uncontrolled breeding practice should be minimized in order to increase productivity, enhance efficient utilization of selected breeding ram and buck.
- Qualitative traits like coat color type and pattern influenced the decision of farmers in selection of breeding sheep and goats so that farmers should consider the performance of the animals besides qualitative traits.
- Designing and implementing of community-based breeding program should focused to genetically improve growth rate and body conformation and litter size of sheep and goats is a vital way to exploit the available large genetic resources.
- Health condition of sheep and goats and health services delivered in all the study districts was poor, particularly in Artuma Fursi and Dewachefa district. To improve reproductive and productivity of sheep and goats, disease prevention, vaccination and treatment strategies should be designed in all the study districts.
- As farmers objective income generation; farmers should be raising goats rather than sheep for better income.
- Parthenium species should be removed from the grazing land in order to improve the natural feed resource and enhance productivity of sheep and goats.

- In all the study districts sheep and goat marketing was traditional i.e. they did not use weighing balance and they did not have market information and the price was fixed by negotiation between the buyers and sellers. Farmers should use weighing balance and should get current market (price per kg) information in their locality.
- The current study results was not agree with the previous study of FARM Africa (1996) particularly in Artuma Fursi and Dewachefa districts in both in coat color type and other linear body measurements. Therefore, molecular characterization studies should be conducted in the study districts to approve the current phenotypic characterization.

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7. APPENDIX

7. Appendix A. Questioner

Phenotypic Characterization of Indigenous Goat Types and Comparative Characterization of Sheep and Goats rearing System in Oromia Zone of Amhara Region, Northeast Ethiopia

1. Household Characteristics

1.1 Respondent's Sex: 1.Male 2.Female

1.2 Respondent's Age (inyears)_____

1.3 Marital status of respondentsB.Married B.Single C.Divorced

1.4 Respondent's Educational level A. Illiterate (unable to read & write) B. Reading and writing

C.Adulteducation D.Religiousschool, E.Primary(1-8) F. Secondary (9-12)

1.5 Household size and composition

Sex	Age group in years							
	<10M	<10F	10-30F	10-30M	30-50M	30-50F	>50M	>50F
Male								
Female								
Total								

2) Livestock species per household and their size structure

2.1 Livestock species per household

Species	Goats	Sheep	Cattle	Chicken	Camel	Donkey	
Total No							

2.2 Households' ranking of livestock species relative preference

Livestock species	Sheep	Goats	Cattle
Rank			

What are the reasons of preference sheep verses goats?_____

2.3 Size and structure of small ruminant according to the age category given below (number)

Goats	Number	Sheep	Number
Male kids < 6 month		Male lamb < 6 month	
Female kids < 6 month		Female lamb < 6 month	
Weaned male kids 6-12 month		Weaned male lamb6-12month	
Weaned female kids 6-12 month		Weaned female lamb6-12month	
Mature male goats(>1year)		Mature male sheep(>1year)	
Mature female goats(>1year)		Mature female sheep(>1year)	
Castrates		Castrates	
Total		Total	

3. Production and Management practices

3.1. Production systems

	Production systems		
	Crop livestock (mixed)	Agro- pastoralists	Pastoralists
Mark			

3.2.Land holding (inha)

A.Croppingland _____ C. Fallowland _____
B. Grazing land _____ D. Others(specify) _____

3.3 For what purpose do you keep sheep and goats? Select one or more, then rank.

Species	Meat	Milk	Skin	Breeding	Gift	Ceremony	Manure	Saving	Income	Other(specify)
Sheep										
Rank										
Goats										
Rank										

3.4 If you use for milkproduction

Species	Amount milk per day(litters)		Frequency of milking		Lactation length
Goats	Wet season	Dry season	Wet season	Dry season	
Sheep					

3.5For what purpose milk A. market B. householdconsumption C.others _____

3.6. How Goat and sheep flock is herded

	Together With cattle	Both are Together	Together with Calves	Together with Equines	All herded Together
Mark					

4. Feeding, Watering and housing

4.1 Feeding

4.1.1 Feed source (*tick under each season and rankthem*)

Type of feed source	Wet season	Rank	Dry season	Rank
Natural pasture				
Established pasture				
Hay				
Crop residues				
Fallow land				
Concentrate				

Others (Specify_____

4.1.2 Grazing and /or browsingmethod

	Wet season	Dry season
Free		
Herded free grazing		
Paddock		
Tethered		
Rotational grazing		

4.1.3. Do you supplement feed for your sheep and goats in addition to grazing? A.Yes B. No

4.1.4. If your answer is yes, what is your supplementation system (Rank according to importance?)

Supplement type	Wet season	Rank	Dry season	Rank
Roughage				
Minerals (salts)/vitamins				
Concentrates				
Others				

4.1.5. Is there seasonal fluctuation in feed supply? A. Yes B. No

4.1.6. If yes at which month(s) of the year do you experience feed shortage?

_____

4.1.7 Members of household and hired labor responsible for goat activities
(Tick one or more boxes in each column and row)

Activity	Family			
	Male		Female	
	≤15years	>15years	≤15years	>15years
1. Purchasing goat				
2. Selling goat				
3. Herding purpose				
4. Breeding				
5. Caring sick for goats				
6. Feeding				
7. Milking				
8. Barn cleaning				
9. slaughtering				

Other (specify----------
--

4.2. Watering

1. 4.2.1. What are the common water source of sheep and goat in thisarea? Rank it

SN	Sources of water	During rainy season	During wet season
1	River		
2	Pond		
3	Rain water		
4	Water harvest		
5	Deep well		
6	Pipe		
7	Any other sources		

4.2.2. Distance to nearest watering point (tick)

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

4.2.3 Frequency of watering and water quality

Frequency	Wet season	Dry season	**Quality**	Wet season	Dry season
Freely available			Muddy		
Once a day			Salty		
Once in 2 days			Smelly		
Once in 3 days			Clean		
Once in 4 days					

4.3 HOUSING

4.3.1. Housing/enclosure for adult sheep and goats (Tick one or more boxes)

1. In family house	With roof	
2. Separate house		
3. Verenda		
4. Kraal	Without roof	
5. Zero-grazing		
6.Gatta		

Other (specify) _____

4.3.2. Housing materials

Type	Iron sheets	Grass /bush	Wood	Stone /bricks	Concrete	Mud	Other
Roof							
Wall							
Floor							

4.3.3. Are kids/lamb housed with adults?(Tick one box) Yes ☐ No ☐

If no, specify_____

5. HEALTH MANAGEMENT

5.1. What are the major sheep and goats diseases occur frequently in your area?

SN	Name of disease	Affect			Symptoms	Seasons/months of occurrence
		Sheep	Goat	Both		
1						
2						
3						
4						
5						
6						

5.2 What would you do when your sheep and goats sick? (Tick from listed)

Treat with local medicine	Sales immediately	Slaughters immediately	Takes to veterinarycenter

Others,specify_____

5.2. Do you have access to veterinary services? A. Yes B. No

5.3. If yes, which type of veterinary service you accessed?

Treatment	Government	Private	NGOs	Other
Mark				

5.4. Distance to nearest veterinary services

Distance	1-5km	6-10km	>10km	Other (specify)
Mark				

5.5. Has there been any death of sheep and goats over the last 12 months? 1=yes2=No. If yes, rank in the followingtable.

SN	Sheep		Goats	
	Structure	*Died*	*Structure*	*Died*
1	Abortion		Abortion	
2	<3 months		<3 months	
3	3-6 months		3-6 months	
4	Ewes		Does	
5	Rams		Bucks	
6	Castrates/fattening		Castrates/fattening	

5.6. Adaptability traits of sheep and goats

Traits	Disease	Parasite	Heat	Frost	Drought	Feed shortage	Water shortage
Good							
Moderate							
Less							

6. CASTRATION, CULLING AND

6.1. CASTRATION

6.1.1. Do you castrate your ram/ buck? A. Yes B. No

6.1.2. If you castrate your ram/buck, what are your reasons for castration? (Tick)

Reason	Control breeding	Improve fattening	Better price	Better temperament
For sheep				
For goats				
For both				

6.1.3. Specify Castration method you used.

A. By your own (traditional) B. Veterinarians (modern)

6.1.4. At what age do youcastratebucks?_____Months,Rams?_____Months

6.2. What is Reason of culling sheep and goats?

Reason of culling	For Sheep and rank	For Goats and rank
Fertility		
Age		
Health		
Physical defect		
Undesirable characteristics		
Other specific		

6.3. Average culling age due to old age and average market age of young stock

Species	Average market age		Average culling age	
	Male	Female	Male	Female
Sheep				
Goats				

7. Sheep and goats breeding and reproductive managements

7.1 Do you have your own breeding male animals (ram& buck)? A=Yes B=No

7.2 What are the common sources of breeding males for your flocks?

S.N	Sources of breeding males	Ram	Buck
1	Own		
2	Neighbors		
4	Others, specify		

7.3 What are the Breeding/mating system of sheep and goats? A. Controlled B. Uncontrolled

7.4. If uncontrolled, what is the reason?

Reason	growth and/or browse together	Lack of awareness	Insufficient number of ram/bucks	Others (specify)
Mark				

7.5 Do you practice selection for breeding male & female A. Yes B. No

7.6. If you yes for question no.7.5 which traits do you consider in selecting breeding sheep and goats?

Traits of selection	Rank		Traits of selection	Rank	
	For ewe	For doe		For ram	For buck
Color			Color		
Body size			Body size		
Kid survival doubt			Fertility		
Paternal history			Paternal history		
Maternal history			Maternal history		
Age at first sexual maturity			Growth rate		
Kidding interval			Adaptability		
Litter size					
Milk yield					
Adaptability					
Others (specify)					

7.7 Age of selection (months) and how many breeding ram and buck in herd?

Species	Age of Breeding female	Age Breeding male	How many ram and buck
Sheep			
Goats			

7.8. What is the Traits preference of goats and sheep that used for future breeding?

Traits	Adaptability	Disease resistances	Milk yield	Reproduction rate	Feed shortage resistances	Coat color	Longevity	Others
Rank for Sheep								
Rank for Goats								

7.9. How is the reproductive performance of sheep and goats in your farm?

S N	Particulars	Sheep		Goats	
		Male	*Female*	*Male*	*Female*
1	Age of males at sexual maturity				
2	Age at first parturition (months)				
3	Kidding/lambing interval (months)				
4	Average number of kids/lambs per life time(y)				
5	Reproductive life span (y)				
6	Age of marketing/slather				
7	Weaning age				

7.10. What is Litter size in your farm? (Tick)

Species	One	Two	Triplet
Sheep			
Goats			

7.11. What are the major breeding (reproductive) problems that affected your flock productivity?

Problem	Late age at first lambing/kidding	Long lambing/ kidding interval	Repeat breeding	Abortion	Dystocia	Lamb/Kid mortality	Low growth rate
Rank for sheep							
Rank for goats							

8. MARKETING AND MAJOR CONSTRANTS

8.1 Have you sold sheep and/or goats in the past12months? A=Yes B=No

8.2 When in the year you prefers to sale and/or purchase price of sheep andgoats?

S N	When	Sheep price in Birr		Goats price in Birr	
		Sale	Purchase	Sale	Purchase
1	During festivals (specify)				
2	During planting				
3	During harvesting				
4	Others, specify				

8.3Who buy your sheep andgoats?

Participants	Rank
1= farmers	
2=Traders	
3=hotels	
4= civil servants	
5= others	

8.4. On average how manysheep_____andgoats_____you sell peryear?

8.5.Rank the major market problems in the followingtable.

Major market problem of sheep and goats	Rank
1=price determine by visual (lack of weighing)	
2=no public market information	
3=long transportation	
4=price determined by brokers	
5=others_____	

8.6 What are the main constraints for sheep and goat production? (Rank with significance)

Constraint	Drought	Feed shortage	Water shortage	Disease	Predator	Market	Lack of labor	Lack of superior genotypes
Mark								
Rank								

Appendix B. Guidelines for the Focal Group Discussion

1. What is the source of the breed (Tick one or more boxes)

	Own bred	Inherited	Neighbor	State farm	Market	NGO/project	Gift/bride price
Mark							

2. The origin of sheep and goat (indigenous found in this area)

3. Would you state your trait and breed preference in justifiable manner?

4. Do you know about history of the sheep and goat types, geographical distribution & its origin?

5. Social lows

- Herding

- Communal land use

6. Traditional management system of sheep and goat in the area?

- Breed identification

Special quality of the breed

- Good and undesirable character of the goat compared to the other breed

What is your relative preference from sheep and goats? Why?

8. What is the special attribute of this sheep and goat (indigenous found in this area)?

9. Do you like to change your goat with other breed like exotic? Why?

10. How do you select your breeding sheep and goats for the next generation?

11. If you face water and feed shortage for your sheep and goat what is your coping mechanism to cope up this problem.

12. Major constraints of sheep and goat production in your area.

13. How do you describe level of resistance / tolerance of some stress factors (such as heat tolerance, drought tolerance, feed shortage, water shortage, tolerance to parasites, resistance to disease, walk ability, cold tolerance etc)

14. How do you manage your grazing land?

15. What are your improving mechanisms of sheep and goat production?

19. Extension services in sheep and goat production

Appendix C: The standard breed descriptor list for goat developed by FAO (2012).

Character name	Description
Location	Artuma Fursi,Dewachefa, and Jile Timuga
Sex	Male , Female
Dentition class	1PPI, 2PPI, 3PPI, 4PPI
Coat color pattern	Plain, patch, spotted
Coat color type	White, black, brown, fawn, grey, red, roan, white dominant, black dominant, brown Dominant
Hair coat type	Glossy , smooth hair, long straight hair, curly rough hair and dull
Hair length	Medium (1-2 mm),long (>2 mm)
Horn presence	Present, absent
Horn shape	Straight, curved, spiral
Horn orientation	Lateral, obliquely upward ,backward
Ear orientation	Erect, semi-pendulous, pendulous, carried horizontally
Head profile	Straight, concave, convex, markedly convex
Back profile	Straight ,slopes up towards the rump, slopes down from withers, dipped (curved)
Rump profile	Flat, sloping, roofy
Wattles	Present, absent
Ruff	Present, absent
Beard	Present, absent

Qualitative Observation traits recording format

Date: _

District:_____Kebele/Village_____ Goattype/breed:_____

No.	Sex	Coat color pattern	Coat color type	Head Profile	hair coat type	Hair length	Horn presence	Horn shape	Horn orientation	Ear orientation	Back profile	Rump profile	Wattles	Ruff	Beard
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															

Appendix D: Description of quantitative traits measured for each sample animal

Measurements	Description
Body weight (BW)	The live body weight taken using spring balance (in kilograms)
Body length (BL)	The horizontal distance from the point of shoulder to the pin bone to the nearest centimeter
Height at wither (WH)	the (vertical) height (in centimeters) from the bottom of the front foot to the highest point of the shoulder between the withers
Chest girth (CG)	the circumference of the body (in centimeters) immediately behind the shoulder blades in a vertical plane, perpendicular to the long axis of the body
Chest width (CW)	The width of the chest between the briskets to the nearest Centimeter
Rump length (RL)	Distance from the most cranial and most dorsal point of the hip to the most caudal point of the pin bone

Pelvic width (PW)	The distance between the pelvic bones, across dorsum to the nearest Centimeter
Horn length (HL)	From the base of the horn at the skull along the dorsal surface to the tip of the horn using tape meters to the nearest centimeter
Ear length (EL)	The length of the ear on its exterior side from its root at the poll to the tip to the nearest centimeter
Scrotal Circumference (SC)	Pushing the testicles to the bottom of the scrotum and the widest Circumference measured to the nearest centimeter

Quantitative traits measurement recording format

Date: _____

District:_____Kebele/Village_____ Goattype/breed:_____

No.	Age	BW	BL	HW	HG	PW	CW	CD	RW	RL	FCH	FCC	HL	EL	SC
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															

Appendix E: Quantitative traits ANOVA Tables

Appendix Table 1.ANOVA of Body Length of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	1596.570865	532.190288	57.11	<.0001
SEX	1	58.699667	58.699667	6.30	0.0123
Loc	2	363.688456	181.844228	19.51	<.0001
Error	593	5526.158394	9.318985		
Corrected Total	599	7386.260000			

Appendix Table 2. ANOVA of Height at Wither of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	671.3829885	223.7943295	31.67	<.0001
SEX	1	102.7218276	102.7218276	14.54	0.0002
Loc	2	281.8446019	140.9223009	19.94	<.0001
Error	593	4190.090715	7.065920		
Corrected Total	599	5131.193333			

Appendix Table 3. ANOVA of Heart Girth of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	2004.062860	668.020953	64.59	<.0001
SEX	1	114.922624	114.922624	11.11	0.0009
Loc	2	351.929666	175.964833	17.01	<.0001
Error	593	6133.300474	10.342834		
Corrected Total	599	8369.673333			

Appendix Table 4. ANOVA of Chest Depth of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	843.8741121	281.2913707	66.98	<.0001
SEX	1	47.4042086	47.4042086	11.29	0.0008
Loc	2	112.4536087	56.2268044	13.39	<.0001
Error	593	2490.297369	4.199490		
Corrected Total	599	3497.193333			

Appendix Table 5. ANOVA of Shoulder Width of Artuma Fursi, Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	225.9902577	75.3300859	31.49	<.0001
SEX	1	4.5053939	4.5053939	1.88	0.1705
Loc	2	306.1401313	153.0700656	63.99	<.0001
Error	593	1418.496779	2.392069		
Corrected Total	599	1909.360000			

Appendix Table 6. ANOVA of Pelvic Width of Artuma Fursi, Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	32.43656552	10.81218851	19.35	<.0001
SEX	1	0.79581559	0.79581559	1.42	0.2332
Loc	2	17.12611264	8.56305632	15.32	<.0001
Error	593	331.3549160	0.5587773		
Corrected Total	599	377.8333333			

Appendix Table 7. ANOVA of Ear Length of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	160.7433078	53.5811026	60.55	<.0001
SEX	1	2.4126403	2.4126403	2.73	0.0992
Loc	2	16.1548671	8.0774336	9.13	0.0001
Error	593	524.7500255	0.8849073		
Corrected Total	599	695.5850000			

Appendix Table 8. ANOVA of Rump Length of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	115.8966653	38.6322218	22.41	<.0001
SEX	1	2.7994460	2.7994460	1.62	0.2031
Loc	2	45.5856183	22.7928091	13.22	<.0001
Error	593	1022.360372	1.724048		
Corrected Total	599	1174.998333			

Appendix Table 9. ANOVA of Rump Width of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	127.3478768	42.4492923	51.71	<.0001
SEX	1	0.3632338	0.3632338	0.44	0.5062
Loc	2	17.0655464	8.5327732	10.40	<.0001
Error	593	486.7580491	0.8208399		
Corrected Total	599	626.9583333			

Appendix Table 10. ANOVA of Canon Bone Length of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	41.23687791	13.74562597	18.85	<.0001
SEX	1	2.75013232	2.75013232	3.77	0.0526
Loc	2	1.52834191	0.76417095	1.05	0.3513
Error	593	432.4090480	0.7291890		
Corrected Total	599	475.9400000			

Appendix Table 11. ANOVA of Canon Bone Circumference of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	12.66419551	4.22139850	13.95	<.0001
SEX	1	0.60930108	0.60930108	2.01	0.1565
Loc	2	1.75483302	0.87741651	2.90	0.0559
Error	593	179.4817304	0.3026673		
Corrected Total	599	193.1850000			

Appendix Table 12. ANOVA of Horn Length of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	2186.226246	728.742082	98.38	<.0001
SEX	1	49.590539	49.590539	6.69	0.0099
Loc	2	165.260856	82.630428	11.15	<.0001
Error	593	4392.747087	7.407668		
Corrected Total	599	6671.985000			

Appendix Table 13. ANOVA of Body Weight of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	3376.964039	1125.654680	117.88	<.0001
SEX	1	584.549483	584.549483	61.22	<.0001
Loc	2	781.024055	390.512027	40.90	<.0001
Error	593	5662.442999	9.548808		
Corrected Total	599	9757.173333			

Appendix Table 14. ANOVA of Scrotal Circumference of Artuma Fursi,Dewachefa and Jile Timuga district goats

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	3	39.94186852	13.31395617	16.72	<.0001
SEX	0	0.00000000	.	.	.
Loc	2	12.06280673	6.03140337	7.57	0.0013
Error	54	43.00813148	0.79644688		
Corrected Total	59	99.25000000			

Appendix 5. Figures

(a) (b) (c)

Figure1. (a) and (b) indicated that interviewing the farmers about sheep and goat rearing system (c) for type of sheep and goat house in Dewachefa districts

(a) (b) (c)

Figure 2. (a) Type of sheep and goat house in Artuma Fursi districts (b) for Jile Timuga

(c) for goat types in Dewachefa districts

Figure 3. Grazing and water sources of sheep and goats in the study area