PHENOTYPIC CHARACTERIZATIONAND FARMERS' TRAIT PREFERENCE OF INDIGENOUS GOAT IN SOUTH GONDAR ZONE, AMHARA NATIONAL REGIONAL STATE, ETHIOPIA

M.Sc. THESIS

BY

ALEBEL MULIA ALENE

OCTOBER, 2018

JIMMA, ETHIOPIA

PHENOTYPIC CHARACTERIZATIONAND FARMERS' TRAIT PREFERENCE OF INDIGENOUS GOAT IN SOUTH GONDAR ZONE, AMHARA NATIONAL REGIONAL STATE, ETHIOPIA

MSc. Thesis

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, JIMMA UNIVERSITY

COLLEGE OF AGRICULTURE AND VETERINARY MEDICINE

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE (ANIMAL BREEDING AND ENETICS)

BY

Alebel Mulia Alene

Major Advisor: Prof. Manzoor Ahmed Kirmani

Co-Advisor: Kassahun Desalegn (Msc, Assis.Prof.)

October, 2018

Jimma, Ethiopia

Jimma University College of Agriculture and Veterinary Medicine

Thesis Submission Request Form (F-08)

Name of Student: **Alebel Mulia Alene** ID NO: **RM1426/09**

Program of Study: **Animal Breeding and Genetics**

Title: **Phenotypic Characterization and Farmers' Trait Preference of Indigenous Goat in South Gondar Zone, Amhara National Regional State, Ethiopia**

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Major Advisor: **Prof. Manzoor Ahmed Kirmani**  _____

Name Signature Date

Co-Adviser: **Kassahun Desalegn (Msc, Assis.Prof.)**  _____

Name Signature Date

Internal Examiner (If Depends on the Verdict)

Name: **Ahmed Seid (MSc, Ass. Prof)**Signature _____Date_____

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DEDICATION

I dedicate this piece of work to my father Mulia Alene and my mother Ayew Alitaseb, for their unreserved love, encouragement and partnership in the success of my life. This thesis also dedicated to my beloved brother Abebaw Alene and Mekuanent Adane who passed away and I deeply wish that God might give his peaceful rest forever.

STATEMENT OF THE AUTHOR

I the undersigned, hereby declare that the thesis:- Phenotypic characterization and farmers' trait preference of indigenous goat in south Gondar zone, Amhara regional state, Ethiopia; and this thesis is my own work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M. Sc degree at Jimma University and is deposited at the University Library to be available to borrowers under rules of the library. I truly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate. I concede copyright of the thesis in favor of the Jimma University, Collage of Agriculture and Veterinary Medicine.

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BIOGRAPHICAL SKETCH

The author Alebel Mulia was born on December 07, 1994 at Farta District, South Gondar Zone, Amhara Regional State, Ethiopia from his father Mulia Alene and mother Ayew Alitaseb.

He attended his primary education at Tewodros Elementary School and his secondary education at Tewodros Preparatory and Secondary School. Then he joined Debre Tabor University, College of Agriculture and Veterinary Medicine in the department of Animal Science in 2013 and awarded B.Sc. degree in Animal Science in June 2016.

Soon after his graduation, he was employed as Graduate assistance by the Ministry of Education. Then in October 2016, he immediately joined the School of Graduate Studies at Jimma University for a Master of Science study in Animal Breeding and Genetics.

ACKNOWLEDGEMENTS

First and above all I would like to thank the Almighty God with His Mother St. Virgin Mary for his willingness to reach at this stage; without his assistance nothing would be happened. He has unreservedly offered me during the study and all the time.

I would like to express my deepest and sincere appreciation to my respected Major Advisor Manzoor Ahmed Kirmani (Prof.) for his unreserved advice, guidance and his excellent teaching and constructive criticism and comments from the initial conception to the end of this work, It is highly appreciated. I am very grateful to my co-advisor Kassahun Desalegn (ASS.Prof) for his valuable comments and advice. He shaped me to be more analytical in many aspects. Thank you very much my major advisor Manzoor Ahmed Kirmani (Prof.) and Kassahun Desalegn (ASS.Prof).

I would like to express my deepest gratitude and appreciation to Ministry of Education for fully sponsoring my study and research work and Department Graduate Committee (DGC) of Animal Sciences and the School of Graduate Studies of Jimma University for their conducive learning program and provision of various services.

I also wish to express my thanks to agricultural office of South Gondar Zone, all developmental agent (DA), kebele administrations and farmers of all the study districts for their kindness, encouragement and help during data collection who responded to my numerous questions with patience.

LIST OF ABBREVIATIONS

AFK	Age at First Kidding
AnGR	Animal Genetic Resources
ASMF	Age at Sexual Maturity Females
ASMM	Age at Sexual Maturity Males
BL	Body Length
BW	Body Weight
CBC	Canon Bone Circumference
CBL	Canon Bone Length
CD	Chest Depth
CSA	Central Statistics Agency
CV	Coefficient of Variation
DA's	Development Agents
DAGRIS	Domestic Animal Genetic Resource Information System
DISCRIM	Discriminant Analysis
EL	Ear Length
ENMA	Ethiopian-National Meteorology Agency
ESGPIP	Ethiopia Sheep and Goat Productivity Improvement Program
FAO	Food and Agricultural Organization of the United Nations
GLM	General Linear Model
HDL	Head Length
HG	Heart Girth
HL	Horn Length
HW	Height at Wither
IBC	Institute of Biodiversity Conservation
ILCA	International Livestock Center for Africa
KI	Kidding Intervals
LBMs	Linear Body Measurements
LS	Litter Size

LIST OF ABBREVIATIONS (CONTINUED)

LSM	Least Square Means
MASL	Meter Above Sea Level
RDOSGZ	Rural Development office of south Gondar zone
RH	Rump Height
RL	Rump Length
RW	Rump Width
SAS	Statistical Analysis System
SC	Scrotum Circumference
SE	Standard Error
SPSS	Statistical Package for Social Science

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Phenotypic characterization and farmers' trait preference of indigenous goats in South Gondar Zone, Amhara National Regional State, Ethiopia

By:
Alebel Mulia
Major Advisor: Prof. Manzoor Ahmed Kirmani
Co-Advisor: Kassahun Desalegn (MSc, ASS.Prof.)

ABSTRACT

This study was conducted to phenotypically characterize and assess farmer's trait preference of indigenous goats in South Gondar zone, Amhara National Regional State, Ethiopia with the objective of phenotypically characterize and production system of indigenous goat in the study areas. The study was conducted based on household survey, visual observation and field measurements. The zone was stratified into highland, midland and lowland agro-ecology and then selected one district from each agro-ecology. For household survey, 171 households (57per agro-ecology) were involved whilst body measurements were taken from 603 goats (201 per agro-ecology) of both sexes that have one and above pair of permanent incisor (PPI).Questionnaire and qualitative data were analyzed by using SPSS version 20. General Linear Model (GLM) procedure of SAS Ver.9.3 (2014) was used on quantitative data.Correlation between body weight and linear body measurements as well as REG procedure to regress body weight from linear body measurement for male and female goats were computed by SAS Ver.9.3 (2014).Results revealed that Source of income was a primary purpose of goat rearing in all agro-ecology followed by meat and saving asset in highland and midland while saving and meat in lowland was ranked 1st, 2nd and 3rd respectively. Natural pasture was the major source of feed with an index value of 0.50 for all agro-ecology in wet season and 0.49 both for highland and midland, and 0.50 for lowland in dry season. Body conformation was the most preferable trait across all three agro-ecology of the study area followed by reproduction rate and adaptability in highland, coat color and reproduction rate both for midland and lowland. Disease in the study area was ranked as first constraint for goat production across all agro-ecologies with an index value of 0.36, 0.37 and 0.34 followed by feed shortage and predator. Pasteurellosis (in highland and midland) and shoat-pox in lowland were the common and primary goat diseases reported by the respondents in the study area. The overall AFMM, AFMF, (AFK), LS, and reproductive life span of goat in the study area were 7.44±0.08, 7.88±0.08, 12.88±0.08, 1.65±0.0 and 7.04±0.11 respectively. Most qualitative traits observed in the study area for sample goat population were significantly different across agro-ecology except. The most dominant coat color pattern was plain with the proportion of 51.7%, 50.7% and 65.2% in highland, midland and lowland, respectively. White with red (28.4 and 23.9%) in highland and midland respectively while in lowland white (29.9%) were the most frequent observed coat color types in the population. All quantitative traits were significantly (P< 0.05) different between sex, age and agro-ecology of goat except tail length, canon bone length, head length and horn length. Most quantitative traits showed significantly higher average values in the lowland, than the rest two (highland and midland) agro-ecologies and most quantitative trait of the sample goat population for male were significantly higher than the female one. Body weight was significantly correlated with all continuous traits of both male and female goats but higher in heart girth. As a result, the stepwise regressions revealed that heart girth was the most important variable in the prediction of live body weight. Generally the difference and similarities of indigenous goat in morphometric trait and adaptability should be supported by further study on characterization at molecular level under their production environments.

Key words: East Este, Farta, Goat, Phenotypic Characterization, South Gondar Zone, Tach Gayint

1. INTRODUCTION

Ethiopia has the largest livestock population in Africa, and is endowed with different agro-ecological zones of highlands, sub-humid, semi-arid and arid environments (FARM Africa, 1996). In developing countries, livestock production is mostly subsistence oriented and fulfills multiple functions that contribute more for food security (Dugum*aet al*., 2010). The demand for livestock products is increasing due to the expands of urban population, while farm areas are decreasing considerably as a result of an increase in the rural population (Siegmund-Schultze *et al*., 2009).

Goats (*Capra hircus*) are the most abundant domesticated livestock species widely found all over the world (Galal, 2005). Indigenous goat populations generally dominate the goat flocks in Ethiopia and have developed certain valuable genetic traits such as ability to perform better under low input condition and climatic stress, tolerance to infectious diseases and parasites as well as heat stresses (Philipsson*et al*., 2006; Kosgey and Okeyo, 2007). Ethiopian goats have a high reproductive performance and are drought resistant (Peacock, 1996). They have also socio-economic importance whereby they provide meat, milk, skin and fiber, as well as manure and serve as the sole or subsidiary livelihood for a large number of small and marginal farmers and landless laborers (Thiruvenkadan and Karunanithi, 2006).

The wide ranging agro-ecology of Ethiopia has further contributed to the existence of a large diversity of farm animal genetic resources (IBC, 2004). According to the livestock survey result (CSA, 2016), the country has an estimated 30.20 million heads of goats. This puts the country eighth among the top ten countries (China, India, Pakistan, Bangladesh, Nigeria, Sudan, Iran, Ethiopia, Mongolia and Indonesia) in the world and third in Africa next to Nigeria and Sudan regarding goat populations (FAOSTAT, 2013). In Ethiopia goat production contributesabout 16.8% of total meat supply and 16.7% of milk consumed in the country (Tsedeke, 2007). The average carcass weight of Ethiopian goats is 10kg, which is the second lowest in sub-Saharan Africa. This may be due to different factors such as poor nutrition, prevalence of diseases, lack of appropriate breeding strategies and poor understanding of the production system as a whole (Tesfaye, 2009).

Morphological differences of goat have important socio-cultural and economic values to the Ethiopian communities; as a result, most farmers have specific consideration and choices for goat coat colour followed by body sizes. Goat owners in Metema and Abergelle districts of the Amhara National Regional State of Ethiopiawere highly interested in body conformation, fast growth rate, milk yield, and drought tolerance (adaptability) and disease tolerance and reproduction rate. The farmers select breeding does on the basis of multiple births, body conformation, mothering ability, kid growth, Coat color, fertility traits (KI and AFK),and appearances (Solomon, 2014).

The Ethiopian goat populations are phenotypically classified into 12 distinct major breed types or populations and four additional sub-types (FARM-Africa, 1996; IBC, 2004). However, genetic/molecular characterization revealed only the presence of eight distinctively different breed types or populations in the country (Tesfaye, 2004). Despite this,these goat populations further regrouped in to seven goat types (Getnet, 2016).

Characterization of goat breeds based on their morphological traits variations are the first step towards the use of the available AnGRs (Lanari*et al*., 2003). Morphometric measurements have been used to evaluate the characteristics of various breeds of goats, and could provide firsthand information on the suitability of animals for selection (Nesamvuni*et al*., 2000 and Mwacharo*et al.*, 2006) and for further characterization studies using modern molecular methods.

To increase and sustain the productivity of goats so as to respond to the growing of domestic and foreign demands for live goats and its products, improvement programs are necessary and should be crafted, especially for countries like Ethiopia where extensive system of husbandry is the commonest type. Studies on characterization of goat is essential for planning improvement, sustainable utilization and conservation strategies of a breed at local, regional, national and global levels (FAO, 2012). In the absence of baseline characterization information, some breed populations and unique characteristics possessed by them may decline significantly, or be lost, before their value is recognized and measures taken to conserve them (FAO, 2007). In Ethiopia, various goat characterization studies have been executed (FARM-Africa, 1996; Tsegaye, 2009; Gebreyesus, 2010; Ahmed, 2013; Bekalu, 2014; Yaekob *et al.*, 2015 and Belay and Meseretu, 2017).

According to CSA (2016) the population of goat in south Gondar zone is relatively high and the area is suitable for goat production; beside this most of the farmers in south Gondar zone were highly depend on rearing of goat and other related livestock population. Despite its significance in terms of meat, cash income and skin production, research on theses goat genetic resources has not been done so far.The goat type found in South Gondar zone known as western highland goat breed were phenotypically characterized before twenty two years back by FARM Africa (1996) considering Ethiopia and Eritrea as a study part.However, information on phenotypic characterization, production system and farmers trait preference of this goat population was very limited and further studies was required for designing and developing genetic improvement programs for sustainable utilization of the most promising and widely used breeds at the country level as well as regional and zonal level. Therefore, the objectivesof the study were to fill the above gap in South Gondar Zone, Amhara region, Ethiopia.

(I) General objective

- To characterize indigenous goat populations, their production system and farmers trait preference in South Gondar, Ethiopia.

(II) Specific Objectives

- To assesses information on farmer's trait preference, selection criteria, management practices and utilization of indigenous goat in study area.
- To assessesand calculate the reproductive performances and inbreeding coefficient of indigenous goat populations in study area.
- To phenotypically characterize the indigenous goat populations and their production system in study area.

2. LITERATURE REVIEW

2.1. Classification and Distribution of Goat Breeds of Ethiopia

Ethiopia has diverse topographic, climatic conditions and wide production systems (IBC, 2004). Indigenous goat breeds/types are widely distributed and are found in all agro-ecologies of Ethiopia and it appears that they have evolved through a process of natural selection (Galal 2005) that favored adaptation and survival rather than production. 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 (horn, wattle, ruff and beard). Few physical features can be used to identify major groups of breeds. Many physical features have to be collected and analyzed to identify specific breeds within major groups. 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; and analysis of the genetic material which is called DNA is required (Solomon, 2009).

Based on differences in physical characteristics, four families and 12 breeds of goats have been identified in Ethiopia (FARM-Africa, 1996; Solomon*et al.*, 2010). 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 (Solomon, 2009; Farm-Africa 1996 and Solomon*et al.,* 2010). The details of these four families and 12 breeds of goat are presented in table 1.

However, a genetic characterization of Ethiopian goats by Tesfaye (2004) was inconsistent with the classification of Farm Africa. Following the analysis of 15 micro satellite loci, the results indicate eight separate genetic entities viz:Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergelle, 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) (Tesfaye, 2004). Despite this, these goat populations further regrouped in to seven goat types (Getnet, 2016).

The goat population in the Amhara National RegionalState of Ethiopia were Characterized based on their morphological characteristics, into six goat ecotypes, namely Gumuz, Begie-Medir, Agew (West Amhara Region goat population), Bati, Central Abergelle and Abergelle (East Amhara region goat population) by Halima *et al.* (2012). These goat populations were further clustered in to two main groups, (a) Gumuz, Agew and Begie-Medir; and (b) Bati, Abergelle and Central Abergelle. The authors indicated the presence of clear morphological variations between and within these goat breeds in terms of coat colour, head profile, horn orientation, and ear form and head shape. However, molecular characterization on the same six goat populations Halima *et al.* (2012) showed that about 95% of the variation is represented within populations indicating the presence of low genetic sub-differentiation among the goat populations.

Table 1: Goat Breeds of Ethiopia and Their Geographical Distribution

Family name	Breed name	Other Local name	Distribution
Nubian family	Nubian	Barka, Begayit	west Tigray
Rift valley family	Afar	Adal, Denakil	Afar region, Northern and Western Hararghe
	Abergelle	-	Along Tekeze river Tigray region, Wag Himra, East Gondar
	Arsi-Bale	Gishe, Sidamo	Arsi, Bale and Western Hararghe
	Woyto-Guji	Woyto, Guji, Konso	South Omo, Southern Sidama and Wolayita
Somali family	Hararghe Highland	-	Hararghe
	Short –eared Somali	Denghier	Northern and Eastern Ogaden
	Long-eared Somali	Degheir, Digodi, Melebo	Ogaden, Lowland of Bale and Borena
Small east African family	Central highland	Brown	Centeral highlands, West of the rift valley Wollo, Gondar and Shoa
	Western highland	-	South Gondar, Gojam, Wollega and West Shoa
	Western Lowland	Gumuz	Along the area bordering the Sudan Keffa Highlands and Lowlands of Keffa and South Shoa Zone
	Keffa	-	Keffa. part of Illubabor and south Shewa

Source: Farm-Africa (1996); Solomon*et al.* (2010)

2.2. Livestock Composition and goat Flock Structure of Farmers in Ethiopia

Farmers in different part of Ethiopia have different Livestock composition in general and flock structure of goat in particular due to different agro-ecology, availability of feed and

water, the availability of land (communal grazing land and private grazing land) and behavior of farmers. The major livestock species in Eastern and Central Tigray of Northern Ethiopia include goat, sheep, cattle and donkey (26.63, 26.19, 10.49 and 1.15)respectively; and 87.32% of Begait goat flock structure were mainly composed by large number of female goats (Gebrekiros*et al.*, 2016). According to Yaekob *et al.* (2015) the major livestock species in Southern Ethiopia were goats (15.47), cattle (5.50), sheep (2.15), chicken (4.22), donkeys (0.64), mules (2.33) and horses (0.1). The proportion of female goat aged greater than one year constituted 28.7, 29.3 and 29.6% of total flock strength in lowland, midland and highland area of northern Omo (Yaekob *et al.*, 2016). Breeding does more than one year old constituted 47.4% of the whole population in HorroGuduru Wollega zone while breeding bucks of the same age made up only 3.9% of the population (Ahmed, 2013).

2.3. Description of Goat Production System in Ethiopia

Goat husbandry practices in Africa follow the diverse agro–ecologies (classified based on altitude) prevalent across the continent and broadly classified as mixed, pastoral and agro–pastoral systems (Lebbie, 2004; Peacock, 2005).

Goats are distributed in all agro-ecological zones of the Ethiopia while the majority of the goat population is found in large flocks in lowlands in pastoral and agro–pastoral production systems, in arid and semi-arid agro–ecological zones, where goats are kept by nearly all pastoralists, often in mixed flocks with sheep, freely grazing or browsing in the rangelands (Mekasha, 2007).

In Ethiopia, depending on the environmental and social conditions different management systems are prevailing in goat production. The majority of systems are operated by smallholder farmers and described under low input production system which is characterized by land scarcity, severe resources degradation and recurrent drought. It accommodates more than 95% of the livestock population (IBC, 2004).

According to Solomon *et al.* (2010) goat production and livestock systems in Ethiopia have evolved largely as a result of natural production environments and socio-economic circumstances of farmers/pastoralists. Ethiopian small ruminant production systems are broadly classified into “modern” and “traditional” (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 (Solomon *et al*., 2010). Common features of traditional production systems are limited number of animals per unit area, low productivity per animal, relatively limited use of improved technology and use of on farm by products rather than purchased inputs (Solomon *et al*., 2010). According to the degree of integration with crop production and contribution of livelihood, level of input and intensity of production, agro-ecology, length of growing period and relation to land and type of commodity to be produced, mobility and duration of movement, the traditional production system is sub divided into three systems (Solomon *et al*., 2008). These are mixed crop-livestock, pastoral and agro pastoral system.

2.3.1. Mixed Crop-Livestock Farming System

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 masl. Mixed farming system is predominantly found in highland agro-ecological zones where the climatic factors are conducive for farming of crops and raising livestock. In this system, livestock and crops are maintained as complementary enterprises (IBC, 2004). The area has adequate rainfall and moderate temperature and is thus suitable for grain production. The average land size per household is often less than two hectares (Solomon *et al.*, 2008). 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 (Lebbie, 2004). The integration and the importance of small ruminants (goat) in this 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*., 2010).

2.3.2. Pastoral and Agro- Pastoral Production System

In pastoral and agro–pastoral production systems, which are found in arid and semi-arid agro–ecological zones within altitudes below 1500 masl goats are kept by nearly all pastoralists, often in mixed flocks with sheep, freely grazing or browsing in the rangelands (Solomon *et al.*, 2008). The area which is practiced pastoral production system is not suitable for crop

production and receives less than 500mm of rainfall. The livelihoods of the pastoral people depend entirely on livestock and more than 50% of the household income and 20% of the food comes from the livestock or livestock related activities. Goats are kept by nearly all pastoralists with higher flock size, often in mixed flocks with sheep. High mobility of animals in search of feed and water is common in this system (IBC, 2004 and Solomon *et al., 2008*).

In the agro-pastoral system, human pressure on natural resources is relatively lighter than that observed in higher altitudes. Land holding per households was higher than in the mixed farming system. Comparing to the pastoral system the area receives relatively higher rain and people and animals are less mobile. 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).

2.4. Socio-Economic Importance of 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 are of great importance as major sources of livelihood (Kosgey, 2004) and contribute to the sustenance of landless, smallholder and marginal farmers especially to the poor in the rural areas throughout the developing countries.

Goats are important for diversifying production, creating employment, increasing income, building capital, contributing to human nutrition and reducing risk, in addition to their quantifiable outputs of several products (Banerjee *et al*., 2000).The short generation interval of sheep and goats coupled with high frequency of multiple births allow for rapid increases in animal numbers. This builds financial capital and allows the sale of surplus animals for cash that can be used for other agricultural enterprises, school fees, and medical bills. The objectives of keeping goats go beyond the products of meat, milk, fiber, manure and offspring, and owing to increased demand for goat products, more livestock producers are raising goats in developing countries, including Ethiopia (Tsedeke, 2007; Getahun, 2008;

Tesfaye, 2009; Grum, 2010 and Hulunim, 2014). Goat productions provide employment for poor rural families, especially for women and children and also they can be sold to attain immediate cash assets for poor goat holders, helping them improve livestock and crop farming and financing social events (Lebbie, 2004 andMorand- Fehr *et al*., 2004).

2.5. Reproductive Performance of Goat

The reproductive performance in terms of age at first service, age at first kidding, kidding interval and litter size has been presented in Table 2.

2.5.1. Age at First Service (AFS)

AFS in small ruminants is related to age and body weight. Most does/bucks reach puberty at the age of 4–6 months and 60 % of mature body weight (Jainudeen*et al.,* 2000). Age at first service for both sexes is not fixed. The AFS reported by several workers have been summarized in table 2. According to Yadeta (2016) age at first service for Western highland goat was 8.39±0.06 months for males whereas it was 8.2±1.64 months for Western lowland goat in Metema (Tesfaye, 2009). The AFS of female indigenous goat in Horro Guduru Wollega is 7.11±0.02month (Table 2) indicating that indigenous goat in Horro Guduru Wollega has a short AFS as compared to other goat breed in different area. According to Solomon (2014) age at first sexual maturity of Western lowland goat in Metema and Abergelle goat is 7.4± 2.01 and 12.3±4.48 months respectively. In western zone of Tigray region, age at first service of Begait goats reached between 6 and 8 months (Gebrekiros*et al*., 2016). This finding is similar to that of Gimenez and Rodning (2007) who reported that most of does and bucks reach puberty at about 5 and 9 months, respectively. Generally the reproductive performance in (Table 2) indicates that the AFS of different goat breed is different and this variation may be depends on type of breed, season of birth, forage availability and management system.

2.5.2. Age at First Kidding

Age at first kidding is the period between birth and first kidding and influences the reproductive life of the female. The AFK reported by several workers have been summarized in Table 2 and earliest AFK was recorded in some traditional production systems. This indicated that the existing uncontrolled breeding practice in this system is in favour of early

kidding of indigenous goats than the controlled breeding practices in the improved system. Age at first kidding is closely related to the rearing intensity, generation interval and response to selection. According to Tesfaye (2009), the AFK of western lowland goat in Metema were 13.6±2.44 while the AFK of indigenous goat in Horro Guduru Wollega were 12.11 (Ahmed, 2013). The earlier studies indicated that indigenous goat in Horro Guduru Wollega, Keffa and Western Lowland goat produce its first lamb at earlier age as compared to other goat breed in Ethiopia. On the contrary the AFK of Short-eared Somali were 20.15±0.12 month (Hulunim, 2014). The present review shows that most indigenous goat breeds of Ethiopia tend to have their first kids before they are two years old.

Table 2: Age at First Kidding (AFK), Kidding Interval (KI) and Litter Size (LS) Of Some of Ethiopian Goat Breeds under Different Management Condition in Different Area

Breed	Location	AFS(month)	AFK(month)	KI(month)	LS(No)	Source
Keffa	Keffa	-	12.5	7.9	1.7	Belete, 2007
Central high land	N.Gondar	-	13.6	10.27	1.16	Belay, 2008
Western Lowland	Metema	8.2 ± 1.64(F)	13.6 ±2.44	8.4 ± 1.37	-	Tesfaye, 2009
Arsi-Bale	Bale	-	19.17	9.33	1.60	Kebede *et al*., 2012
Goat in Horro Guduru	Horro Guduru	7.11±0.02(F)	12.11±0.02	5.76± 0.04	1.77 ±0.03	Ahmed, 2013
Abergelle	Abergelle	12.3±4.48(M)	15.5±5.48	8.3±3.37	1.04	Solomon, 2014
Western Lowland	Metema	7.4± 2.01(M)	12.4±1.39	6.3±0.64	-	Solomon, 2014
Western highland	West showa	8.39±0.06(M)	13.85±0.12	8.25±0.52	1.28±0.33	Yadeta, 2016

2.5.3. Kidding Interval (KI)

Kidding interval is defined as the interval between two consecutive parturitions; and is one of the main components of reproductive performance of small ruminant which is affected by season; type of management to be used and nutrition can prolong the interval between kidding for goat (Mengiste, 2008). The KI reported by several workers have been summarized in Table 2. InMetema district the KI of western lowland goat were 6.3±0.64 month (Solomon, 2014); and in the same district for the same breed Tesfaye (2009) reported 8.4±1.37 month and this indicated that the same breed in the same district have difference kidding interval. Solomon (2014) and Ahmed (2013) reported a kidding interval of 6.3±0.64 and 5.76±0.04 months for western lowland goat and indigenous goat in Horro Guduru Wollega respectively which could reflect that the breed can produce three lambing in two years even under the traditional management system.

Reproductive efficiency is related to the length of kidding interval; i.e. doe with long kidding interval has lower reproductive efficiency (Deribe, 2009). There are reports on the possibility of attaining three parturitions from indigenous small ruminants in two years (Getahun, 2008). To attain this, kidding interval of goat should not exceed 8 months (245 days). Generally, past research reports revealed variations in KI among indigenous goats of Ethiopia. The longer KI reported from some research stations are mainly due to the result of controlled breeding with the objective to achieve the best breeding season and synchronization of birth for research purpose. Shorter KI is also reported from some other research stations where good management systems are in place and breeding males are available in the herd for most period of the year.

2.5.4. Litter Size

Litter size is defined as the number of progenies born per kidding. Goat is the most prolific ruminant of all domesticated ruminants in tropical and sub-tropical regions. Indifferent area of Ethiopia, The LS reported by several workers have been summarized in Table 2. The LS have been recorded to be 1.21 (FARM-Africa, 1996). The average LS estimated for local goats in Alaba, Southern Ethiopia, is about 1.47 (Deribe 2009). Litter size of 1.04, 1.28 and 1.77 was

reported for Abergelle, western highland and indigeneous goat in Horro GuduruWollega under village conditions (Belay, 2008; Ahmed, 2013and Yadeta, 2016).

It is also found that LS of Somali and Afar goats are smaller than the values reported for most of the indigenous goats in Ethiopia even under traditional systems. This is consistent with the results of other studies (Cossins and Upton 1987; Dereje*et al.*, 2014) and appears to be one mechanism of adaptation to the harsh environmental conditions of the rangelands and to the seasonal scarcity of feed resources. Litter size is significantly affected by parity, and weight of doe at mating (Belay, 2008).

The results of previous studies generally show that LS is the most variable traits reported for indigenous goats in Ethiopia. This shows the presence of huge opportunity to improve these traits through selection and improved management focusing on breeds having better potential for the traits.

2.6. Trait Preference and Selection Criteria of Goats

In breeding programs for most species, animals in dam and sire selection pathways are selected very intensely with a higher accuracy than in the other selection pathways. Goat owners across the selected areas were highly interested in body size (conformation), fast growth rate, milk yield, and drought tolerance (adaptability) and disease tolerance and reproduction rate. For Western Lowland goat owners, the most important selection criteria for breeding does were multiple births, body conformation, mothering ability and kid growth with index values of 0.34, 0.16, 0.15 and 0.11, respectively (Solomon, 2014)., Coat color, fertility traits (kidding interval and age at first kidding) were also mentioned as selection criteria but with lower rank. Appearance, color and better milk yield used as the major selection criteria for breeding does in the MadaWalabu and Rayitu districts of Oromia region. From those selection criteria appearance and color took the first and the second rank and better milk yield as the 3rd criteria, respectively (Belete, 2013). However, in Sawena district of the region appearance, better milk yield and color took the first, second and third rank, respectively (Belete, 2013).

The most important coat color preferences in Bati area for both sexes were brown but plain white coat color was the most preferred one by both Borena and Siti pastoralist and agro-

pastoralists (Hulunim, 2014). Similarly, Halima *et al.* (2012) reported, black coat color was not preferred by the producers in all selected district of Amhara region. Body conformation followed by coat color were found as the most important selection criteria of breeding bucks with the index values of 0.33 and 0.22 for Western Lowland goat keepers and 0 .31 and 0.25 for Abergelle, respectively (Solomon, 2014).

Productive and reproductive traits (Age at first service, Kidding interval, litter size, body weight, milk yield, weaning age and weaning weight as well as daily weight gain) of a goat were more important than beauty and adaptation related traits for selection of breeding stock. Selection of breeding stock by farmers is through using their indigenous knowledge. There were no records on performance of individuals and their pedigree. Lack of animal records and identification has very serious implications, as no effective selection and breeding programme can be applied in the absence of records (Semakula*et al*., 2010).

2.7. Inbreeding coefficient

The rate of inbreeding coefficient per generation changes with any change in the effective population size. The effective population size (Ne) is influenced by actual number of breeding male and female in the flock at a given time and thus subject to change due to variation in the flock size, type of rearing practice (mixed flock or individual flocks) (Yadeta, 2016).Utilization of breeding buck/s born within the flock, uncontrolled mating, lack of awareness about inbreeding and small flock size may lead to accumulation of inbreeding and decreased genetic diversity also reported by (Kosgey, 2004). The maximum acceptable level of inbreeding coefficient is 0.063 (Armstrong, 2006).The rate of inbreeding for indigenous goat in west showa zone were estimated 0.129, 0.007 and 0.006 (Mixed goat flock) and 0.136, 0.027 and 0.022 (Individual goat flocks) in highland, midland and lowland areas, respectively (Yadeta, 2016). This indicates that the value in highland goat was higher than the maximum acceptable level where as in lowland and midland goat the value is less than the acceptable level for both mixed and individual goat flock. On the contrary Bekalu (2014) and (Belete, 2013) reported that, higher inbreeding coefficient (0.30, 0.19 and 0.22) and (0.13, 0.23 and 0.37) than the maximum acceptable level in BahirdarZuria, YilmanaDensa and Gonji Kolela districts of west Gojjam and MadaWalabu, Sawena and Rayitu district of Bale, respectively and mixed goat flockis recommendedto increase genetic diversity of those population.

2.8. Management system of goat

2.8.1. Feed Source and Grazing Management

The study of Belay and Meseretu (2018) in Gamo-Gofa zone, Southern Ethiopia reported that natural pasture was the major source of feed both in dry and wet seasons in all selected districts. Yadeta (2016) also reported that natural pasture ranked as first feed source for small ruminants in both wet (with index value of 0.98, 0.96 and 0.95) and dry season with index value of (0.49, 0.48 and 0.49) in three AEZs (highland, midland and lowland, respectively) in west showa zone of Oromia region.Apart from natural pasture, the other major feed sources were crop residues, crop aftermath and hay in order of their importance in all the three AEZs of west showa and Gamo-Gofa zone of southern Ethiopia (Yadeta, 2016 and Belay and Meseretu, 2018). Supplementation was practiced by 87.7, 85.7 and 88.6 % of respondents in lowland, midland and highland areas of Loma district, respectively (Yaekob*et al.*, 2015).

According to Belay and Meseretu (2018) grazing was practiced without sex and age separation except kids which were usually separated until they grow strong enough to browse in wild. The herding system of goat is varies with in season of the year; free grazing is practice more in dry season (47.11%) while herded grazing (29.77%) is practice during wet season. This could be due to the fact that in dry season there is shortage of feed which leads for communal grazing where farmer allow their animal to graze anywhere. The proportion of farmers using both communal and private grazing land is (68.3, 67.4 and 61.6)% in lowland, midland and highland, respectively whereas proportions of farmers using only communal grazing land was 31.7%, 32.6% and 38.4% for corresponding agro-ecologies(Yaekob*et al.*, 2015).

2.8.2. Housing System of Goat in Ethiopia

Providing of a shelter for goat has a positive impact on their productivity. Goats being small in size they are exposed to danger. Hence providing of a good house can decrease environmental stress and improve productivity. According to Bekalu (2014) the types of house that farmers accommodate their goat flock in separate house with roof (57.41%), together with family house (33.3%) and veranda (9.26%). The type and way of housing vary among individual farmers and livestock housing is a common practice in Ethiopia. Hence in

Gamo-Gofa zone,farmers housed their goat with family inside the house (17.25%)and separate house (25.75 %) while the rest 57% used conditional housing means they provide the house whenever necessary (Belay and Meseretu, 2018). Majority of the farmers housed kids separately from the adult flock in Bati, Borena and short Eared Somali goat populations of Ethiopia (Hulunim, 2014). The proportion farmers who possess both sheep and goat keep them together and the proportions of farmers who keep their goats in separated house were 30% and 15.56% in Lare and Jikawo districts of Gambella, respectively (Tsigabu, 2015).

2.8.3. Water Source and Watering

Small ruminates as any other animal require water to maintain the water content of the body and water availability affects voluntary feed intake; less water leads to inadequate intake of dry matter. According to the report of Yadeta (2016) and Yaekob *et al.*(2015) the major source of water were river followed by rain water in Ada barga district of west showa zone and southern Ethiopia. In KaftaHumera district of Tigray region goat owners allowed their goats to drink water (76%) once a day and (24%) provide water two times a day for their goat flock. In SetitHumera, 40% of goat owners watered their flock once a day and 60% those farmers provided water two times a day (Gebrekiros*et al.,* 2016). This indicates that goats have ability to live without water for more than one day indicating their adaptation to stressful environment. During the wet season farmers allowed their goat flock to take water as they needed and when they want, while in dry season they allowed access to water only once per day which accounts 94.64% and 69.34%, respectively(Belay and Meseretu, 2018).

2.9. Castration and Mating System

Castration of goats was less common in Lare and Jikawo district of Gambella regional state, south western Ethiopia. About 85.55% of goat owners in these two districts were not practicing castration (Tsigabu, 2015). The finding of Tsigabu (2015) contradicts with the work of Mahilet (2012) who reported that castration was practiced in 70.99% of the sampled household in eastern Hararghe. Castration was practiced by 81.7% at MeanitShasha, 68.3% at Sheko and 65% at Shey Bench district of Bench Maji zone, south western Ethiopia (Tegegn*et al*., 2015). Among the sampled households who practice castration, majority of them castrate at the age of 1-2 years. The farmers have multiple castration objectives such as for improving

fattening potential and temperament of buck and indirectly controlling breeding. Castration was entirely done through traditional method using local materials such as wood and stone. Majority of the goat owners did not supplement castrated bucks (Tegegn*et al*., 2015).

In Lare and Jikawo district of Gambella regional state, majorlyuncontrolled mating is practiced and which accounted 81.12% (Tsigabu, 2015). According to Tegegn*et al*. (2015) mating was predominantly uncontrolled in the Bench Maji zone, south western Ethiopia, and accounted 23.3, 20 and 76.7% in Sheko, Shey Bench and MeanitShasha, respectively, kept their own breeding buck.

2.10. Breeding Objectives of Farmers

Clear definition of breeding objectives might be difficult under subsistence level of managements with a wide range of production objectives and marketing strategies. Any breeding program for goats should be implemented to achieve a certain clearly defined objective. In general the result of many studies (Tesfaye *et al*., 2012; Solomon, 2013; Bekalu, 2014; Yaekob *et al.,* 2015; Yadeta, 2016 and Belay and Meseretu, 2018) indicated that farmers have multiple breeding objectives of goat; but the purpose of production differs based on the interest of producer households. The main purpose of producing goat includes cash from sale, meat consumption, reproduction or replacement, milk consumption, ceremony, cultural and manure in order of their importance.The main objective is to maximize output (meat, milk, wool, skin) per unit input. Therefore, the first step in a breeding program is to define realistic and attainable objectives.

Farmers breeding management decision is determined by the merit of livestock species and breed, farmers breeding objectives and the production environment (Solomon *et al*., 2010). The main objective of rearing goat's population in Northern Omo, Ethiopia was expected to provide multifaceted benefits to farmers. The sale of live goat and meat were preferred production objectives with index of 0.40, 0.48 and 0.44 (sale of live animals) and 0.35, 0.30 and 0.43 (meat) in lowland, midland and highland area of Northern Omo, Ethiopia, respectively (Yaekob *et al.,* 2015). The same result also reported by Yadeta (2016) the major reason for goat rearing was income generations through sale of live animals with an index value of 0.6, 0.42 and 0.47 in highland, midland and lowland agro-ecology of in West

ShoaZone, Ethiopia, respectively. The report of (Tegegn*et al*., 2013) shows that the breeding objectives of goats in Bench-magi zone were to improve growth of goats and increase income.

2.11. Constraints of Goats

Despite their value to society as a source of milk, meat, cash and security, goat research and development was neglected for many years. The identification of major constraints for a given farm animal production system in a given area is a prerequisite to plan appropriate intervention strategies for improving productivity (Yadeta, 2016). The integration and full utilization of goats is constrained by various factors including high prevalence of diseases, low genetic potential, poor management and extensive production systems. Disease, feed shortage, predators, shortage of land, lack of labor and drought were the most pertinent constraint of goat production (Ahmed, 2013; Bekalu, 2014; Yaekob*et al.,* 2015; Yadeta, 2016 and Belay and Meseretu, 2018). Disease, shortage of feed and lack of land (with an index value of 0.35.0.14 and 0.14) in Southern Omo of Ethiopia were the major constraint of goat production (Yaekob*et al.,* 2015). According to Yadeta (2016) disease was ranked as first constraint for goat production with index values of 0.40, 0.42, and 0.23 in highland, midland and lowland area of west Shoa zone, Ethiopia, respectively. Similarly (Belete, 2013) reported that diseases is the serious problem and have a significant impact on the performance of goat across the entire studied district with an index value of 0.34, 0.27 and 0.30 for MadaWalabu, Sawena and Rayitu districts of Bale zone, respectively). On the contrary in addition to disease, Scarcity of water, drought and genotype, scarcity of land and feed shortage is a major constraint in Gamo-Gofa zone of southern Ethiopia (Belay and Meseretu, 2018).

2.12. Phenotypic Characterization of Goat

Characterization is corner stone for efficient and effective management of goat breeds for conservation, especially for those which are not adequately characterized and are in danger of becoming threatened but are better performing in stress full environment (Gebrekiros, 2016). 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. The information provided

by characterization studies is essential for planning the management of AnGR at local, national, regional and global levels (FAO, 2011).

The classical description of breeds using the phenotype is based upon morphological characters such as coat color, horn, tails, body measurements and other specific visible traits. Phenotypic relationships, based upon the comparison of morphological characters, are used to estimate variations within breeds and distances between breeds, and are used to describe them in terms of the frequency of the most typical characteristics. Morphological or phenotypic characterization has been suggested and used to describe and classify breeds of farm animal species (FARM-Africa, 1996 and Lanari*et al.*, 2003).

2.12.1. 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 characteristics are those that can be categorized like coat color, presence/absence of horns, beard, ruff, muzzle, toggle, facial profile, ear form etc. The observed overall coat color patterns(Table 3) for both sexes were 64.20% plain, 33.33% patchy/pied and 2.47% spotted in Bati; 72.36% plain, 23.98% patchy/pied and 3.66% spotted in Borena; and 45.08% plain, 39.90% patchy/pied and 15.03% spotted in Short-eared Somali goat populations (Hulunim, 2014). Tesfaye *et al.* (2006) reported higher proportion (93%) of plain coat color pattern for central highland goats around South Wollo (Bati) and North Shewa (Shewa Robit and Ankober). Alubel (2015) reported coat color pattern observed in Abergelle goat was plain (38.34%), patchy (39.88%) and spotted (21.78%).The majority of Bati and Borena goats were characterized by lateral/sideway ear orientation accounting a total of 59.9 and 78.9%, respectively (Hulunim, 2014). Majority of Abergelle goat coat color was brown/red (30.40%) and its combination with other coat colors (50.61%), whereas relatively high proportion of central highland goat had white coat color (21.66) and its combination with other coat colors 55.09 % (Alubel, 2015). The red/brown coat color has dominancy in Abergelle goat. The detailed information on qualitative traits was presented in Table 3.

Table 3: Coat Color Pattern, Coat Color Type, Horn Shape, Presence or Absence of Wattle and Presence or Absence of Ruff for Different Goat Breeds in Different Area of Ethiopia.

Breed	Location	Characteristics										Source
		Color	%	Coat pattern	%	Horn shape	%	Wattle	%	Ruff	%	
Bati	Bati and Kalu	Dark red/brown Light red White+ Light brown White Others	29.63 22.22 19.14 11.11 17.95	Plain Spotted Patchy	64.2 4.48 23.88	Straight Curved Spiral	96.73 2.61 0.65	Present Absent	0 100	Present Absent	11.73 88.27	Hulunim, 2014
Borena	Yabello	White White+ brown White +Black Gray Others	71.54 16.67 6.91 2.03 2.85	Plain Spotted Patchy	72.36 3.66 23.98	Straight Curved Spiral	68.72 27.69 3.59	Present Absent	1.63 98.37	Present Absent	12.60 87.40	Hulunim, 2014
Arsi- bale	Bale	White Blank +white Black Red Others	45.71 20.63 7.94 8.25 16.27	Plain Spotted Patchy	64.44 12.54 23.02	Straight Curved polled	59.52 33.49 6.98	Present Absent	7.62 92.38	Present Absent	70.63 29.37	Belete, 2013
Woyto-Guji	Loma	White Brown Grey White Black	19.9 45.7 6.5 7.8 20.1	Plain Spotted Patchy	91.2 6.3 2.5	Straight Polled Spiral	71.4 9.9 18.8	Present Absent	12.7 87.3	Present Absent	90.3 9.6	Yaekob *et a*l., 2015

Table 3(Continued)

Short-eared Somali	Siti (Somali)	White White +Black White+ brown Others	36.2 21.24 20.21 22.29	Plain Spotted Patchy	45.08 15.03 39.90	Straight Curved Spiral	54.49 35.26 10.26	Present Absent	5.68 94.32	Present Absent	10.36 89.64	Hulunim , 2014
Gumuz	North Gondar	White White with spot Black with spot Brown with patch Others	16.67 23.33 26.67 13.33 20	Plain Spotted Patchy	23.33 53.33 16.67	Polled Straight Curved	3.33 30.00 46.6	Present Absent	26.67 73.33	Present Absent		Halima et al., 2012
Central Highland	Ziquala and Lay Armachiho (Amhara)	White White and red Red/brown Black and white Others	21.66 34.71 13.38 11.46 18.79	Plain Spotted Patchy	38.22 21.97 39.81	Straight Curved Spiral	18.15 74.32 7.53	Present Absent	15.29 84.71	Present Absent	15.29 84.71	Alubel, 2015
Abergelle	Tanqua Abergelle (Tigray)	Red/brown White and red black Black and white Others	30.98 30.06 6.44 11.04 21.37	Plain Spotted Patchy	38.34 21.78 39.88	Straight Curved Spiral	8.38 70.19 21.43	Present Absent	7.67 92.33	Present Absent	23.62 76.38	Alubel, 2015

Table 3 (Continued)

Abergelle	Abergelle	Red brown	23.85	Plain	54.2	-	-	Present	10.11	Present	8.02	Solomon, 2014
		White and brown	15.65									
		Brown	19.66	Patchy	45.8	-	-	Absent	89.89	Absent	91.98	
		Red bro and white	12.79			-	-					
		Others	12.02									
Woyto-Guji	Bench-mage	brown dominant	25.28	Plain	65.73	curved	19.10	Present	11.80	-	-	Belay, 2017
		fawn	15.17									
		white dominant	13.48	Spotted	22.47	straight	78.09	absent	88.20	-	-	
		black	11.80	Patchy	11.80	pooled	2.81					
		black dominant	9.55									
		others	24.72									

Others=colour without listed colour for each breed of goat

2.3.2. Quantitative Characteristics

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). The Body weight (kg), Chest girth (cm), Body length (cm) and Height at Wither (CM) for various Goat breeds in different area of the country Ethiopia is presented in Table 4.

Table 4: Body Weight, Heart Girth, Body Length and Height at Wither for Different Goat Breeds in Different Area of Ethiopia

Breed	Location	Body weight(kg)	Chest girth (cm)	Body length(cm)	Height at Wither (cm)	Source
Gumuz	North Gonder	34.65	75.03	63.69	65.09	Halima *et al*., 2012
Agew	Agew-Awi	31.47	73.00	63.52	67.4	Halima *et al*., 2012
Central Abergelle	South-Wollo	27.88	70.53	63.15	68.0	Halima *et al*., 2012
Bati	Oromia	29.87	70.02	61.78	66.36	Halima *et al*., 2012
Arsi- bale	Bale	29.52	71.95	56.02	66.66	Belete, 2013
Western Lowland	Metema	24.00	65.27	54.80	62.60	Solomon, 2014
Abergelle	Abergelle	18.34	61.03	51.00	58.99	Solomon, 2014
Short-eared Somali	Siti (Somali)	24.67	67.27	57.85	62.88	Hulunim, 2014
Central Highland	Ziquala and Lay Armachiho (Amhara)	33.95	74.90	61.44	71.02	Alubel, 2015
Abergelle	Tanqua Abergelle (Tigray)	27.52	70.21	58.32	65.31	Alubel,2015
Woyto-Guji	Loma	26.7	73.11	58.20	66.65	Yaekob *et al.*, 2015
Woyto-Guji	Gamo-Gofa	28.596	73.63	60.66	65.60	Belay and Meseretu, 2017

2.12.3. Correlation between Body Weight and Linear Body Measurements

The correlation between body weight and other LBM was higher in male than female counter parts and this variation may be explained due to the difference in fat deposition variation between male and female goats. Body weight was highly correlated with all continuous traits of both female and male goats except some quantitative traits (Belete, 2013; Ahmed, 2013;

Bekalu, 2014; Alubel, 2015; Yaekob *et al.,* 2015 and Belay and Meseretu, 2017). Body weight was highly correlated with HG, BL, HW and HDL (0.96, 0.92, 0.90 and 0.74 in male Begaitgoats respectively) and (0.89, 0.85, 0.83 and 0.54 in female Begait goats) respectively (Gebrekiros*et al.,* 2016). Among measured linear quantitative variables chest girth (r=0.769 up to 0.928), body length (r=0.494 up to 0.796) and height at withers(r=0.471 up to 0.856) was the highest positively associated variable with body weight both for male and female Abergelle and Central Highland goat breeds, respectively (Alubel, 2015). The correlation coefficient between linear body measurement and body weight were positive and significant except ear length for both sexes in bale zone of Oromia region (Belete, 2013).

2.12.4. Prediction of Body Weight from LBMs

Multiple linear regression analysis was carried out to predict live body weight of an animal. 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. According Cankaya (2008) regression analysis is a decisive instrument in livestock research to mark out the relationship between quantitative response variable and explanatory variable like body weight and linear body measurement, this mechanism of analysis is more important in absence of weighing balances. The prediction of body weight could be based on regression equation developed for male and female by using heart girth and other variables (HG, BL and TL) for male and (HG, BL, HW and EL) for female (Gebrekiros*et al.,* 2016). For Abergelle and Central Highland Goat five (CG, BL, HW, RL and PW) and four (CG, BL, SC and PW) predictors (quantitative traits) were selected in order to develop the prediction equation for Abergelle female and male goats respectively (Alubel, 2015). In the selected districts of west Gojjam Chest girth selected first, which explain more variation than any other linear body measurements in both does (88%) and bucks (91%). In addition to chest girth only eight quantitative trait (CG, HW, CW, RL, RW, HDL, BL and TL) and only seven linear body measurements were taken to be incorporated in to the model for bucks (CG, BL, RL, RH, HW, HDL and CBL) (Bekalu, 2014).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in south Gondar zone of the Amhara region. South Gondar Zone is one of the 11 zones in the Amhara National Regional State of Ethiopia. The area is characterized by scarce vegetation cover, serious natural resource degradation, and erratic rainfall (Sisay, 2009). Three districts known to rear indigenous goat were purposively selected based on agro ecology and relatively high number of goat population. The climate of the zone were *Wurch* and *Kola* accounting for 2.5% and 16% respectively whereas *WoinaDega* and *Dega* accounted for 27% and 54% of the zone. As reported by Ethiopia metrologies, agency Bahir Dar metrologies branch office, Zone Agriculture and Development Office data, its altitude range from 550-4135 m above sea level.

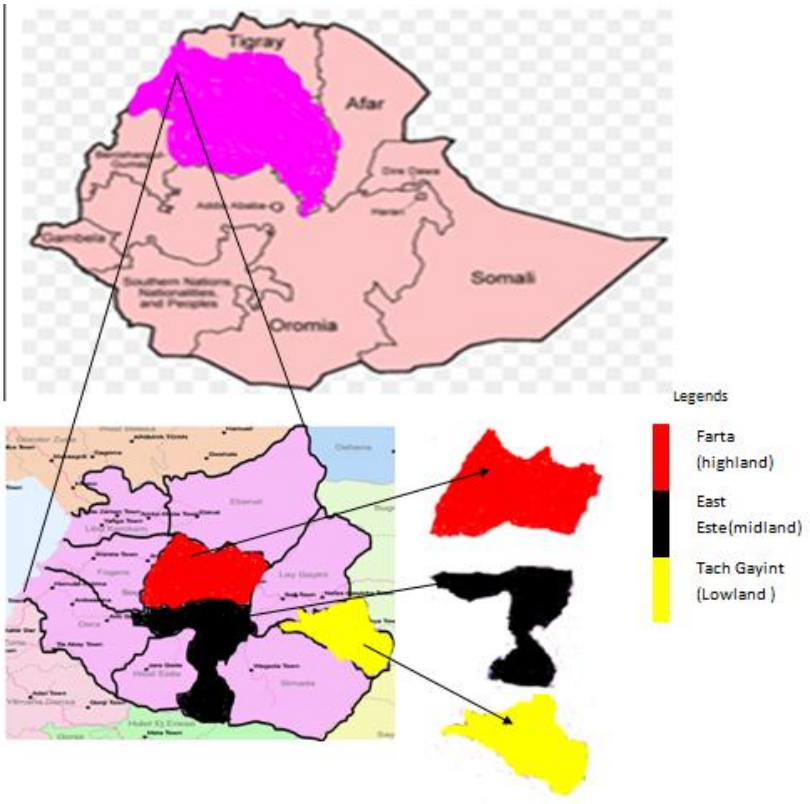


Figure 1: Map of the study area

3.1.1. Farta

Farta is one of the districts in the Amhara National Regional State of Ethiopia and part of South Gondar Zone. It represents a district for highland agro-ecology with an altitude range of 1920-4135 masl and the climate condition of this district is 56% moist *dega*,41.5% *weina dega* and 2.5% *kola.*Farta is bordered on the south by East Este, on the west by Fogera, on the north by Ebenat, and on the east by Lay Gayint. Debre Tabor town is surrounded by this district. There are 37 rural peasant associations and 2 (Gasay and Kimir Dingay) urban peasant associations in Farta district with an estimated area of 1077.77 square kilometers. Farta district is located about 100 km north-east of Bahir Dar, capital of the Amhara National Regional State and 666 km from Addis Ababa which is capital city of Ethiopia. The total number of cattle, sheep, goat, equines, chicken, and beehives are 213188, 113978, 51556, 36072, 132050 and 17615, respectively(SGZARD, 2017). This district is located between 11°32’ to 12°03’N latitude and 37°31’ to 38°43’E longitude. The district receives an average annual rain fall of 1250 -1599 mm and a mean-range temperature of 9^0-25^0C (Farta District OoARD, annual report).The major crops grown in the district were: teff, wheat, and barley, minor crop like pea, sorghum and maize. In addition to these, irrigated vegetables like potato, onion and cabbage was also produced in the area. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 99.61% reporting that as their religion and the rest 0.39% the populations were Muslim.

3.1.2. East Este

The second district, East Este is one of the districtsin the Amhara National Regional State of Ethiopia and Part of South Gondar Zone.It represents a district for midland agro-ecology with an altitude range of 1500-4000 masland the climate condition of this district is 19% moist *dega*,70%*weina dega* and 11% *kola*. East Este is bordered on the south by the Abay River which separates it from the East Gojjam Zone, on the west by West Este, on the northwest by Fogera, on the north by Farta, on the northeast by Lay Gayint, and on the east by Simada. MekaneYesus is the main town in this district. There are 36 rural peasant associations and 3 urban peasant associations in East Este with an estimated area of 1374.98 square kilometers. This district is located between 11° 37' N latitude and 38° 4'E longitudes. East Este district is located 109.9 km North West of Bahir Dar city and 675.9 km from Addis Ababa which is

capital city of Ethiopia. The total number of Cattle, sheep, goat, equines, chicken, and beehives are 190853, 141985, 104604, 30428, 130985 and 14137, respectively (SGZARD, 2017). The minimum and maximum mean annual rainfall of the area is 900-1100 mm and the mean annual minimum and maximum temperature is 8.3^0C-25^0C (ENMA, unpublished). The major crops grown in the district were: teff, wheat, barley, sorghum, maize, pea, chick pea and vegetables were also grown as major source of cash income and household consumption. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 97.08%, while 2.91% of the populations were Muslim.

3.1.3. Tach Gayint

The third district, Tach Gayintis one of the districts in the Amhara National Regional State of Ethiopia and part of south Gondar Zone.It represents a district for lowland agro-ecology with an altitude range of 750-2800 masland the climate condition of this district is 22.3% moist *dega*, 23% *weina dega* and 54.7%*kola*.Tach Gayint is bordered on the south by the Bshilo River which separates it from the south Wollo zone, on the west by Simada, on the north by Lay Gayint, and on the east by the Checheho River which separates it from the north Wollo zone. The major town in Tach Gayint is Arb Gebeya. There are 15 rural peasant associations and 1 urban peasant associations in Tach Gayint with an estimated area of 825.03 square kilometers. This district is located between 11° 22' to 11° 42'N latitude and 28° 19' to 38° 43'E longitudes. Tach Gayintdistrict is located 194.9 km North West of Bahir Dar city and 760.9 km from Addis Ababa. The total number of Cattle, sheep, goat, equines, chicken, and beehives are 78531, 51628, 62691, 58168, 25111, and 9751 respectively (SGZARD, 2017). The mean minimum and maximum annual rainfall ranges from 900 to 1000 mm per annum and the mean minimum and maximum annual temperature ranges from 13^oc to 27^oc (ENMA, unpublished). The major agricultural crops in Tach Gayint include: cereals such as teff, barley and wheat; pulses such as fava beans, field peas, haricot beans and chick peas; vegetables such as potatoes; bananas and hops (TGWAO, 2014). The majority of the inhabitants practiced Ethiopian Orthodox Christianity with 92.7%, while the rest 7.3% of the population were Muslims.

3.2. Sample Size Determination and Sampling Techniques

Purposive sampling technique was employed to select representative district. Before deciding the sample districts, secondary data sources were used and discussion with south Gondar Zone Livestock and Fishery Resources Development Office expertise was held to stratify districts based on agro-ecology. After we discussed with the Zonal Agricultural Officers, three district were selected (Farta for highland, East Este for midland, and Tach Gayint for lowland) from those districts of South Gondar Zone based on agro-ecology and relatively large goat population. From each district, three kebele (Peasant Association) were selected based on relatively large goat population.From each Peasant Association, households which had at least two goats were randomly selected and interviewed.

The representative households sample size was 171 (57 from each agro-ecologies) determined by Cochran's (1977).

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

Where: n=sample size

Z=standard normal deviation (1.96 for 95% confidence interval

p=0.128(estimated population variability proportion, 12.8% the conservative population variability)

q=1-p i.e. (1-0.128) =0.872(87.2%)

e= (0.05) level of precision (sampling error).

$$\frac{1.96^2 * (0.128(1-0.128)}{0.05^2} = \frac{3.8416 * (0.111616)}{0.0025} = \frac{0.428784}{0.0025} = 171.5136 = \mathbf{171}$$

For body weight and other linear body measurements and qualitative trait descriptions, a total of 603 goat populations were selected randomly from three selected districts. These 603 goats comprised of 67 goats per each selected Peasant Association (201 adult goats per each selected district). Out of this 603 goats 10% (63) were bucks and 90% (540) were does as per recommendation of FAO (FAO, 2012). The details are shown in Table 2. Dentition was used to determine the age of goats and goats which had one and above pair of permanent incisor (1PPI) were 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).

The sample size of adult goat was determined by the formula given by Cochran's (1977) as recommended by FAO (FAO, 2012) for phenotypic characterization of livestock for simple random sampling.

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

Where: n=sample size

Z=standard normal deviation (1.96 for 95% confidence interval

p=0.155(estimated population variability proportion, 15.5% the conservative population variability)

q=1-p i.e. (1-0.155) =0.845(84.5%)

e= (0.05) level of precision (sampling error).

$\frac{1.96^2 * (0.155(1-0.155)}{0.05^2} = \frac{3.8416 * (0.130975)}{0.0025} = \frac{0.503154}{0.0025}$ = 201.2614=**201**

This is only for one district; in order to calculate the overall sample size of goat (the three district) multiplied by three (3) the given value; 3*201=603

Table 5: Summary of the Total Number of House Hold and Goat Samples

District	Agro-ecologies	Kebele	Morphological Trait			Number of Household	Focal group discussion
			Adult females	Adult males	Total		
Farta	Highland	Kanat H/Abargay Kuskuam	180	21	201	57	3
East Este	Midland	Zegora Dangute Belta	180	21	201	57	3
Tach Gayint	Lowland	Gedoda Agat Anseta	180	21	201	57	3
Pooled			**540**	**63**	**603**	**171**	**9**

3.3. Method of Data Collection

For each household survey, structured and pre-tested questionnaires were used. The structured questionnaires were developed to collect all the pertinent information in a single visit. The questionnaire was designed to obtain information from respondents about household socio-economic situation, composition of livestock species, selection criteria for breeding, and

management practices of goat, feed resource utilization and availability, animal health condition, trends in population and production constraints. Group discussions were also carried out with DAs, model farmers, village leaders, women and socially respected individuals. Type of data collected from group discussions in each district were production potential of indigenous goat as well as the production constraints, production system, husbandry practice and breeding methods.

Secondary data like climatic data (temperature and rainfall), and human and livestock demography were collected from the zone administrative office, the district office of livestock and fishery resources and other written documents.

Data (for quantitative and qualitative traits) was recorded based on breed morphological characteristics descriptor list of FAO (2012) for phenotypic characterization of goat. Data for heart girth (HG), body length (BL), height at wither (WH), rump height (RH), chest depth (CD), horn length (HL), ear length (EL), rump length (RL), rump width (RW), cannon bone length (CBL), cannon bone circumference (CBC) and head length (HDL) as well scrotum circumference only for male were collected using tailors measuring tape while body weight (BW) was measured using suspended spring balance.

Data were generated for qualitative traits (coat color pattern, coat color type, hair length, hair type, presence or absence of (horn, toggle, beard, ruff, and wattle), horn shape, horn orientation, ear orientation, head profile, back profile and rump profile)) through visual observations.

3.4. Statistical Analyses Techniques

All data gathered during the study period were coded and recorded in Microsoft Excel 2007. All the collected data was double-checked for any types of errors occurred during data collection and entry. Different types of statistical analysis were used depending upon the nature of the data. Data generated from questionnaires were described and summarized by using descriptive statistics, general linear model (GLM) and chi-square (x^2) test was carried out to assess the statistical difference among categorical variables using agro-ecology as fixed effect. Index was calculated for data which need ranking like reasons for purpose keeping goat, selection criteria associated with breeding females and males, trait preferences by

farmers for breeding goat, feed resources for goat during dry and wet seasons, reproductive problem, constraints and major disease of goat production.

Indexes were calculated according to a formula:

Index = sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) given for an individual attribute divided by the sum of (3 for rank 1 + 2 for rank 2 + 1for rank 3) for overall attributes.

The percentage of each level of qualitative data was obtained by using SPSS ver. 20; and Chi-square (x^2) test were used to detect a significance difference of qualitative trait using agro-ecology as a fixed effect. A general linear model procedure (PROC GLM) of SAS was used for quantitative variables to detect statistical differences among sample goat populations. For adult animals, sex, age group and agro-ecology of the goat were fitted as fixed effect while body weight and other linear body measurements were fitted as response variables. Least square means (LSM) with their corresponding standard errors was calculated for each body trait over sex, age, agro-ecology, and the interaction of age by sex and sex by agro-ecology. The means of significant effect were compared by Tukey test.

The model employed for analyses of mature body weight and other linear body measurements of males and females, except scrotum circumference for female was as under:

$Y_{ijkl=} \mu + A_i + D_j + S_k + (DS)_{jk} + (SA)ki + e_{ijkl}$

Where:

Y_{ijkl} = the observation of body weight and LBMs excluding scrotum circumference for female in the i^{th} agro-ecology, j^{th} age group and k^{th} sex

μ = overall mean

A_i = the effect of i^{th} agro-ecology (i = highland, and midland lowland)

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

S_k= the effect of k^{th} sex (k =male and female)

$(DS)_{jk}$=the interaction effect of j^{th} age group and k^{th} sex

(SA)ki = the interaction effect of k^{th} sex and i^{th} agro-ecology

e_{ijkl} = random residual error

Live body weight and other body measurements including Chest Girth (HG), Height at Wither (WH), Body Length (BL), Rump Height (RH), Chest depth (CD), Horn length(HL), Ear

length (EL), Rump width (RW), Rump Length (RL), Canon bone length (CBL), Canon bone circumference (CBC) and (Head Length (HDL) were considered both for male and female goats. In addition, Scrotum Circumference (SC) was included for male goats in the analysis.

Correlations of live body weight with different body measurement

Correlation coefficient was computed for each sex using Pearson correlation coefficient in order to determine the relationship between body weight and other linear body measurements. Stepwise regression procedure of SAS ver. 9.3(2014) were used to regress body weight for both male and female using PROC REG procedure of SAS in order to determine the best-fitted regression equation for the prediction of live body weight. The following model was used for the estimation of body weight from LBMs:

$$y=\beta_0+ \beta 1X_1+\beta 2 X_2 \ldots+\beta_{14} X_{14}+ e_j$$

Where:

y= the response variable (live body weight)

β_0 = the intercept

$X_1 \ldots, X_{14}$ are independent variables (all linear body measurements) for males and females except SC (for female $X_n = 13$)

$B_1 \ldots, \beta_{14}$, are regression coefficients of the variables $X_1 \ldots, X_{14}$(for female $\beta_n = 13$)

ej =the residual random error

Inbreeding Coefficient

Inbreedingcoefficient was calculated on the basis of effective population size according to Falconer and Mackay (1996). The effective population size was estimated as:

$$\text{Ne} = \frac{4(Nm)(Nf)}{(Nm+Nf)}$$

Where:

Ne = effective population size

Nm = number of breeding male population

Nf = number of breeding female population

$$F = \frac{1}{2(Ne)}$$

Where: F= coefficient of inbreeding

Discriminate and Canonical Discriminate Analysis

The quantitative variables from female and male animals were separately subjected to discriminate (DISCRIM) and canonical discriminate analysis (CANDISC) procedure of SAS to ascertain the existence of population level phenotypic differences among the goat populations. The stepwise discriminate analysis procedure (PROC STEPDISC) of SAS was applied to determine which morphological traits have more discriminate power than others.

Principal component Analyses

Principal component analysis was carried out to study the linear relationships between characters. The PRINCOMP procedure (SAS, ver. 9.3, 2014) was carried out to investigate the core structure of the goat traits in order to check whether the traits could be reduced to uncorrelated dimension (principal component).

4. RESULTS AND DISCUSSION

4.1. Characterization of Production System

4.1.1. General Household Characteristics

The result of demographic and socio-economic characteristics of the households in the study areas is presented in Table 6. In this study male headed household accounted for the largest proportion of the studied samples (respondents) throughout the study area. Of the total interviewed, majority of the households in the study area were male headed, which accounted for 89.5%. This result is congruent with the study undertaken by Wossenie (2012) and Ahmed (2013) who reported that 85% and 89.87% of the households in Eastern Hararghe and Horro Guduru Wollega were male headed, respectively. The proportion of male headed household in highland, midland and lowland agro-ecology were 84.2, 89.5 and 94.7, respectively. The remaining lower proportion of women respondents in highland, midland and lowland area were 15.8%, 10.5% and 5.3% respectively. The occurrence of less percentage of women respondents in the study area might be due to work load at house and as a result the probability of getting them outside the house is less.

The results on age structure showed that majority of respondent farmers fell in age group of 31-40 and 41-50 years in all the three agro ecologies. The overall proportions were 37.4% and 36.8% of the household were within age of 41 to 50 and 31 to 40 year respectively. This indicated that the farmers were in high productive age group.

The current results showed that though there were primary and high schools in all agro-ecology of South Gondar, yet the respondent households in the study area have different educational backgrounds. The largest proportions of household heads in highland (45.6%) were able to read and write; whereas the largest proportion in midland (57.9%) and lowland (68.4%) were illiterate. The proportions of household heads who attended primary school were 12.3% and 14.0% in highland and midland respectively; whereas the proportion for lowland was 7.0%. The highest proportion of literate farmers (primary, high school and read and write)especially in highland area of the study might be a good chance for adoption of new technologies and to implement breed and management practice to improve the productivity of goat. The overall educational statuses of the respondent farmers in the study area were 34

illiterate (55.0%), read and write (30.4%), reaches to primary and high school (11.1% and 3.5% respectively). This highest proportion in illiterate educational status was higher than the report of Ahmed (2013) who reported that 31.1% of the households in Horro Guduru Wollega were illiterate. On the contrary, Wossenie (2012) reported that higher proportion (85.8%) of the households in Eastern Hararghe were illiterate. The overall proportion of marital status showed that married, divorced and widowed were 95.3%, 2.3% and 2.3%, respectively.

Table 6: Sex, Age, Educational and Marital Status of the Respondent Households

Variables	Agro ecology								X^2 value
	Highland		Midland		Lowland		Overall		
	N	%	N	%	N	%	N	%	
Sex of the respondent									3.353^{NS}
Male	48	84.2	51	89.5	54	94.7	153	89.5	
Female	9	15.8	6	10.5	3	5.3	18	10.5	
Age structure									15.606^{*}
20-30	5	8.8	6	10.5	4	7.0	15	8.8	
31-40	30	52.6	21	36.8	12	21.1	63	36.8	
41-50	17	29.8	19	33.3	28	49.1	64	37.4	
51-60	3	5.3	6	10.5	9	15.8	18	10.5	
>60	2	3.5	5	8.8	4	7.0	11	6.4	
Educational status									13.613^{*}
Illiterate	22	38.6	33	57.9	39	68.4	94	55.0	
Read and write	26	45.6	13	22.8	13	22.8	52	30.4	
Primary	7	12.3	8	14.0	4	7.0	19	11.1	
High school	2	3.5	3	5.3	1	1.8	6	3.5	
Marital status									5.660^{Ns}
Married	52	91.2	44	96.5	56	98.2	163	95.3	
Divorced	3	5.3	0	0.0	1	1.8	4	2.3	
Widowed	2	3.5	2	3.5	0	0.0	4	2.3	

4.1.2. Family Size, Land Holding and Farming Activities

The result on family size, land holding and farming activities are presented in Table 7. The family size in terms of total and both sexes were not significantly (P <0.5) different across all the three districts. Average family size in highland, midland and lowland were 5.77, 5.74 and 6.35, respectively. The current studies regarding family size in all agro-ecology were higher than both the National (4.9) and average family size of Amhara Region (4.5) in 2007 census (CSA, 2007). Similar to the current study, Zewdu (2008) and Ahmed (2013) reported higher family size than the national family size in Horro (7.3) and 7.4 in HorroGuduruWollega Zone.

The current study revealed that there was highly significant ($p<0.05$) differences between highland goat keepers and lowland goat keepers in terms of total land holding. The average total land holding (crop and grazing land) in highland, midland and lowland agro-ecology were 1.89, 2.16 and 2.40 hectare, respectively. The overall results showed that out of the total land holding; only 0.53 hectare (ha) was used for grazing purpose while the remaining 1.62 hectare of total land was used for cultivated purpose like growing cereal crops which is used for food as a human being (Table 7). The overall total land holding of the farmers in the current study area was 2.15ha which is less than the report of Ahmed (2013), Alubel (2014) and Biratu (2008) who reported that 3.3, 2.9 and 2.78 hectors, respectively. On the other hand, the current study was slightly greater than the result of Derbie (2009) who reported that the total land holding of the farmers in Alaba, Southern Ethiopia was 1.5 ha.

Regarding trend in land holding of respondent farmers in the study area, 89.5%, 86.0% and 96.5% reported that the land was decreasing over time in highland, midland and lowland, respectively. Similarly, all respondent (100%) in all three agro-ecologies revealed that the trend in communal grazing areas is decreasing in the study area. According to the report of key informants during the group discussion, the reason for decreasing of land holding and communal grazing area in the study area was due to increase in human population, expansion of the existing town, establishment of governmental institutes (school, clinic, farmer training center), land degradation and soil erosion across all the agro-ecologies; and farmers violate the rule of management and utilization of communal grazing land.

The study showed that major source of income of respondent farmers were both livestock and crop production (87.7%), crop production (6.4%) and livestock rearing (5.8%).About 89.5%, 91.2% and 82.5% of the respondents in highland, midland and lowland practiced both crop production and livestock rearing respectively. This showed that the livelihood of the community in the study area was based on both crop and livestock production due to high potential for crop production and livestock rearing in the study area. The current results were in conformity with the earlier report of Yadeta (2016) who reported that 100% of the respondent farmers practiced mixed crop-livestock production system. On the contrary the current study was not in agreement with Alemu (2014) who reported that 80.2% of the respondent practiced only rearing of livestock rather than crop production in Shebelle zone, South Eastern Ethiopia.

The agricultural production system in the study area was mixed crop-livestock production system. Integration of crop and Livestock production were the main agricultural activity for the livelihood of the smallholder farmers in highland, midland and lowland agro-ecology. The majority of the farmers (98.8%) in the study area were highly depended on mixed crop-livestock production system while the rest 2.2% of the respondents were depended on agro pastoral production system. The key farmers revealed, during group discussion, that the major crops grown in the study area include barely, wheat, grass pea, field pea and potato in both areas. Especially in the highland area livestock and crop production complement each other in such a way that livestock were used as a source of draft and manure for crop production and from crop production the crop residues, straws and aftermath serve as main components of livestock feed. This was in agreement with Mengistie *et al.*(2010) who reported that livestock and crop production complement each other; livestock used as source of draft and manure while crop production were used for livestock as a source feed in Amhara region.

Table 7: Family Size, Trend Inland Holding and Communal Grazing Land, Major Source of Income and Production System in the Study Area

	Agro ecology								
	Highland		Midland		Lowland		Overall		p-value
	Mean±SE		Mean±SE		Mean±SE		Mean±SE		
(A) Family size:									
Male	3.18±0.14		3.16±0.15		3.28±0.18		3.20±0.09		0.836
Female	3.40±0.13		3.54±0.17		3.61±0.20		3.16±0.11		0.677
Total family size	6.58±0.17		6.70±0.22		6.89±0.29		6.72±0.13		0.631
(B) Land holding:									
Crop land	1.46±0.09		1.64±0.08		1.77±0.11		1.62±0.05		0.074
Grazing land	0.43^{b}±0.04		0.52^{ab}±0.04		0.63^{a}±0.044		0.53±0.03		0.005
Total land holding	1.89^{b}±0.11		2.16^{ab}±0.11		2.40^{a}±0.13		2.15±0.07		0.012
(C) Major source of income:	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	11.353^{*}
Livestock rearing	1	1.8	1	1.8	8	14.0	10	5.8	
Crop production	5	8.8	4	7	2	3.5	11	6.4	
Both	51	89.5	52	91.2	47	82.5	150	87.7	
(D)Trend in land holding:									3.861^{Ns}
Decrease	51	89.5	49	86.0	56	96.5	155	90.6	
Stable	6	10.5	8	14.0	2	3.5	16	9.4	
(E)Trend in communal grazing:									
Decreasing	57	100	57	100	57	100	171	100	
(F) Production system:									4.047^{Ns}
Crop livestock	57	100	57	100	55	96.5	169	98.8	
Agro pastoralists	0	0.0	0	0.0	2	3.5	2	1.2	

N=number of household; means on the same row with different superscripts (for mean ±SD) are (*) significantly different (P<0.05) and NS=non-significant (p>0.05)

4.1.3. Composition, Flock Structure and Trends in Livestock Population

4.1.3.1. Composition of Livestock per House Hold

The major livestock species in the study area were goat, sheep, cattle, chicken, donkey, horses and mule (Table 8). In the study area the average number of chicken per household were higher followed by goat, sheep and cattle (7.70, 7.34, 7.02 and 6.06) respectively. The mean goat flock size per household in highland, midland and lowland was 4.81, 6.75 and 10.48, respectively. There was highly significant difference between agro-ecology in goat population ($p<0.05$). The possible reason for this was that lowland agro-ecology is more suitable for survival, production and productivity of goats. On the other hand sheep in the study area were more reared by farmers in highland area. This is also due to highland agro-ecology is more suitable for sheep with respect to adaptation, production and productivity. Not only goat but also other species such as cattle and sheep have significantly ($p<0.05$) difference in all agro-ecologies. On the other hand, there is no significant difference on chicken and horse between agro-ecology.

The overall mean of goat in the study area was 7.34 which was in line with the result of Ahmed (2013) who reported 7.6 in Horro Guduru Wollega. On the contrary, the present result was less than the finding of Yaekob *et al.* (2015) for Woyto-Guji goat population across three agro-ecology of northern Omo, Belete (2013) in Bale Zone of Oromia Region, Alubel (2014) in Amhara National Regional State (in Ziquala and Lay Armachiho districts) and Tigray National Regional State (in Tanqua Abergelle district) and Alemu (2014) in Shebelle zone, South Eastern Ethiopia who reported 15.47, 13.5, 24.9 and 37.6, respectively. Whereas the overall mean goat population (5.0) reported by Yadeta (2016) in west showa zone was relatively lower than the current finding. Generally, the mean of goat population was high in lowland and less in highland whereas the mean of sheep per house hold was highest in high land and less in low land. This was strongly agreed with the result of Yadeta (2016) and Yaekob *et al.*, (2015) who reported the flock of sheep is high in highland and less in lowland where as for goat population high in lowland. The numbers of horses per household (Table 8) were 0.72, 0.75 and 0.35 in highland, midland and lowland area of the study area, respectively. The differences among highland-midland and midland-lowland were found to be

significant. The overall mean of mule per household was 0.29 and there was no significant difference across all agro-ecology.

4.1.3.2. Flock structure of indigenous goat in the study area

The flock structure by sex and age group of goat in three agro-ecology are presented in Table 8. The current study revealed both sexes with age groups of goat were significantly affected by agro-ecology except Kids between 6 and 12 months.

Table 8: Composition of Livestock Population and Flock Structure of Goat per Household in the Study Area

(A) Livestock composition	Agro ecology			Overall	P-value
	High land	Mid land	Low land		
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	
Goat	4.80^{c}±0.18	6.75^{b}±0.20	10.48^{a}±0.62	7.34±0.28	0.000
Sheep	8.30^{a}±0.71	7.56^{b}±0.65	5.21^{c}±0.29	7.02±0.35	0.000
Cattle	5.40^{b}±0.31	5.70^{b}±0.25	7.09^{a}±0.41	6.06±0.20	0.001
Chicken	8.11±0.80	7.32±0.91	7.67±0.86	7.70±0.50	0.809
Donkey	0.98±0.12	0.95±0.10	0.86±0.08	0.93±0.06	0.689
Horse	0.72^{a}±0.10	0.75^{a}±0.10	0.35^{b}±0.08	0.61±0.06	0.006
Mule	0.28±0.08	0.28±0.11	0.30±0.07	0.29±0.05	0.986
(B) Goat flock structure:	**%(Mean±SE)**	**%(Mean±SE)**	**%(Mean±SE)**	**%(Mean±SE)**	**p-value**
Kids < 6 month	26.2(1.26^{c}±0.12)	28.3(1.91^{b}±0.09)	26.5(2.78^{a}±0.18)	27.0(1.98±0.09)	0.000
Kids 6 - 12 months	15.6(0.75±0.12)	12.4(0.84±0.12)	10.9(1.14±0.14)	12.4(0.91±0.08)	0.088
Mature male >1 year	11.3(0.54^{b}±0.07)	8.6(0.58^{b}±0.07)	8.9(0.93^{a}±0.08)	9.3(0.68±0.04)	0.000
Mature female > 1 year	45.4(2.18^{c}±0.09)	46.2(3.12^{b}±0.13)	45.2(4.74±0.26)	45.6(3.35±0.12)	0.000
Castrated male	1.4(0.07^{b}±0.03)	4.4(0.30^{b}±0.06)	8.5(0.89^{a}±0.12)	5.7(0.42±0.05)	0.000

a,b,c means on the same row with different superscripts (for mean ±SD) are significantly different (P<0.05)

The pair-wise comparison of means in goat population per household was significant among highland-midland, highland-lowland and midland-lowland agro-ecology in Kids < 6 month, mature male >one year and mature female > one year. Similarly, the pair-wise comparison of means in goat population per household showed significant difference among all three agro-ecology for small ruminant in West showa and for Woyto-Guji goat in northern Omo (Yadeta, 2016 and Yaekob *et al.,* 2015), respectively. The difference of castrated male between highland-lowland and midland-lowland agro-ecology of south Gondar zone were significant, whereas differences in the castrated male in highland-midland were not significant. The number of castrated male in highland and lowland were less than lowland. This might possibly be due to the fact that highland and midland goat keepers have relatively less number of breeding male as a result the farmer in these agro-ecology keep those breeding male without castrate for a long period of time for breeding purpose. Goat flock size by sex in highland, midland and lowland agro-ecology of the study area are presented in appendix figure 1.

Perusal of table 8 showed that number of goats across all ages in both sexes was higher for lowland followed by midland and highland. In lowland agro-ecology, mature female (breeding doe) accounted for the largest number (4.74±0.26); followed by Kids <6-month (2.78±0.18), Kids 6 - 12 months (1.14±0.5), Mature male > one year (0.93±0.08) and Castrated male (0.89±0.12). In midland and highland agro-ecology, mature female greater than one year also accounted for the largest number (3.11±0.13 and 2.18±0.09) respectively. The Possible reason for higher number of goats in lowland agro-ecology might be that goat showed good adaptation in lowland area than highland and midland; and as they are browsing animal the lowland agro-ecology has sufficient browsing feed as well as goats requires large area as compared to sheep.

The overall mean of goat per household were lower in Castrated male (0.42±0.05), mature male > one year (0.68±0.04) and Kids 6 - 12 months (0.91±0.08) compared to other groups. However the overall means number of goat per household was highest in mature female > one year (3.35±0.12) and Kids < 6 month (1.98±0.09). The possible reason for lower mean numbers of farmer groups might be sale of these animals. However, the number of breeding buck (mature male greater than one year) in a flock was generally small. In fact, the

proportion of breeding buck and doe can determine the production of kids in a flock. Generally, the current results were lower than the reports of Solomon (2014) who reported that breeding doe were accounted higher number than the rest flock structure and (4.2, 3.1, 0.6) and (25.9, 9.5 and 2.8) for breeding does, kids and breeding buck in lowland Metema district and highland Abergelle goat of the Amhara National Regional State of Ethiopia respectively.

4.1.3.3. Trends of Major Livestock Population in the Study Area

The results presented in Table 9 showed that 50.9%, 64.9% and 78.9% of the respondent farmers in highland, midland and lowland, respectively, areas reported that goat population increased. This might be possible to associate with the decreasing land holding that farmers tend to rears small ruminant and browsers. Those, there is a tendency to select species due to climate change. This was in agreement with Ahmed (2013) who reported that majority of the respondents (78.43% in Guduru, 65.69% in Amuru and 71.59% in Horro) reported that the goat population was increasing from time to time. Contrary to this 38.6%, 26.3% and 7.0% of the respondent farmers in highland, midland and lowland, respectively, reported that goat population was decreasing and attributed this to decreasing grazing and communal grazing land, frequent occurrence of disease, shortage of feed, lack of labor, predator and other related factors. The present results were in agreement with the reports of Bekalu (2014) in west Gojjam.

A large proportion of farmers in highland (52.6%) and midland (57.9%) agro-ecology of south Gondar zone reported a decreasing trend in cattle population. However in lowland the respondent farmers were equally divided in their opinion on increase and / or decreasing trend in cattle population.

The trend of sheep population in highland and midland was increasing (66.7% and 64%) where as in lowland half (52.6%) of the respondents reported that sheep population was decreasing. This might possibly be due the fact that sheep were mainly kept by the farmers in the highland while goats mainly adapted in lowland area. Similar trend was shown by the chicken population where-under the population increased in high and midland but decreased in lowland agro-ecology.

Table 9: Population Trend of Major Livestock Species in the Study Area

Major livestock species	Agro ecology Highland N	Highland %	Midland N	Midland %	Lowland N	Lowland %	Overall N	Overall %	X^2 value
(A) Goat:									16.245*
Increase	29	50.9	37	64.9	45	78.9	111	64.9	
Decrease	22	38.6	15	26.3	4	7.0	41	24.0	
Stable	6	10.5	5	8.8	8	14.0	19	11.1	
(B) Cattle:									11.090*
Increase	22	38.6	16	28.1	21	36.8	59	34.5	
Decrease	30	52.6	33	57.9	20	35.1	83	48.5	
Stable	5	8.8	8	14.0	16	28.1	29	17.0	
(C) **Sheep:**									10.858*
Increase	38	66.7	35	61.4	24	42.1	97	56.7	
Decrease	18	31.6	17	29.8	30	52.6	65	38.0	
Stable	1	1.8	5	8.8	3	5.3	9	5.3	
(D) **Chicken:**									10.367*
Increase	36	63.2	32	56.1	22	38.6	90	52.6	
Decrease	15	26.3	19	33.3	31	54.4	65	38.0	
Stable	6	10.5	6	10.5	4	7.0	16	9.4	

N=Number of households;*significant difference at $p < 0.05$, NS=non-significant ($p>0.05$)

4.2. Purposes of Keeping Goat

The purposes of keeping goat by farmers in the study area were presented in Table 10. In the present study farmers keep their goat for generation of income, meat forhuman consumption, saving (to be used as an asset), for the purpose of manure and skin. As presented in Table 10 the primary purpose of goat for all agro-ecology is income generating. The current study is in agreement with the report of Yadeta (2016) who reported that generating of income is the primary purpose of keeping goat. On the contrary Belete (2013) reported the primary purpose of goat rearing in Bale Zone Oromia Region was milk for human consumption. The primary purpose of keeping goat in highland and midland farmers was income generating with an index value of 0.47 and 0.50 followed by meat (0.32 and 0.29) and saving (to be used as an asset) with an index value of 0.15 and 0.18 respectively. Lowland farmers keep their goat primarily for income with an index value of 0.36 followed by saving and meat with an index value of 0.33 and 0.28, respectively. The finding was in disagreement with report of Gurmesa*et al.* (2011), who reported that farmers in ArsiNegelle district rear their goats for milk, cash income and meat in order of their importance. Generally, in all agro ecology of the study area, most of the farmers reared their goats primarily for generating income which is

used for emergency cases, exchange of different material and for household expenses. Farmers in all agro ecology also use their goat as a source manure and skin rarely.

Table 10: Purpose of Keeping Goat by Farmers

Purpose of keeping goat	Agro ecology											
	High land				Mid land				Low land			
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index
Income	47	10	0	0.47	55	3	0	0.50	28	15	10	0.36
Meat	10	33	14	0.32	2	39	16	0.29	4	32	21	0.28
Saving	0	12	29	0.15	0	15	31	0.18	25	10	17	0.33
Manure	0	2	7	0.03	0	0	7	0.02	0	0	5	0.01
Skin	0	0	7	0.02	0	0	3	0.01	0	0	4	0.01

4.3. Management System of Goat

4.3.1. Housing System of Goat

Type of house and housing system of goat with other animal is presented in Table 11. Perusal of this results showed that majority of respondent farmers (75.4, 80.7 and 92.9% in highland, midland and lowland, respectively) housed their goat in separate house with roof which was contradicted with Tsedeke (2007) and Bekalu (2014) who reported about 98.6% and 57.41% of respondents accommodate their flocks in the main houses together with the family members respectively. On the contrary the current finding was in disagreement with reports of Belay and Meseretu (2018), who reported that goatflock in Gamo-Gofa zone was housedin conditional housing means they provide the house whenever necessary. The representative types of house used for housing of goat is shown in Figure 2.

Majority of respondent farmers (57.9%, 75.4% and 77.2%) in highland, midland and lowland area housed their kid separately from the adult flock respectively, which was in agreement with the report of Hulunim (2014) who reported that majority of the farmers housed kids separately from the adult flock in Bati, Borena and short Eared Somali goat populations of

Ethiopia. The remaining 42.1%, 22.8% and 24.6% of respondent farmers in highland, midland and lowland areas housed together in a confined house.

Table 11: Type of house and housing system of goat

Variable	Agro ecology						Overall		X^2 value
	Highland		Midland		Lowland				
	N	%	N	%	N	%	N	%	
(A) Type of house:									15.041*
In family house with roof	9	15.8	6	10.5	4	7.0	19	11.1	
Separate house with roof	43	75.4	46	80.7	53	92.9	142	83.1	
Veranda with roof	5	8.8	5	8.8	0	0.0	10	5.8	
(B) Housing system by herd structure									6.203*
Kids mixed	24	42.1	14	24.6	13	22.8	51	29.8	
Kids separate	33	57.9	43	75.4	44	77.2	120	70.2	
(C) Housing system of goat with other livestock									8.534*
Goat housed with other	49	86.0	36	63.2	45	78.9	130	76.0	
Goat separately	8	14.0	21	36.8	12	21.1	41	24.0	

N=Number of household, *significant difference at $p < 0.05$, NS=non-significant ($p>0.05$)

(i) Highland and Midland

(ii) Lowland

Figure 2 (a): Representative goat houses in Highland, Midland and Lowland Areas

Figure2 (b): Representative House of Kids and Does Together

Perusal of present study showed that majority of the respondent 86.0%, 63.2% and 78.9% (76.0% overall agro-ecologies) were housed their goat flock with other livestock population in highland, midland and lowland agro-ecology of the study area, respectively.

4.3.2. Herding System of Goat

The main objective of herding is to prevent goat from damaging crops, theft and predators. The present study (Table 12) showed that majority of respondent farmers in midland and lowland (93 and 96.3%, respectively) herded all classes of goat together whereas in highland majority (75.4%) of respondents herded kids separately. This was in agreement with the study of Belete (2013) who reported that majority of the respondent's herded kids separately from the adult goats in Bati zone of Oromia region. Similarly Belay and Meseretu (2018) reported that herding was practiced without sex and age separation except kidswhich were usually separated until they grow strong enough to browse in the wild.

Goat flocks in all agro-ecology were herded separately or with sheep/ cattle/ all class together. In highland, respondent farmers herded goats with all other livestock (54.4%), cattle (38.6%), Sheep (3.5%) and separately (3.5%). However in midland and lowland majority of respondent herded goat with sheep (56.1 and 45.6%, respectively) followed with all other livestock (17.5 and 33.3%, respectively). The present results were not in agreement with the study of Bekalu (2014), who reported that majority of the farmers herded their goat flock with cattle in west Gojjam. This might possibly be due to the fact that goat have different grazing behavior than cattle. The way of herding for goat population in the study area was showed in appendix figure 2.

Majority of the respondents (78.9, 61.4, and 52.6%) did not mix goat flock in the communal grazing land rather they herded in private grazing land in highland, midland and lowland, respectively; and the remaining 21.1, 39.6 and 47.4% of the farmers herded their goat flock with adjacent households in the communal grazing land in highland, midland and lowland, respectively. The overall way of herding in the study area were keeping their goats separately (64.3%) from other household goats around homesteads and the remaining 35.7% of the goat owners herded their goat together with neighboring household's which is in line with the report of Bekalu (2014) who reported that majority of goat owners (56.7%) did not mix their

goat flock with the village and the remaining 43.3% mixed with adjacent village in selected districts of west Gojjam. On the contrary Ahmed (2013) reported that majority of farmers (80.4%) herded their goat together with neighboring household's goat while the remaining 19.6% of the farmers herded separately.

Table 12: Herding System of Goat during the Day Time

Variable	Highland		Midland		Lowland		Overall		X^2 value
	N	%	N	%	N	%	N	%	
(A) Goat flock herded during the daytime:									14.042*
All class of goats herded together	14	24.6	53	93.0	55	96.5	122	71.35	
Kids herded separate	43	75.4	4	7.0	2	3.5	49	28.65	
(B) Goat flock herded with:									21.629*
Herded separately	2	3.5	9	15.8	10	17.5	21	12.3	
Herded with cattle	2	3.5	6	10.5	2	3.5	10	5.8	
Herded with sheep	22	38.6	32	56.1	26	45.6	80	46.8	
All herded together	31	54.4	10	17.5	19	33.3	60	35.1	
(C) Way of herding:									8.747*
Goat of house hold herd separately	45	78.9	35	61.4	30	52.6	112	64.3	
Goat of more than one household herd together	12	21.1	22	39.6	27	47.4	59	35.7	

N=Number of household, *significant difference at $p < 0.05$, NS=non-significant ($p>0.05$)

4.3.3. Source of Feed and Grazing Practice of Goat

Source of feed in wet and dry season for goat in the study area are presented in Table 13. The respondent farmers ranked natural pasture, fallow land and food left over, in decreasing order, with an index value of 0.60, 0.21 and 0.17 in highland; 0.55, 0.30 and 0.14 in midland; and 0.51, 0.30 and 0.18 in lowland, respectively, as the main feed source for goat during wet season. Similarly respondent farmers ranked natural pasture, crop residue and crop aftermath, in decreasing order, with an index value of 0.48, 0.25 and 0.16 in highland; 0.49, 0.25 and

0.16 in midland; and 0.50, 0.27 and 0.14 in lowland, respectively, as the main feed source for goat during dry season, which was in agreement with Alubel (2015), Yadeta (2016), and Belay and Meseretu (2018) who reported that natural pasture was the major source of feed both in dry and wet seasons in (around Amhara and Tigray National Regional States), (Ada Barga and Ejere districts of West Shoa Zone) and (Gamo-Gofa zone of southern Ethiopia respectively). Farmers in the study area ranked feed left over, as a source of goat feed during both wet and dry season, as third and fourth rank, respectively. The possible reason may be that during dry season other sources of feed like crop after math and crop residues are available. Besides this farmers assume that natural pastures are sufficient as a goat feed in wet season. According to key farmers reported during group discussion, severe seasonal shortage of feed occurred for a period of three to four months (March to June) every year. During this period most farmers in the study area feed their goat with leaves of trees, bushes, crop residues, hay, feed left over, local brewery by-products and crop after math.

Table 13: Source of Feed of Goat in the Study Area

Variable	Agro ecology											
	High land				Mid land				Low land			
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index
(A)Source of feed in wet season:												
Natural pasture	57	0	0	0.60	57	0	0	0.55	57	0	0	0.51
Fallow land	0	27	6	0.21	0	39	15	0.30	0	45	12	0.30
Food left over	0	23	3	0.17	0	17	10	0.14	0	12	38	0.18
Concentrate	0	2	0	0.01	0	1	1	0.01	0	0	2	0.01
(B) Source of feed in dry season:												
Natural pasture	50	7	0	0.48	55	2	0	0.49	57	0	0	0.50
Crop residue	4	25	22	0.25	2	25	30	0.25	0	38	17	0.27
Crop aftermath	2	14	22	0.16	0	20	15	0.16	0	15	18	0.14
Food left over	1	9	13	0.10	0	9	10	0.08	0	4	15	0.07
Concentrate	0	2	0	0.01	0	1	2	0.01	0	0	7	0.01

The grazing practices in the study areas are presented in Table 14. During dry season the respondent farmers in highland and midland agro-ecology grazed their goats either by free grazing (43.9 and 47.4%, respectively) or by herding (42.1% and 40.4%, respectively) almost in equal proportion with little difference. However in lowland 77.2% and 17.5% of respondent farmers reported that they graze their goats by free grazing and by herding, respectively, during dry season.However, during the wet season majority (73.7% in highland, 71.9% in midland and 57.9% in lowland) of farmers practiced herded during grazing of goat flock either in private grazing or communal grazing land. The result indicated that in the study area farmers did not practiced tethering only as a grazing method. The goat keepers in all agro-ecologies herded their goat with different degree in dry season and mainly in wet season possibly to avoid crop damage; protect the stock against theft, protect goat from predator and proper utilization of limited grazing land. Generally, the present study indicated that majority of the respondent use freely grazing in dry season while herded in wet season. This in agreement with the report of Yadeta (2016), Bekalu (2014) and Belay and Meseretu (2018) who reported that majority of the respondent practiced free grazing in dry season and herded during wet season in all the three agro-ecology of west Showa, all selected districts of west Gojjam zone and Gamo-Gofa zone, respectively.

The results as reported by goat owners in the study area (Table 14) showed that 35.1, 29.8 and 19.3 % of respondent farmers practiced supplementation of feed for their goat in highland, midland and lowland, respectively. The current finding was not comparable with the report of Yaekob *et al.,* (2016) who reported that feed supplementation was practiced by 87.7, 85.7 and 88.6% of respondents in lowland, midland and highland agro-ecologies of Northern Omo respectively. According to focus group discussion in the study area, key farmers reported as majority of goat owners practiced supplementation mainly in dry seasons of the year due to the shortage of forages in grazing land due to harsh climate affecting growth of vegetation and other shrubs / plants. The types of feed used as supplementation for goat in the study area were, “Attela’’, and frusica.

Table 14: Grazing system of indigenous goat

Variable	Agro ecology						Overall		X^2 value
	Highland		Midland		Lowland				
	N	%	N	%	N	%	N	%	
(A) Grazing in dry season:									15.567*
Free grazing	25	43.9	27	47.4	44	77.2	96	56.1	
Herded	24	42.1	23	40.4	10	17.5	57	33.3	
Herded and tethered	8	14.0	7	12.3	3	5.3	18	10.5	
(B) Grazing in wet season:									12.889*
Free grazing	7	12.3	9	15.8	21	36.83	37	21.6	
Herded	42	73.7	41	71.9	33	57.9	116	67.8	
Herded and tethered	8	14.0	7	12.3	3	5.3	18	10.5	
(C) Do you supplemental feeding to your goat:									3.649Ns
Yes	20	35.1	17	29.8	11	19.3	48	28.1	
No	37	64.9	40	70.2	46	80.7	123	71.9	

N=Number of household, *significant difference at $p < 0.05$, NS=non-significant ($p>0.05$)

4.3.4. Water Resource and Utilization

The availability of different water sources varied between agro-ecologies and seasons of the year. Water sources, distance to water point and frequency of watering reported by the respondents in the study area both for dry and wet season are presented in Table 15. The main sources of water in the study area were rivers, water wells, springs and rain water but, their importance is slightly different across all agro-ecology. In all studied agro-ecology river was the major source of water in both dry and wet season for goats in the study area. The proportion of goat watered by river were 52.6% and 63.2 % (dry and wet seasons respectively) in highland; 72.2% both for wet and dry seasons in midland; and 64.9 and 73.7 % (dry and wet seasons respectively) in lowland. The current study was in agreement with the

report of Alubel (2015), Ahmed (2013) and Yaekob *et al.*, (2015) who reported that rivers were an important source of water during dry and wet seasons in crop livestock system of Abergelle and Central Highland Goat; indigenous goat in Horro Guduru Wollega and Woyto-Guji goat in Northern Omo respectively. The results also showed that spring (21.6%) in dry season and rain water (14.6%) in wet season was the major water source in the study area next to river. This was in agreement with Yadeta (2016) who reported that rain water was the major water source in the wet season across all agro-ecology of west showa.

The resultof table 15 showed that the distance travelled by goat for watering, during both dry and wet season, was less than 1 km as per majority of respondent farmers (66.7 and 50.9% in highland; 47.4 and 59.6% in midland; and 56.1 and 47.4% in lowland) in the study area.

The majority of the respondent provided (56.1, 70.2 and 78.9 % in highland, midland and lowland, respectively) water to goats once a day during dry season, whereas water was provided freely during wet seasons by majority of respondents farmers 71.9, 54.4 and 49.1% in highland, midland and lowland, respectively. Some proportion of farmers in all agro-ecology of the study area provided water once in two days (14.0, 10.5 and 3.5%) in highland, midland and lowland, respectively, in dry season; and the overall watering frequency of goat in the study area were once a day 68.4% in dry season. This result was comparable with Bekalu (2014) who reported that majority of the farmers (64.81%) watered their goat frequently a day in dry season.

Table 15: Water Source, Distance to Water point and Frequency of water in the Study Area

Variable	Agro ecology						Overall		X^2 value
	Highland		Midland		Lowland				
	N	%	N	%	N	%	N	%	
(A) Source of water in dry season:									15.819*
Water well	16	28.1	1	1.8	10	17.5	27	15.8	
River	30	52.6	40	70.2	37	64.9	107	62.6	
Spring	11	19.3	16	28.1	10	17.5	37	21.6	
(B) Source of water in wet season:									5.231Ns
Water well	3	5.3	4	7.0	6	10.5	13	7.6	
Rain water	12	21.1	7	12.3	6	10.5	25	14.6	
River	36	63.2	40	70.2	42	73.7	118	69.0	
Spring	6	10.5	6	10.5	3	5.3	15	8.8	
(C) Distance of water point in dry season:									16.541*
watered at home	7	12.3	18	31.6	17	29.8	42	24.5	
<1km	38	66.7	27	47.4	32	56.1	97	56.7	
1–5 km	12	21.1	12	21.1	5	8.8	29	17.0	
6–10 km	0	0.0	0	0.0	3	5.3	3	1.8	
(D) Distance of watering in wet season:									7.564Ns
Watered at home	27	47.4	7	29.8	23	40.4	67	39.2	
<1km	29	50.9	34	59.6	27	47.4	90	52.6	
1–5 km	1	1.8	6	10.5	7	12.3	14	8.2	

Table 15 (continued)

(E) Frequency of watering in dry season:									10.872^{Ns}
Freely available	2	3.5	0	0.0	0	0.0	2	1.2	
once in a day	32	56.1	40	70.2	45	78.9	117	68.4	
twice in a day	15	26.3	11	19.3	10	17.5	36	21.1	
once in two day	8	14.0	6	10.5	2	3.5	16	9.4	
(F) Frequency of watering in wet season:									10.107^{*}
Freely available	41	71.9	31	54.4	28	49.1	100	58.5	
once in a day	13	22.8	25	43.9	28	49.1	66	38.6	
twice in a day	3	5.3	1	1.8	1	1.8	5	2.9	

N=Number of household, *significant difference at $p < 0.05$, NS=non-significant ($p>0.05$)

4.4. Inbreeding Coefficient

The effective population size (Ne) and the inbreeding coefficient (F) calculated for goats in highland, midland and lowland area are presented in Table 16. When the flocks were not mixed, the inbreeding coefficient of goat in highland, midland and lowland agro-ecologies were 0.19, 0.15 and 0.09, respectively. However, 0.18, 0.11 and 0.08 of in breeding coefficient were calculated for goat population when goats of more than one household were mixed in communal grazing land. This indicates that the inbreeding coefficients are not much different whether the populations are mixed or not. The current finding was lower than the report of Bekalu (2014) who reported that inbreeding coefficient of indigenous goat population at BahirdarZuria, Yilmana-densa and Gonji-Kolela were 0.30, 0.19 and 0.22, respectively. On the contrary these values were higher than the maximum acceptable level of 0.063 (Armstrong, 2006). The effective population size (Ne) in both types of flocks (individual flocks; mixed flocks) was higher in lowland compared to the other two agro-ecology (Highland and midland), and thus the inbreeding coefficient (F) is low in lowland compared to the other two agro-ecology. This was in agreement with the report of Yadeta (2016) who reported that the inbreeding coefficient of goat in lowland area were lower than the rest two agro-ecologies (highland and midland).The possible reason for high inbreeding

coefficient, in both types of flocks, may be low effective population size of both sexes in general and male goats in particular. The high inbreeding coefficient in individual flocks compared to mixed flocks may possibly be due to low effective population size of male goat and prolong use of same bucks over a long period of time resulting in mating of closely related individuals. The utilization of breeding buck(s) born within the flock, uncontrolled mating, lack of awareness about inbreeding and small flock size may lead to accumulation of inbreeding and decreased genetic diversity (Kosgey, 2004).

Table 16: Effective population size and level of inbreeding in the study area

	In private grazing (not mixed)				Communal grazing (mixed)			
Agro-ecology	**Nm**	**Nf**	**Ne**	**f**	**Nm**	**Nf**	**Ne**	**f**
Highland	0.47	2.22	2.69	0.19	0.83	2.00	2.83	0.18
Midland	0.31	2.97	3.29	0.15	1.00	3.36	4.36	0.11
Lowland	0.80	4.60	5.40	0.09	1.07	4.88	5.96	0.08
Overall	0.53	3.26	3.78	0.14	0.97	3.22	4.20	0.10

Ne = effective population size; Nm = Number of male; Nf = Number of female
F = coefficient of inbreeding;

The results presented in Table 17 regarding source of breeding buck showed that respondent farmers were using bucks produced in their own and/or same village flocks; there was no exchange / purchase of bucks from different areas. This may possibly be a reason for high inbreeding coefficient in the present study. Therefore periodic changing of breeding buck (either by purchase or lease), increasing effective population size, and implementation of controlled mating, regular culling of unwanted bucks (either by castration or sale) and initiation of pedigree recording is recommended to decrease the rate of inbreeding and improve productivity.

4.5. Breeding Management:

4.5.1. Mating Practices:

The result on breeding management in the study areas is presented in Table 17. Perusal of results showed that in lowland area higher proportion (78.9%) of respondents owned their breeding bucks whereas this proportion was around 50% (54.4 and 57.9% in highland and midland, respectively). In overall, 67.3% of the respondent were had their own breeding buck which was not comparable with the report of Bekalu (2014) who reported that almost all respondent in west Gojjam zone had their own breeding buck. On the contrary this was contradicted to the report of Ahmed (2013) who reported that majority (67.7%) of the goat owners in Horro Gudruu Wollega zone do not have own breeding bucks.

The respondents reported that the objectives of keeping buck were mating, socio-cultural and fattening purposes. The bucks were kept for mating (51.6, 60.6 and 54% in highland, midland and lowland respectively) and fattening (41.9, 27.3 and 35.6% in highland, midland and lowland respectively). The present results were in agreement with reports of Bekalu (2014) wherein majority of the respondent used their local buck for mating followed by fattening in West Gojjam zone of Amhara region.

The study showed that breeding buck (produced in their flock) were owned by 52.6 and 77.2% of respondent in lowland and midland, whereas only 36.8% of respondents owned breeding buck in highland agro-ecology. The remaining respondents used neighbor' buck (42.1, 38.6 and17.5% in highland, midland and lowland, respectively); purchased from neighbor (17.5, 5.3 and 5.3% in highland, midland and lowland, respectively); and communal buck (3.5% in highland, midland and lowland, respectively) for mating. These results indicated that respondent farmers were using bucks produced in their flocks and there was no exchange / purchase of bucks from different areas. This may possibly be a reason for high inbreeding coefficient (Table 16).

Table 17: breeding practice of goat owners in the study area across three agro-ecology

Variable	Agro ecology Highland		Midland		Lowland		Overall		X^2 value
	N	%	N	%	N	%	N	%	
(A) Breeding buck ownership:									**8.704***
Own	31	54.4	33	57.9	45	78.9	109	63.7	
Others	26	45.6	24	42.1	12	21.1	62	36.3	
(B) Objectives of keeping buck:									**6.842NS**
Mating	16	51.6	20	60.6	18	40.0	54	49.5	
Socio-cultural	2	6.5	4	12.1	11	24.4	17	15.6	
Fattening	13	41.9	9	27.3	16	35.6	38	34.9	
(C) Source of breeding buck:									**24.198***
Own buck (bred)	21	36.8	30	52.6	44	77.2	95	55.6	
Own buck (bought)	10	17.5	3	5.3	1	1.8	14	8.2	
Neighbor's buck	24	42.1	22	38.6	10	17.5	56	32.7	
Communal buck	2	3.5	2	3.5	2	3.5	6	3.5	
(D) Breeding or mating system:									**6.107***
Controlled	13	22.8	7	12.3	4	7.0	24	14.0	
Uncontrolled	44	77.2	50	87.7	53	93.0	147	86.0	
(E) Reason for uncontrolled mating:									**8.123***
Goat browse together	30	68.2	24	48.0	21	39.6	75	51.0	
Lack of awareness	14	31.8	26	52.0	32	60.4	72	49.0	
(F) Do you allow another buck to mate your flock?									**2.608NS**
Yes	53	93.0	48	84.2	52	91.2	153	89.5	
No	4	7.0	9	15.8	5	8.8	18	10.5	
(G) Do you give special management to your buck?									**3.410NS**
Yes	5	8.8	2	3.5	1	1.8	8	4.7	
No	52	91.2	55	96.5	56	98.2	163	95.3	

N=Number of household, *significant difference at $p < 0.05$, NS=non-significant ($p>0.05$)

In the study area, 77.2%, 87.7% and 93.0% of the respondent farmers in highland, midland and lowland, respectively, reported that mating system of goats was uncontrolled. This was in agreement with Ahmed (2013) who reported that most of the farmers (72.22%) practiced uncontrolled mating system in Horro Guduru Wollega zone of Oromia region. The reason for uncontrolled mating, as reported by respondents, was either mixed grazing of goat flock or lack of awareness of demerits of uncontrolled mating.

The majority (91.2, 96.5 and 98.2% in highland, midland and lowland areas, respectively) of the households in the study area were not practiced any special management for breeding bucks which was in agreement with the finding of Bekalu (2014) who reported that majority (91.1%) of the respondent farmers were no practiced special management for breeding buck. Only a small proportion of farmers (8.8, 3.5 and 1.8% in highland, midland and lowland, respectively) were practiced any special management for their breeding bucks by providing additional feed and water. This clearly showed that farmers were not aware of the special requirement of breeding bucks and this will be affecting goat productivity.

4.5.2. Fattening Practices

The results on fattening and castration practices in the study area are presented in Table 18. The results showed that in the study area above half of the respondent (66.1% overall three agro-ecologies) practiced fattening of goat in order to increase household income and the rest 33.9% did not practice fattening. This was not in agreement with Belete (2013) who reported that about 79.2% of the respondents in the Bale zone of Oromia region did not practice fattening. The study further revealed that mainly castrated male goats were used for fattening purpose (91.2% overall three agro-ecologies). However a small proportion (8.8% overall agro-ecologies) of older does were also fattened.

About 73.7%, 87.7% and 89.5% (83.6% overall agro-ecologies) of the goat owners in the study area practiced castration and the remaining 26.3%, 12.3% and 10.5% did not castrate their own goat in highland, midland and lowland agro-ecologies, respectively. This in line with the report of Bekalu (2014) and Belete (2013) wherein majority of goat owners (93.33% and 97.78% and 82.22%;and 85.3%) practiced castration in BahirdarZuria, YilmanaDensa and GonjiKolela districts of west Gojjam; and bale zone of Oromia region, respectively. The

possible reason for castration of breeding buck was to improve fattening (81.8% overall agro-ecologies), indirectly to increase the price of buck; to control breeding (11.9% overall agro-ecologies); and for better temperament (6.3% overall agro-ecologies).

Table 18: Fattening and Castration Practices in the Study Areas

Variable	Agro ecology						Overall		X^2 value
	Highland		Midland		Lowland				
	N	%	N	%	N	%	N	%	
(A) fattening practices:									1.461^{NS}
Yes	35	61.4	41	71.9	37	64.9	113	66.1	
No	22	38.6	16	28.1	20	35.1	58	33.9	
(B) Type of flock fattened:									2.286^{NS}
Older female	2	5.7	3	7.3	5	13.5	10	8.8	
Castrated male	33	94.3	38	92.7	32	86.5	103	91.2	
(C) Castration practices:									6.235^{*}
Yes	42	73.7	50	87.7	51	89.5	143	83.6	
No	15	26.3	7	12.3	6	10.5	28	16.4	
(D) Reason for castration:									10.616^{*}
Improve fattening	41	97.6	38	74.0	39	76.5	118	81.8	
control breeding	1	2.4	9	18.0	7	13.7	17	11.9	
Better temperament	0	0.0	4	8.0	5	9.8	9	6.3	
(E) Method of castration:									6.843^{*}
Modern	6	14.3	9	18.0	18	35.3	33	23.1	
Traditional	36	85.7	41	82.0	33	64.7	110	76.9	
(F) Age of castration:									6.016^{*}
6- 12 months	9	21.4	20	40.0	23	45.1	52	36.4	
> 12months	33	78.6	30	60.0	28	54.9	91	63.6	
(H) **Supplementation to castrated buck:**									NS
Yes	42	100	50	100	51	100	143	100	
No	-	-	-	-	-	-	-	-	

Method of castration practiced by goat keepers in the study area were both traditional (repeatedly crushing the cord) and modern method. In the present study majority of respondent (76.9% overall agro-ecologies) used traditional method of castration. This was in agreement with the report of Hulunim (2014) who reported that above 50% of respondents in Bati, Borena and Short Eared Somali goat populations of Ethiopia castrate their bucks by traditional method of castration. The study also showed that majority (63.6%) of the farmers in the study area castrated their buck aged greater than one year or 12 months. The present study revealed that all respondent farmers (100%) provided feed supplement to castrated bucks in all agro-ecologies of the study area.

4.6. Farmers Trait Preference and Selection Criteria of Indigenous Goat

4.6.1. Trait Preferences of Farmers

Trait preferences of farmers for breeding of indigenous goat are presented in Table 19. Farmers in the study area prefer body conformation, reproduction rate, adaptability, longevity, disease tolerance and feed shortage tolerance. Hulunim (2014) reported similar finding wherein goat owners across the selected areas were highly interested in body size (conformation), adaptability, and reproduction rate and disease tolerance but were not interested milk yield. The ranking of trait preference in order of descent was body conformation (0.20), reproduction rate (0.17), adaptability (0.16), disease tolerance (0.14), feed shortage tolerance (0.14), coat color (0.12) and longevity (0.07) in highland agro-ecology. Similarly, the sampled respondents in midlands ranked traits in descending order as body conformation (0.21), coat color (0.19), reproduction rate (0.17), feed shortage tolerance (0.17) disease tolerance (0.13), adaptability (0.09) and longevity (0.04). In lowland agro-ecology of the study area body conformation (0.23), coat color (0.21), reproduction rate (0.19), feed shortage tolerance (0.16), disease tolerance (0.12), adaptability (0.07) and longevity (0.02) were ranked 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, 6^{th}, and 7^{th} by the respondents. This indicated that body conformation across all three agro-ecologies of the study area were ranked first for the next generation followed by reproduction rate and adaptability in highland; and coat color and reproduction rate both in midland and lowland. Similarly, the finding of Yaekob *et al*. (2015) reported that body conformation, reproduction rate, and coat color type was the most preferable traits in Northern Omo. The finding of current study was also in line with the

report of Ahmed (2013) who reported as body conformation and coat color is the most preferable trait. Preference of body conformation across all three agro-ecology was mainly associated with meat production (i.e. a goat having high body conformation were expected to produce high amount of meat), and preference of coat color in midland and lowland farmers might be associated with socio-cultural practices and market demand.

Table 19: Farmer's Trait Preference in the Study Area

Trait preference of farmers	Agro ecology											
	High land				Mid land				Low land			
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index
Body conformation	16	9	3	0.20	15	9	9	0.21	17	13	0	0.23
Reproduction rate	10	6	17	0.17	14	6	5	0.17	5	13	23	0.19
Adaptability	7	10	13	0.16	3	9	5	0.09	3	5	6	0.07
Disease tolerance	9	8	4	0.14	8	6	9	0.13	5	9	8	0.12
Feed shortage tolerance	10	5	7	0.14	7	11	14	0.17	10	6	12	0.16
Coat color	5	11	5	0.12	10	16	3	0.19	17	11	0	0.21
Longevity	0	8	8	0.07	0	0	12	0.04	0	0	8	0.02

4.6.2. Selection Criteria of Breeding Bucks/ Does

Selection criteria for breeding doe and breeding buck are presented in Table 20. In the present study respondent farmers ranked appearance, color and litter size as first (with index value 0.32, 0.33 and 0.34 in highland, midland and lowland, respectively), second (with index value 0.27, 0.30 and 0.29 in highland, midland and lowland, respectively) and third (with index value 0.23, 0.20 and 0.20 in highland, midland and lowland, respectively) criteria, respectively, for doe selection. The findings were in agreement with the report of Belete (2013) who reported that selection criteria for breeding does in Bale zone of Oromia region include appearance and color (used as first and second criteria). The respondent farmers also considered family history, Age at first kidding, kidding interval and adaptability for selecting breeding doe with relatively low index value.

The respondent farmers ranked appearance (0.40 and 0.40) and color (0.37 and 0.30) as the first and second criteria in highland and midland agro-ecology, respectively, for buck selection. However, in lowland colour (0.34) and appearance (0.33) were ranked as first and second criteria for buck selection. The present study was in line with the result of Yadeta (2016) who reported that in all the three agro-ecologies appearances was the primary selection criterion for breeding buck for the next generation. Family history was selected as the 3rd criteria, with an index value of 0.12, 0.15 and 0.18 in highland, midland and lowland, respectively, for selection of breeding buck. This was in agreement with the study of Belete, (2013) who reported that family history was selected as the 3rd criteria in MadaWalabu and Sawena district.

Appearance or body size was the primary selected criteria for both breeding buck and doe, and the possible reason might be that body size was an important economic trait that influenced market price, particularly in the traditional markets of Ethiopia. The primary selected criteria for body size in the present study was in agreement with the report of Yadeta (2016) who reported that body size is the primary selected criteria and carcass output was strongly correlated with body size. The current study indicated that overall attention was focused on observable traits, like body size, coat color compared to production and reproduction traits in selecting breeding does. The possible reason for this may be due to lack of weighing balances during buying / selling and thus use observable traits. However absence of animal recording in Ethiopia seems to be an important impediment in improving goat productivity. Accordingly an efficient but economical animal recording system needs to be designed for Ethiopian farming conditions.

Table 20: Selection Criteria for Breeding Doe and Buck

Variables	Agro ecology											
	High land				Mid land				Low land			
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index
(A) Selection criteria for breeding doe:												
Color	20	17	0	0.27	21	18	3	0.30	17	20	9	0.29
Appearance	22	21	0	0.32	19	26	3	0.33	25	20	1	0.34
Family history	0	0	14	0.04	0	0	15	0.04	0	5	13	0.07
Age at first kidding	0	0	6	0.02	2	2	5	0.04	0	0	6	0.02
Kidding Interval	0	1	14	0.05	0	0	6	0.02	1	1	2	0.02
Litter Size	15	12	11	0.23	14	5	17	0.20	12	9	14	0.20
Adaptability	0	6	12	0.07	1	6	8	0.07	2	2	12	0.06
(B) Selection criteria for breeding buck:												
Color	21	27	10	0.37	9	34	9	0.30	14	31	12	0.34
Appearance	28	23	7	0.40	37	12	2	0.40	27	15	3	0.33
Family history	4	0	29	0.12	6	3	29	0.15	7	5	27	0.17
Libido	0	2	5	0.03	2	1	11	0.06	3	2	8	0.06
Adaptability	4	5	6	0.08	3	7	6	0.08	6	4	7	0.10

4.7. Major Constraints of Goat Production in the Study Area

Despite their value to society as a source of saving, meat, income and manure, goat production were faced by different constraints; and the identification these constraints for goat production is a prerequisite to improve productivity of goat. Accordingly, the major constraints that affect goat production system as reported by the respondents in the study area were presented in Table 21. The occurrence of diseases in the study area was ranked as first

constraint for goat production across all agro-ecologies with an index value of 0.36, 0.37 and 0.34 in highland, midland and lowland, respectively. Yadeta (2016) also identified diseases as first constraint in goat production in all three agro-ecology of west showa. The current finding was also in agreement with the report of Belete (2013) who reported that diseases were serious problem and had a significant impact on the performance of goat with an index value of 0.34, 0.27 and 0.30 for MadaWalabu, Sawena and Rayitu districts, respectively.

Feed shortage and predator were identified as other major constraints, ranked as second and third by respondents, for goat production in all agro-ecology with an index value of 0.34, 0.27 and 0.23 (for feed shortage) and 0.12, 0.13 and 0.19 (for predator) in highland, midland and lowland agro-ecology of the study area, respectively. But the degree of feed shortage in the high land area is higher than midland and lowland. This may be due to shrinking of grazing land due to increasing human population, expansion of urban areas and increased cropping. Farmers also complained that due to climate variability, there is no regular rainfall which aggravated feed shortage and increased infestation of grazing land with pest and insects. The present finding with regard to feed shortage and predator were in disagreement with Ahmed (2013) who reported that primarily predator and feed shortage are the major constraints for goat production across all districts of Horro Guduru Wollega. The other constraints listed by interviewers for goat production included lack of labor, Lack of improve breed, water shortage, market problem and drought with their order of importance.

Table 21: Major Constraint of Goat Production

Major constraint	Agro ecology											
	High land				Mid land				Low land			
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index
Disease	16	29	12	0.35	30	16	4	0.37	30	11	5	0.34
Feed shortage	27	12	10	0.34	17	16	9	0.27	14	16	5	0.23
Predator	5	9	8	0.12	7	6	10	0.13	11	11	10	0.19
Lack of labor	6	3	6	0.09	2	2	11	0.06	0	3	5	0.03
Lack of improve breed	2	2	5	0.04	0	2	11	0.04	0	0	11	0.03
Water shortage	0	0	10	0.03	1	13	9	0.11	0	13	10	0.11
Market problem	1	0	1	0.01	0	2	0	0.01	2	1	6	0.04
Drought	0	0	3	0.01	0	0	4	0.01	0	2	5	0.03

4.8. Major Disease and Veterinary Service of the Study Area

Healthy animals which have normal physiological function and structure might produce maximum product of their potential. The major diseases reported by the respondents in the study area were Pasteurellosis, FMD, anthrax, diarrhea, shoat pox, internal and external parasites in order of their importance are presented in Table 22. The prevalence of disease was somewhat different across the three agro-ecologies of the study area. Among these listed major disease: Pasteurellosis, FMD, diarrhea and anthrax were the most frequently occurring disease with an index value of 0.24, 0.20, 0.19, and 0.15, respectively in highland; and 0.20, 0.18, 0.17 and 0.17, respectively, in midland whereas in lowland internal and external parasites (0.22), shoat-pox (0.22), FMD (0.17), and anthrax (0.16) were occurring frequently in order of importance. This study was similar with the report of Bekalu (2014) in West Gojjam Zone where Pasteurellosis were the most commonly affecting diseases of goats and causing most losses. The great production loss caused by disease problems could be due to climatic condition of the study area, which might aggravate the prevalence of disease and poor nutrition for goats. Key informants, during group discussion in the study area, reported

that most of the farmers were using modern drugs from government clinics, and some other farmers used traditional mode of treatments.

Table 22: Major Disease of Goat Production System

Major disease	Agro ecology											
	High land				Mid land				Low land			
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index
Pasteurellosis	23	4	3	0.24	13	4	22	0.20	6	2	7	0.08
FMD	11	10	15	0.20	13	8	8	0.18	11	8	14	0.17
Anthrax	5	11	16	0.15	5	14	14	0.17	4	17	10	0.16
Diarrhea	12	10	8	0.19	11	12	2	0.17	0	18	8	0.13
Shoat pox	2	16	1	0.11	4	8	4	0.09	18	7	7	0.22
Internal and external parasite	4	6	14	0.11	11	11	7	0.18	18	5	11	0.22

The status of veterinary services (Table 23) showed that majority of respondent (94.7% in highland and 91.2% in midland and 56.1% in lowland) farmers take sick goat to veterinary service. In addition to taking sick goat to veterinary service, a small proportion of farmers treat their sick goat by local traders using different traditional knowledge in all agro-ecology; this is in line with Bekalu (2014) which showed that farmers treat their sick goat by a means of traditional methods in West Gojjam Zone.

The respondents stated that all (100%) of farmers get veterinary service for their goat population in the study area. Out of the total majority (60.8%) of the goat owners get their veterinary service from government veterinary services and the rest 28.7 and 10.5% get it from private and both government and private veterinary services.

Table 23: Status of Veterinary Services

Variables	Agro ecology								X^2value
	Highland		Midland		Lowland		Overall		
	N	%	N	%	N	%	N	%	
(A) What would you do when your goat is sick?									36.586*
Sales immediately	0	0.0	2	3.5	2	3.5	4	2.3	
Slaughter immediately	1	1.8	2	3.5	15	26.3	18	10.5	
Takes to veterinary center	54	94.7	52	91.2	32	56.1	138	80.7	
Treat with treatments from local traders	2	3.5	1	1.8	8	14.0	11	6.4	
(B) **Do you have access veterinary service?**									NS
Yes	57	100.0	57	100.0	57	100.0	171	100.0	
(C) If yes, what type of service?									12.551*
Government	28	49.1	35	61.4	41	71.9	104	60.8	
Private	19	33.3	14	24.6	16	28.1	49	28.7	
Government and private	10	17.5	8	14.0	0	0.0	18	10.5	
(D) Distance to veterinary service facility:									14.240*
<5km	36	63.2	26	45.6	16	28.1	78	45.6	
6-10km	13	22.8	19	33.3	24	42.1	56	32.7	
>10km	8	14.0	12	21.1	17	29.8	37	21.6	

Regarding the distance of veterinary service facility, 45.6% of the farmers travelled not more than 5 km with their goats to get veterinary services while 32.7% of them travelled 6 to10 km to get veterinary services. The remaining 21.6% of farmers can accesses veterinary services by moving greater than 10 km. This leads to death of many goats before getting the service especially in lowland agro-ecology of the study area. This was in line with Ahmed (2013) wherein majority (65.02%) and (39.87%) of the farmers in the study area accessed to only government veterinary clinics and travelled 1 to 5 km with their goats to get veterinary service, respectively.

4.9. Reproductive Problems of the Study Area

Major reproductive problems of goats in the study area are presented in Table 24. In the study area, breeding problems frequently observed were Abortion, kid mortality, repeat breeding and low growth rate, ranked as first four breeding problems with an index value 0.22, 0.20, 0.15, and 0.14 in highland, respectively; and 0.24, 0.20, 0.15, and 0.12 in midland, respectively. In lowland agro-ecology of the study area kid mortality and abortion were ranked the first followed by low growth rate and repeat breeding with an index value of 0.23, 0.18, 0.18 and 0.15, respectively. Discussion with key informants in the study area showed that abortion, kid mortality, repeated breeding and low growth rate were the serious problem of goat production in the study area. The current finding was in agreement with Belete (2013) who reported that abortion and kid mortality were serious problem of goat production. Late at first kidding, long kidding interval and Dystocia were also reported as reproductive problem in the study area with low index value in all agro-ecology.

Table 24: Reproductive problem of goat production

Major reproductive problem	Agro ecology											
	High land				Mid land				Low land			
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index
Abortion	16	11	6	0.22	18	11	8	0.24	13	8	8	0.18
Kid mortality	12	13	6	0.20	12	12	9	0.20	14	17	2	0.23
Repeat breeding	11	8	4	0.15	11	5	8	0.15	6	12	10	0.15
Low growth rate	8	6	12	0.14	9	4	5	0.12	11	7	14	0.18
Late at first kidding	6	3	13	0.11	0	12	13	0.11	5	8	8	0.11
Long kidding interval	0	10	14	0.10	2	8	13	0.10	3	2	12	0.07
Dystocia	4	6	2	0.08	5	6	1	0.08	5	3	3	0.07

4.10. Reproductive Performances of Indigenous Goat

The average reproductive performances of goats as reported by the respondents are presented in Table 25. There was a significant difference between goats in all agro-ecology for all studied traits of reproductive performance except kidding interval. The Lowland goats showed overall better performance for all studied traits which was in line with the report of

Yadeta (2016) who reported that the lowland goat have better performance than the rest two (highland and midland) goat and this may possibly be due to better environmental conditions, namely sufficient availability of feed / fodder including browsing forage, suitable climate for goat production and high genetic potential of lowland goats compared to the two agro-ecologies.

4.10.1. Age at Sexual Maturity of Males (ASMM)

The age at sexual maturity of males showed significant differences between goats of highland and lowland area whereas goats of midland showed non-significant difference with both lowland and highland. The ages at sexual maturity of males were 7.78, 7.46 and 7.09 months in highland, midland and lowland, respectively; and the overall mean of age at sexual maturity of males was 7.44 months. The current findings were lower than the results reported by Solomon (2014) who reported age at sexual maturity of male of 12.3 months for Abergele goat of Tigray region; results of 7.4 months reported by the same author for western lowland goat; but slightly higher than 7.04 months reported by Bekalu (2014) for west Gojjam zone of Amhara region.

4.10.2. Age at Sexual Maturity in Females (ASMF)

The age at sexual maturity of female goat (Table 25) showed that a significant difference between highland and lowland area whereas goats of midland showed non-significant difference with both lowland and highland. The age at sexual maturity of female were 8.18, 7.86 and 7.61 months in highland, midland and lowland, respectively; and the overall mean of age at sexual maturity of females was 7.88 months. Belete (2013) reported relatively comparable result with the current result for ASM of female (8.2, 8.1 and 7.5 months) for MadaWalabu, Sawena and Rayitu districts, respectively, of Bale zone of Oromia region. On the contrary, the current result dis-agreed with the report of Jainudeen*et al.* (2000) who reported that puberty in small ruminants reached at the age of 4–6 months. The current finding was higher than the report of Ahmed (2013) who reported the ASM of female was 7.11 months.

The age at first sexual maturity may be affected by agro-ecology, weaning season and nutrition and thus through good management age at first sexual maturity could be substantially improved. The time taken for female and male goats to reach maturity varies based on genotype, nutrition, season and other environmental factors (Girma, 2008).

Table 25: Reproductive Performance of Goat in the Study Area

Traits	High land	Mid land	Lowland	overall	p-value
	Means	Mean±SE	Mean±SE	Mean±SE	
ASM of male (months)	7.78^{a}±0.12	7.46^{ab}±0.14	7.09^{b}±0.12	7.44±0.08	0.001
ASM of female (months)	8.18^{a}±0.11	7.86^{ab}±0.14	7.61^{b}±0.13	7.88±.008	0.010
AFK (months)	13.18^{a}±0.11	12.86^{ab}±0.14	12.61^{b}±0.13	12.88±0.08	0.010
Kidding Interval (months)	8.42±0.10	8.21±0.11	8.09±0.13	8.24±0.07	0.114
Litter Size	1.56^{b}±0.08	1.58^{b}±0.07	1.81^{a}±0.09	1.65±0.05	0.050
Average reproductive lifetime (Years)	6.72^{b}±0.12	6.84^{b}±0.12	7.54^{a}±0.11	7.04±0.11	0.004
Average number of kids/doe's life time	11.39^{b}±0.59	12.32^{b}±0.58	14.18^{a}±0.48	12.63±0.33	0.002

$^{a, b}$, means on the same row with different superscripts (for mean ±SD) are (*)significantly different (P<0.05), NS=(p>0.05)

4.10.3. Age at First Kidding (AFK)

AFK is used to indicate the overall productivity of goat flock. The differences in AFK were found to be statistically significant (Table 25) across the three agro ecology of the study area. The AFK between highland and lowland goats were significant. The AFK of current study was 13.18, 12.86 and 12.61 months in highland, midland and lowland, respectively. The overall mean for AFK for indigenous goat in the study area were 12.88 months. The differences in AFK of different agro ecology indicated that AFK were highly dependent on agro-ecology due to differences in environmental conditions, availability of quality/quantity of feed. Similarly different AFK for different agro-ecology was reported for indigenous goat (15.33, 13.82 and 13.60 month in highland, midland and lowland agro-ecology of west

showa) by Yadeta (2016). The overall mean for AFK of 12.88 months for indigenous goat, in the present study, was relatively similar with the result of Getahun (2008) for Adilo (12.9 months); and Ahmed (2013) for Horro Guduru Wollega goat were (12.5 and 12.11 months). On the contrary results of Dadi*et al.* (2008) for Arsi-Bale goats (28 months); Belete (2009) for Keffa (20.15); Bekalu (2014) for western highland (13.54 months); and Hulunim (2014) for short earned Somali (28 months), were greater than the current result.

4.10.3. Kidding Interval (KI)

Kidding interval is the interval between two consecutive parturitions that determines reproductive efficiency in goat production. There were non-significant differences among agro-ecology on kidding interval. The average kidding interval of highland, midland, and lowland agro-ecology were 8.42, 8.21 and 8.09 months, respectively, with overall mean KI of 8.24 months which was in agreement with Bekalu (2014) who reported that KI of indigenous goat in west Gojjam was 8.39 months. On the contrary the current finding was higher than the result of Solomon (2014) and Ahmed (2013), who reported kidding interval of 6.3 and 5.76 months for western lowland goat and indigenous goat in Horro Guduru Wollega, respectively. According to Getahun (2008) indigenous goat can reproduce three times in two years with 8 months of kidding interval and thus goats in the study area can produce three times in two years. This could be reflecting that the breed in the study area can produce three kids in two years.

4.10.4. Litter Size

Litter size is defined as the number of progenies born per parturition. The differences in LS were found to be statistically significant (Table 25) among the three agro-ecologies except highland with midland agro-ecology of the study area. The average mean of LS reported by the respondents were 1.56, 1.58 and 1.81 in highland, midland, and lowland agro-ecology, respectively, with overall LS of 1.65, in the present study. The LS of lowland goat were significantly higher than the other two agro-ecologies; and this implied that lowland goat was the most prolific goat as compared to highland and midland goat. The current finding was higher than the finding of Yadeta (2016) who reported that the litter size of goats was 1.25, 1.32 and 1.21 in highland, midland, and lowland agro-ecology of west showa zone,

respectively; and LS of 1.21 in the central highlands of Ethiopian (FARM-Africa, 1996). The overall mean of LS in the study area was reported 1.65 and this result was relatively lower than the reported (1.77) of Ahmed (2013) for indigeneous goat in Horro Guduru wollega zone.

4.10.5 Average Reproductive Life Time and Average Number of Kids/Doe's Life Time

It was stressed that long term reproductive performance (long living, high fertility, ability to produce more offspring) of dams should be given more importance in selection programs (Zewdu, 2008). The average reproductive life span of highland, midland and lowland does were 6.72±0.12, 6.84±0.12 and 7.54±0.11 years, respectively. The overall mean of reproductive life time of goat in the study area as reported by the respondents were 7.04 years. This was in agreement with the finding of Bekalu (2014) who reported that the reproductive life time of indigenous goat in west Gojjam zone of Amhara region were 7.47 years. The difference in reproductive life span between highland-lowland and midland-lowland was non-significant. The variations in the reproductive life span of female goats were significant due to agro-ecology. This result was in line with the report of Yadeta (2016) who reported that reproductive life time of goat is strongly affected by agro-ecology.

The average number of kids/doe's life time, as reported by respondent farmers, showed significant differences among agro-ecologies. The pair wise comparisons further showed significant differences among highland-lowland and midland-lowland. The results showed that on an average a doe can produce 11.39±0.59, 12.32±0.58 and 14.18±0.48 kids in highland, midland and lowland agro-ecology of the study area in her life time. This indicated that doe in lowland agro-ecology can produce large number of kids than the rest two agro-ecology of south Gondar zone and it is directly related to LS, reproductive life time and other related factors. Without any argument average number of kids/doe's life time is very important trait to improve goat productivity and profitability. This will provide a base for selection of better replacement stock.

4.11. Phenotypic Characterization

4.11.1. Qualitative traits

The phenotypic characterization of goat breed includes all the qualitative description and morphological measurements of the animal. The participatory descriptions of qualitative characters for both female and male goats found in highland, midland and lowland agro-ecologies are presented in Table 26. The qualitative traits observed in the study area were significantly different across the agro-ecologies except the hair type, horn, head profile, ruff, wattle, back profile and rump profile.

(I(Coat Colour Pattern and Type:

The most frequent coat color patterns observed in the study area were Plain, Patchy and Spotted (55.9%, 22.9 % and 14.3% respectively) and this was in agreement with Belay and Meseretu (2017) and Bekalu (2014) who reported that the most frequent color patterns observed were Plain (65.73%), Patchy (22.47 %) and Spotted (11.8%); and patchy (44.5%), plain (42.83%) and spotted (12.67%) across three agro-ecology of Gamo-Gofa zone and three district of west Gojjam, respectively. The dominant coat color pattern (51.7%, 50.7% and 65.2% in highland, midland and lowland, respectively) mostly observed in the study area was plain (uniform) which was in agreement with the report of Ahmed (2013) who reported that the most observed coat color pattern in all the study districts was plain/uniform (75.49% in Guduru, 63.24% in Amuru and 55.88% in Horro) in Horro Guduru Wollega. On the contrary, Halima *et al.* (2012) reported that the most frequently observed coat color pattern in Ethiopian indigenous goat population were spotted (36.1 %) followed by patchy (32.4 %) and plain (30.4 %) of various colors.

The studied population has a diversified coat color. Of the eight observed coat color, white with red (22.9%), White (22.7%) and red (16.1%) color were the most frequent coat colors. The dominant coat color types mostly observed in the study area were white with red, white and red (28.4, 20.9 and 15.4) in highland and (23.9, 17.4 and 12.9%) in midland whereas in lowland white, red and white with red (29.9, 19.9 and 16.4%) were observed respectively. Generally, in south Gondar zone red with white coat color type was the most dominant coat color type in highland and midland where as in lowland agro-ecology of the study area white

coat color type was the most dominant one. The overall most frequent coat color type in the study area (white with red 22.9%; white 22.7; and red 16.1%) was in disagreement with Hulunim (2014) who reported that white (36.27), white with black (21.24%) and white with light brown (20.21) were the most frequent coat color type of Bati, Borena and Short Eared Somali goat and Bekalu (2014) who reported that Brown/fawn (23.33%) and white (22.83%) coat color type was mostly observed in west Gojjam. In the present study gray, brown, black, white with black and red with black coat color type were also observed but in small proportion in highland, midland and lowland agro-ecology which indicated that goat populations found in the study area have a wide range of coat colors types. The representative coat colour type of goat population across the three agro-ecologies showed in Figure 3.

(ii) Hair Length and Type

The length of hair was significantly different in agro-ecology while hair types of goat population were not significant different as presented Table 26. Majority of goat population in highland, midland and lowland agro-ecology of the study area had short hair accounting 53.7%, 67.7% and 86.1% respectively, which was in agreement with Ahmed (2013) and Alemu (2014) who reported that majority of goat population had short hair in all selected districts of Horro Guduru Wollega zone and Shabelle zone respectively. In a small proportion of goat population across three agro-ecologies were also observed medium hair followed by long hair accounting (34.3%, 22.9% and, 8.0%) and (11.9%, 9.5% and 6.0%) in highland, midland and lowland respectively.

Regarding hair coat type as presented in table 26, majority of goat population (76.6%, 77.1% and 82.1) in highland, midland and lowland agro-ecology were smooth hair type with the overall 78.6%; which was in agreement with Alemu (2014) who reported that smooth hair type was the most dominant (99.48%) hair cot type of goat in Shabelle zone.

(iii) Horn Shape and Orientation

The majority of sampled goat populations in the study area were found to be horned (98.5%, 98.0%, and 97.0% in highland, midland and lowland, respectively). The overall figures showed that 97.8% of sample goat populations were horned and the rest 2.2% sample goat populations were spiral. In the study area different horn shapes (straight, curved and spiral)

and orientations (Obliquely and backward) were observed for sampled goat populations. The majority of goat population had curved and straight in highland (58.1and 36.4%) and lowland (52.3 and 46.7%) areas where as in midland straight and curved (47.7 and 45.5%) horn shape was most frequently observed. Spiral horn shape was also observed across all agro-ecology of the study area in varied frequencies.

Two types of horn orientation (Obliquely and backward) were observed in the present study across all agro-ecologies. The backward horn orientation was more numerous in all three agro-ecologies. The overall results showed that 56.4% and 43.6% of goat had backward and oblique horn orientation. This result was comparable with the report of Bekalu (2014) who reported majority of sampled goat population in west Gojjam were horned (85.67%) with back ward horn orientation (65.5%).

(iv) Ear Orientation

In the present study three types of ear orientations (Erect, semi-pendulous and horizontal) were observed. However, semi-pendulous ear orientation followed by horizontal ear orientation was the most frequently observed in midland (39.8 and 38.6%) and lowland (42.4 and 38.8%) of the sampled population respectively, whereas in highland horizontal ear orientation followed by Semi-pendulous ear orientation was the most frequent accounting for 52.7 and 39.4%, respectively. A small proportion of goat had erect hair orientation in the three agro-ecologies. Even if ear orientation across the three agro-ecologies was different, the overall results showed that ear orientations were horizontal (43.4%) followed by semi-pendulous (37.3%) and erect (19.2%) in the study area. The current finding was in disagreement with the report of Tsigabu (2015) who reported that pendulous ear orientation was the most frequent observed in Nuer zone of Gambella people regional state.

(iv) Head Profile

In the present study three types of head profile (concave, straight and convex) were observed. However, concave head profile followed by straight head profile was the most frequently observed in highland (61.7 and 39.3%), midland (62.7 and 36.3%) and lowland (64.2 and 33.8%) which was in agreement with Farm Africa (1996) majority of Western Highland goat had concave facial profile. A small proportion of goat had convex head profile in the midland

(1%) and lowland (1.5%) areas. In overall only 0.8% of goat population in the study area was convex head profile. The current finding was in disagreement with the report of Belay and Meseretu (2017) who reported that straight head profile followed by concave head profile was the most frequent observed in Gamo-Gofa Zone of South Western Ethiopia.

(v) Toggle, Beard, Ruff and Wattle

In the present study, the goat population, across all agro-ecologies, showed presence of toggle (18.4%), beard (34.5%), ruff (10.6%) and wattle (9.5%). The remaining 81.6%, 65.5%, 89.4% and 90.5% of goat population across three agro-ecologies of the study area were absence of toggle, beard, ruff and wattle which was in agreement with Belete (2014) and Alemu (2015) who reported that majority of indigenous goat population in Bale were absence of toggle, beard and ruff.

(vi) Back and Rump Profile

In the study area different back profile (straight, slop up to the rump and dipped) and rump profile (flat and sloppy) were observed in sampled goat populations. The most population of sample goat was described with straight back profile (74.5%) and sloppy rump profile (76.6%), which was in agreement with Ahmed (2013) who reported that straight back profile and slopping rump profile was the most dominantly observed back and rump profile in Horro Guduru Wollega zone of Oromia region Ethiopia. Similarly Bekalu (2014) reported that the dominant back profile was straight back profile in west Gojjam zone of Amhara region.

Table 26: qualitative traits of sampled goat population in the study area

Character and level	Highland						Midland						Lowland						Overall	
	Male		Female		Total		Male		Female		Total		Male		Female		Total			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Coat color pattern:																				
Plain	10	47.6	94	52.2	104	51.7	10	47.6	92	51.1	102	50.7	12	57.1	119	66.1	131	65.2	337	55.9
Patchy	8	38.1	57	31.7	65	32.3	6	28.6	57	31.7	63	31.3	6	28.6	46	25.6	52	25.9	180	29.9
Spotted	3	14.3	29	16.1	32	15.9	5	23.8	31	17.2	36	17.9	3	14.3	15	8.3	18	9.0	86	14.3
X^2value																			**12.537***	
Coat color type:																				
White	2	9.5	40	22.2	42	20.9	4	19.0	31	17.2	35	17.4	6	28.6	54	30.0	60	29.9	137	22.7
Red	4	19.0	27	15.0	31	15.4	2	9.5	24	13.3	26	12.9	4	19.0	36	20.0	40	19.9	97	16.1
Black	0	0.0	17	9.4	17	8.5	2	9.5	17	9.4	19	9.5	0	0.0	11	6.1	11	5.5	47	7.8
Brown	4	19.0	9	5.5	13	6.5	2	9.5	19	10.6	21	10.4	2	9.5	18	10.0	20	10.0	54	9.0
Gray	1	4.8	18	10.0	19	9.5	2	9.5	21	11.7	23	11.4	3	14.3	11	6.1	14	7.0	56	9.3
Red +black	1	4.8	12	6.7	13	6.5	2	9.5	10	5.6	12	6.0	0	0	5	2.8	5	2.5	30	5.0
Red +white	9	42.9	48	26.7	57	28.4	4	19.0	44	24.4	48	23.9	5	23.8	28	15.6	33	16.4	138	22.9
Black +white	0	0.0	9	5.0	9	4.5	3	14.3	14	7.8	17	8.5	1	4.8	17	9.4	18	9.0	44	7.3
X^2value																			**30.410***	
Hair length:																				
Short	9	42.9	99	55.0	108	53.7	12	57.1	124	68.9	136	67.7	16	76.2	157	87.2	173	86.1	417	69.2
Medium	7	33.3	62	34.4	69	34.3	5	3.8	41	22.8	46	22.9	3	14.3	13	7.2	16	8.0	131	21.7
Large	5	23.8	19	10.6	24	11.9	4	19.0	15	8.3	19	9.5	2	9.5	10	5.6	12	6.0	55	9.1
X^2value																			**40.406***	
Hair type:																				
Smooth	16	76.2	138	76.7	154	76.6	16	76.2	139	77.2	155	77.1	17	81.0	148	82.2	165	82.1	474	78.6
Glossy	5	23.8	42	23.3	47	23.4	5	23.8	41	22.8	46	22.9	4	19.0	32	17.8	36	17.9	129	21.4
X^2value																			**2.189^{NS}**	

Table 26 (continued)

Character and level	Highland						Midland						Lowland						Overall	
	Male		Female		Total		Male		Female		Total		Male		Female		Total			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Horn:																				
Present	21	100	177	98.3	198	98.5	21	100	176	97.8	197	98.0	21	100	174	96.7	195	97.0	590	97.8
Absent	0	0.0	3	1.7	3	1.5	0	0.0	4	2.2	4	2.0	0	0.0	6	3.3	6	3.0	13	2.2
X^2 value																			**1.101^{NS}**	
Horn shape:																				
Straight	8	38.1	64	36.2	72	36.4	9	42.9	85	48.3	94	47.7	12	57.1	79	45.4	91	46.7	257	43.6
Curved	12	57.1	103	58.2	115	58.1	11	52.4	79	44.9	90	45.5	8	38.1	94	54.0	102	52.3	307	52.0
Spiral	1	4.8	10	5.6	11	5.6	1	4.8	12	6.8	13	6.6	1	4.8	1	0.6	2	1.0	26	4.4
X^2 value																			**14.287***	
Horn orientation:																				
Obliquely	13	61.9	80	45.20	93	47.0	9	42.9	80	45.5	89	45.2	12	57.1	63	36.2	75	38.5	257	43.6
Back-ward	8	38.1	97	54.80	105	53.0	12	57.1	96	54.5	108	54.8	9	42.9	111	63.8	120	61.0	333	56.4
X^2 value																			**3.283^{NS}**	
Ear orientation:																				
Erect	2	9.5	34	18.9	36	17.9	5	23.8	38	21.1	43	21.4	3	14.3	34	18.9	37	18.4	116	19.2
Pendul-ous	6	28.6	53	29.4	59	39.4	11	52.4	69	38.3	80	39.8	12	57.1	74	41.1	76	42.4	225	37.3
Horizon-tally	13	61.9	93	51.7	106	52.7	5	23.8	73	40.6	78	38.6	6	28.6	72	40.0	78	38.8	262	43.4
X^2 value																			**12.086***	
Head profile:																				
Straight	9	42.9	70	38.9	79	39.3	10	47.6	63	35.0	73	36.3	4	19.0	64	35.6	68	33.8	220	36.5
Concave	12	57.1	110	61.1	122	61.7	11	52.4	115	63.9	126	62.7	17	81.0	113	62.8	130	64.7	378	62.7
Convex	0	0.0	0	0.0	0	0.0	0	0.0	2	1.1	2	1.0	0	0.0	3	1.7	3	1.5	5	0.8
X^2 value																			**3.881^{NS}**	
Toggle:																				
Present	2	9.5	43	23.9	45	22.4	3	14.3	45	25.0	48	23.9	2	9.5	16	8.9	18	9.0	111	18.4
Absent	19	90.5	137	76.1	156	77.6	18	85.7	135	75.0	153	76.1	19	90.5	164	91.1	183	91.0	492	81.6
X^2 value																			**18.086***	

Table 26 (continued)

Character and level	Highland						Midland						Lowland						Overall	
	Male		Female		Total		Male		Female		Total		Male		Female		Total			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Beard:																				
Present	11	52.4	63	35.0	74	36.8	12	57.1	76	42.2	88	43.8	14	66.7	32	17.8	46	22.9	208	34.5
Absent	10	47.6	117	65.0	127	63.2	9	42.9	104	57.8	113	56.2	7	33.3	148	82.2	155	77.1	395	65.5
X^2 value																			**20.139***	
Ruff:																				
Present	12	57.1	8	4.4	20	10.0	13	61.9	7	3.9	20	10.0	14	66.7	10	5.6	24	11.9	64	10.6
Absent	9	42.9	172	95.6	181	90.0	8	38.1	173	96.1	181	90.0	7	33.3	170	94.4	177	88.1	539	89.4
X^2 value																			**0.559^{NS}**	
Wattle:																				
Present	6	28.6	15	8.3	21	10.4	4	19.0	12	6.7	16	8.0	6	28.6	14	7.8	20	10.0	57	9.5
Absent	15	71.4	165	91.7	180	89.6	17	81.0	168	93.3	185	92.0	15	71.4	166	92.2	181	90.0	546	90.5
X^2 value																			**0.814^{NS}**	
Back profile:																				
Straight	19	90.5	127	70.6	146	72.6	17	81.0	139	72.2	156	77.6	15	71.4	132	73.3	147	73.1	449	74.5
Slops up to rump	2	9.5	47	26.11	49	24.4	4	19.0	37	20.6	41	20.4	6	28.6	39	21.7	45	22.4	135	22.4
Dipped	0	0.0	6	3.3	6	3.0	0	0.0	4	2.2	4	2.0	0	0.0	9	5.0	9	4.5	19	3.2
X^2 value																			**3.116^{NS}**	
Rump profile:																				
Flat	5	23.8	38	21.1	43	21.4	6	28.6	42	23.3	48	23.9	4	19.0	46	25.6	50	24.9	141	23.4
Sloping	16	76.2	142	78.9	158	78.6	15	71.4	138	76.7	154	76.1	17	81.0	134	74.4	151	75.1	462	76.6
X^2 value																			**0.722^{NS}**	

Sample Female goat in highland

Sample male goat in highland

Sample Female goat in midland

Sample male goat in midland

Sample female goat in lowland

Sample male goat in lowland

Figure 3: Sample of Female and Male Goat in The Study Area

4.11.2 Body weight and linear body measurements

The least square ANOVA of body weight (kg) and other linear body measurements are presented in Appendix 3 and least square means ± SE of body weight (kg) and other linear body measurements of goat are presented in Table 27. The importance of body weight and other linear body measurements in breed improving strategies and improve the goat productivity is not doubted. In the study area, overall mean of HG, HW, BL, RH, CD, HL, EL, RW, RL, CBL, CBC, HL, BW and SC were 73.19±0.18cm, 67.30±0.18cm, 60.39±0.18cm, 69.32±0.21cm, 32.09±0.11cm, 12.91±0.18cm, 13.56±0.06cm, 14.74±0.09cm, 11.73±0.12cm, 12.36±0.04cm, 8.38±0.04 cm, 14.92±0.07cm, 28.82±0.17kg and 22.83±0.19cm, respectively. The current finding was comparable with the finding of Bekalu (2013), Yaekob *et al.* (2015) and BelayandMeseretu (2017) indicates that the average body weight, chest girth, height at withers, body length and ear length were 28.03, 74.87 cm, 64.51 cm, 60.19 cm, 13.89 cm for western highland goat in west Gojjam, 26.7 kg, 73.11 cm, 66.65 cm, 58.20 cm, 12.5 cm for Woyto-Guji in Northern Omo, 26.29 kg, 71.17 cm, 64.16 cm, 58.68 cm, 16.16 cm for Woyto-Guji in Bench-Mage zone, respectively.

(i) Effect of Agro-ecology

The effects of agro-ecologies were highly significant ($P < 0.001$) for all quantitative measurements except horn length, rump length, cannon bone length and head length. The present results were in agreement with earlier workers (Solomon, 2014; Yaekob *et al.*, 2015 and Belay and Meseretu, 2017) who reported that the effects of agro-ecologies had significant effect on body measurements in indigenous goat types.The present result is in disagreement with the result of Bekalu (2014), Belete (2013) and Tsigabu (2015) where in body measurements were not affected by location. The lowland goat population showed a significant higher value for all quantitative traits, except horn length, rump width, canon bone circumference and head length, compared to goats' population in midland and highland. Generally lower values were observed in all linear measurements for highland agro-ecology compared to the other two agro-ecologies. This might be due to associated with the temperature difference in different agro-ecologies were lowland goat has higher feed conversion efficiency. On the contrary highland and midland goat's population spent more

energy to generate heat to keep them warm, particularly during colder seasons and this was in line with the report of Belay and Meseretu (2017) who reported that goat populations sampled from lowland area were higher in their linear measurements than highland ones. On the contrary present finding were in disagreement with the report of Yaekob*et al.*(2015) who reported that highland have higher value than the lowland goat population in Woyto-Guji goats. The possible reason for differing values of quantitative traits in the agro-ecologies may be the variation in management, quality/quantity of feeds, climatic conditions and other ecology related factor.

(ii) Effect of Sex

The result revealed that sex is an important source of variation for live body weight and linear body measurements at all age groups. In the study area sex had significant effect on body weight and other linear body measurements except ear length, canon bone length, head length, and rump length. In this study males had higher body weight and other linear body measurements ($p<0.05$) than the corresponding values in females which was in agreement with Farm Africa (1996), reported that most male goat had higher body weight and other linear body measurement than the corresponding value in femalefor western highland goat. This might partly due to hormonal difference, that is, release of androgen in male animals after the testes are well developed (Frandson and Elmer, 1981).

(iii) Effect of Age

Body weight and all body measurements were significantly affected ($p<0.001$) by age. The current finding was in line with Yaekob *et al.*(2015) who reported that the effect of age was highly significant ($p<0.001$) on body weight and all other body measurements across three agro-ecology in Woyto-Guji goat. HG, HW, BL, RH, CD, HL, EL, RW, RL, CBL, CBC, HL, BW and SC increased as the age increased from the youngest (1PPI) to the older (4PPI) age group which was in agreement with Tsigabu (2015) and Yaekob *et al.*(2015) who reported that body weight and other linear body measurement increased with increasing age of goats; and Bekalu (2014) who reported that body weight and other linear body measurement except ear length increased from (1PPI) to (4PPI) age group. The size and shape of the animal increases until the animal reach its maturity and the effect of age on body weight and other

linear body measurements were also observed in different goat breeds of Ethiopia (Yoseph, 2007). This increasing trend with increasing age was due to the growth of goats.

(iv) Effect of Sex by age interaction

The interactions between sex and age groups were also highly significant ($P < 0.05$) on heart girth, height at wither, rump height, chest depth, rump width, cannon bone circumference and live body weight of sampled goat population. In each age group all the parameters considered, males showed significantly (at least $P<0.001$or $p<0.05$) higher measurements than females except, ear length, canon bone length, and head length. The different value of quantitative trait between male and female in different age class is due to hormonal difference between males and females. The value of body weight and other linear body measurements for sampled goat's population increased as age group increased from the youngest 1PPI to the oldest 4PPI for both male and female goats. This was in agreement with Yaekob *et al.* (2015), Alubel (2015) and Bekalu (2014) who reported that the interaction of sex and age group was significant for body weight and all other linear body measurements on Central Highland and Abergelle goat and except ear length, horn length in west Gojjam respectively.

(v) Effect of Sex by agro-ecology interaction

The interactions between sex and agro-ecology were also highly significant ($P < 0.05$) on some quantitative trait such as heart girth, height at wither, body length, rump height, chest depth, cannon bone circumference and live body weight of sampled goat population. In all agro-ecology all quantitative traits showed that males had significantly higher values than females except ear length. The different value of quantitative trait between male and female in different agro-ecology is due to hormonal difference between males and females, as explained above in the interaction sex by age group, together with differences in the management system and agro-ecologies difference. The value for all body measurement for both sex were higher in lowland than the rest two (midland and highland) agro-ecology of the study area except body length for male, cannon bone length for female, ear length, head length and chest depth for both sexes which had higher values in midland.

Table 27: Least Square Means ± SE of Body Weight (Kg) and Other Linear Body Measurements (Cm) By Sex, Age, Agro-Ecology, Interaction of Age by Sex and Sex by Agro-Ecology

Effect and levels	N	HG	WH	BL	RH	CD	HOL	EL
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	603	73.19±0.18	67.30±0.18	60.39±0.18	69.32±0.21	32.09±0.11	12.91±0.18	13.56±0.06
CV%		3.84	4.10	6.71	4.03	6.01	30.10	9.97
R^2		0.62	0.60	0.37	0.59	0.51	0.39	0.21
Agro ecology:		*	*	*	*	*	NS	*
Highland	201	72.73^{b}±0.4	66.85^{b}±0.36	60.57^{b}±0.53	68.86^{b}±0.37	32.79^{b}±0.25	13.20±0.47	$13.09±0.18^{c}$
Midland	201	74.01^{a}±0.3	68.17^{a}±0.32	61.25^{ab}±0.47	70.17^{a}±0.32	33.17^{a}±0.22	13.29±0.41	$13.44±0.16^{b}$
Lowland	201	75.08^{a}±0.3	68.90^{a}±0.32	62.35^{a}±0.47	70.95^{a}±0.33	33.44^{a}±0.23	12.96±0.42	$13.80±0.16^{a}$
Sex:		*	*	*	*	*	*	NS
Male	63	75.57^{a}±0.39	69.51^{a}±0.38	63.17^{a}±0.57	71.53^{a}±0.39	34.79^{a}±0.27	14.11^{a}±0.49	13.39±0.19
Female	540	72.32^{b}±0.12	66.44^{b}±0.12	59.61^{b}±0.18	68.46^{b}±0.12	31.48^{b}±0.09	12.19^{b}±0.16	13.51±0.06
Age:		*	*	*	*	*	*	*
1PPI	121	69.55^{d}±0.33	63.75^{d}±0.32	57.66^{c}±0.47	65.82^{d}±0.32	30.66^{d}±0.22	9.15^{c}±0.42	12.69^{c}±0.16
2PPI	142	72.53^{c}±0.35	66.74^{c}±0.35	59.63^{b}±0.51	68.74^{c}±0.35	31.72^{c}±0.24	11.68^{b}±0.45	13.20^{bc}±0.17
3PPI	144	75.80^{b}±0.43	69.78^{b}±0.42	63.21^{a}±0.62	71.80^{b}±0.43	34.25^{b}±0.29	15.33^{a}±0.54	13.67^{ab}±0.21
4PPI	196	77.88^{a}±0.51	71.61^{a}±0.50	65.06^{a}±0.74	73.662^{a}±0.51	35.89^{a}±0.35	16.43^{a}±0.65	14.20^{a}±0.25

Table 27 (Continued)

Effect and levels	N	HG	WH	BL	RH	CD	HOL	EL
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Sex X age interaction:		*	*	NS	*	*	NS	NS
Male,1PPI	25	71.68^{cd}±0.58	65.88^{cd}±0.57	59.44±0.84	67.93^{cd}±0.58	32.38^{bc}±0.40	9.64±0.74	12.50±0.28
Female,1PPI	96	67.43^{e}±0.29	61.62^{e}±0.28	55.87±0.42	63.70^{e}±0.29	28.94^{e}±0.20	8.67±0.38	12.88±0.14
Male,2PPI	18	74.18^{bc}±0.66	68.41^{bc}±0.65	61.19±0.95	70.41^{bc}±0.66	32.74^{bc}±0.45	12.26±0.83	13.00±0.32
Female,2PPI	124	70.87^{d}±0.25	65.07^{d}±0.25	58.08±0.36	67.07^{d}±0.25	30.70^{d}±0.17	11.09±0.32	13.41±0.12
Male, 3PPI	12	76.73^{ab}±0.82	70.73^{ab}±0.81	64.92±1.19	72.73^{ab}±0.82	35.88^{a}±0.56	17.41±1.04	13.63±0.40
Female,3PPI	132	74.89^{b}±0.24	68.84^{bc}±0.24	61.49±0.35	70.87^{bc}±0.24	32.64^{c}±0.17	13.25±0.31	13.71±0.12
Male, 4PPI	8	79.67^{a}±1.01	73.01^{a}±0.99	67.12±1.46	75.03^{a}±1.00	38.15^{a}±0.69	17.14±1.27	14.38±0.49
Female,4PPI	188	76.08^{b}±0.20	70.22^{b}±0.20	63.00±0.29	72.21^{b}±0.20	33.64^{b}±0.14	15.73±0.26	14.02±0.10
Sex X Agro-ecology:		*	*	*	*	*	NS	NS
Male,highland	21	75.02^{ab}±0.71	68.38^{ab}±0.70	63.09^{a}±1.03	70.40^{ab}±0.71	34.58^{a}±0.49	13.47±0.90	13.18±0.35
Male,midland	21	75.14^{ab}±0.62	69.52^{a}±0.60	63.27^{a}±0.90	71.53^{a}±0.61	34.61^{a}±0.42	14.76±0.78	13.51±0.30
Male, lowland	21	76.55^{a}±0.62	70.62^{a}±0.61	63.14^{a}±0.90	72.65^{a}±0.62	35.17^{a}±0.43	14.10±0.79	13.45±0.30
Fem, highland	180	70.45^{d}±0.21	65.32^{c}±0.21	58.04^{b}±0.31	67.32^{c}±0.21	30.99^{c}±0.15	12.93±0.27	13.01±0.10
Female, midland	180	72.88^{c}±0.22	66.82^{b}±0.21	59.23^{b}±0.31	68.82^{b}±0.22	31.74^{b}±0.15	11.82±0.28	13.37±0.10
Female, lowland	180	73.62^{bc}±0.21	67.17^{b}±0.21	61.55^{a}±0.31	69.25^{b}±0.21	31.70^{b}±0.15	11.82±0.28	14.15±0.10

Table 27 (Continued)

Effect and levels	N	RW	RL	CBL	CBC	HDL	BW	SC
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	603	14.74±0.09	11.73±0.12	12.36±0.04	8.38±0.04	14.92±0.07	28.82±0.17	22.83±0.19
CV%		11.34	23.96	6.78	9.28	9.61	9.42	5.34
R^2		0.27	0.14	0.18	0.26	0.28	0.58	0.83
Agro-ecology:		*	NS	NS	*	NS	*	*
Highland	201	15.97^{a}±0.22	11.43±0.37	12.33±0.11	8.22^{b}±0.10	14.92±0.19	28.71^{b}±0.36	23.80^{b}±0.41
Midland	201	14.56^{ab}±0.19	11.51±0.33	12.38±0.10	8.46^{b}±0.09	15.01±0.17	30.20^{a}±0.32	23.30^{a}±0.27
Lowland	201	15.33^{a}±0.20	12.17±0.33	12.35±0.10	8.95^{a}±0.09	14.71±0.17	30.72^{a}±0.32	24.35^{a}±0.28
Sex:		*	NS	NS	*	NS	*	
Male	63	15.40^{a}±0.23	11.87±0.39	12.41±0.12	8.79^{a}±0.11	15.00±0.20	31.70^{a}±0.38	22.82±0.19
Female	540	14.50^{b}±0.07	11.54±0.12	12.30±0.04	8.29^{b}±0.03	14.77±0.06	28.06^{b}±0.12	-
Age:		*	*	*	*	*	*	*
1PPI	121	13.75^{c}±0.19	10.48^{b}±0.33	11.80^{c}±0.10	8.00^{b}±0.09	13.74^{c}±0.17	25.62^{d}±0.32	20.45^{c}±0.26
2PPI	142	14.16^{c}±0.21	10.77^{b}±0.35	12.00^{c}±0.11	8.16^{b}±0.10	14.21c±0.18	28.23^{c}±0.34	22.49^{b}±0.29
3PPI	144	15.41^{b}±0.26	12.32^{a}±0.43	12.49^{b}±0.13	8.83^{a}±0.12	15.35^{b}±0.22	31.75^{b}±0.42	25.53^{a}±0.39
4PPI	196	16.48^{a}±0.31	13.24^{a}±0.51	13.08^{a}±0.15	9.18^{a}±0.14	16.22^{a}±0.26	33.93^{a}±0.50	26.81^{a}±0.51

Table 27 (Continued)

Effect and levels	N	RW	RL	CBL	CBC	HDL	BW	SC
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Sex X Age:		*	NS	NS	*	NS	*	
Male,1PPI	25	14.14^{bc}±0.35	10.58±0.59	11.78±0.17	8.10^{cd} ±0.16	13.73±0.30	27.21^{ef}±0.57	20.45^{c}±0.26
Female,1PPI	96	13.35^{c}±0.17	10.5±0.29	11.89±0.08	7.89 ^{d}±0.08	13.74±0.15	24.02^{f}±0.28	-
Male,2PPI	18	14.27^{bc}±0.39	10.6±0.66	11.89±0.20	8.26^{bcd}±0.18	14.13±0.34	29.40^{cde}±0.64	22.49^{b}±0.29
Female,2PPI	124	14.05^{c}±0.15	10.9±0.25	12.12±0.07	8.05^{d}±0.07	14.30±0.13	27.05^{e}±0.24	-
Male, 3PPI	12	15.97^{ab}±0.49	12.8±0.83	12.65±0.24	9.22^{a}±0.23	15.62±0.42	33.63^{ab}±0.80	25.53^{a}±0.39
Female, 3PPI	132	14.85^{b}±0.14	11.8±0.24	12.34±0.07	8.43^{c} ±0.07	15.08±0.12	29.87^{d}±0.24	-
Male, 4PPI	8	17.21^{a}±0.60	13.5±1.01	13.33±0.30	9.59^{a}±0.28	16.52±0.51	36.57^{a}±0.97	26.81^{a}±0.51
Female, 4PPI	188	15.75^{ab}±0.12	13.0±0.20	12.84±0.06	8.77^{ab}±0.06	15.92±0.10	31.29^{bc}±0.20	-
Sex X Agro-ecology:		NS	NS	NS	*	NS	*	*
Male,highland	21	15.56±0.42	11.55±0.72	12.37±0.21	8.26^{b}±0.19	14.97±0.36	31.40^{a}±0.69	23.80^{b}±0.41
Male,midland	21	15.12±0.37	11.72±0.62	12.43±0.18	8.76^{ab}±0.17	15.14±0.31	31.35^{a}±0.60	23.30^{a}±0.27
Male, lowland	21	15.52±0.37	12.35±0.63	12.43±0.19	9.35^{a}±0.17	14.89±0.32	32.36^{a}±0.60	24.35^{a}±0.28
Fem, highland	180	14.38±0.13	11.31±0.21	12.29±0.06	8.17^{c}±0.06	14.86±0.11	26.03^{c}±0.21	-
Female, midland	180	13.99±0.13	11.30±0.22	12.32±0.06	8.15^{c}±0.06	14.89±0.11	29.06^{b}±0.21	-
Female, lowland	180	15.13±0.13	11.99±0.21	12.28±0.06	8.55^{bc}±0.06	14.53±0.11	29.09^{b}±0.21	-

a,b,c,d,e,f and g means on the same column with different superscripts within the specified age group, sex, agro-ecology and interaction of age by sex and sex by agro-ecology are significantly different (P<0.05); HG= Heart Girth; BL=Body Length; WH= Wither height; RH= Rump Height; CD=Chest Depth; HOL=horn length, EL= Ear Length; RW=rump width, RL= Rump Length; HDL=head length, SC=scrotum circumference, BW =body weight 1PPI = 1 Pair of Permanent Incisors; 2PPI = 2 Pair of Permanent Incisors; 3PPI = 3 Pairs of Permanent Incisors; 4PPI = 4 Pairs of Permanent Incisors.

4.11.3. Correlation between Body Weight and other Linear Body Measurements

The phenotypic correlation coefficients (r_p)of sampled goat population in the study area obtained between the live body weight and other linear body measurements for both sexes were presented in Table 28. For both male and female goat, the correlation coefficients between body weight and other linear body measurement were varied from moderately significant ($p<0.05$) to highly significant ($p<0.0001$). The heart girth followed by height at Wither, body length, rump height, chest depth, scrotum circumference and horn length with correlation value of 0.92, 0.91, 0.90, 0.90, 0.89, 0.87 and 0.73,respectively had the highest correlation with body weight in male.On the other hand the highest correlated trait with body weight was heart girth followed by height at wither, rump height, chest depth, body length and horn length in females with a correlation value of 0.85, 0.84, 0.83, 0.76, 0.59 and 0.55, respectively. The linear body measurements which have moderate correlation with body weight are (EL, RW, CBC and HDL) for male and (EL, HL, RW, RL, CBL, CB and HDL) for female. Heart girth had the highest correlation with body weight in both sexes, and this suggested that heart girth is the most reliable parameters for prediction body weight of goat population in present study. The current finding is in agreement with the earlier study of Yaekob *et al*. (2015), Alubel (2014), Alefe (2014), Bekalu (2014), Belete (2013) and Ahmed (2013) who reported that heart girth had high correlation with body weight and this parameter may be used to estimate body weight of sample goat population on Woyto-Guji in Loma, Central Highland and Abergelle goat, indigenous goat in (Shabelle, West Gojjam, bale and Horro Gudruu Wollega), respectively.

Table 28: Correlation Coefficients Among Body Weight And Linear Measurements Goat (Values above the Diagonal for Males And Below The Diagonal for Females) (N=63 for Male; N=540 for Females)

	HG	HW	BL	CD	HL	EL	RH	RW	RL	CBL	CBC	HDL	BW	SC
HG		0.93*	0.80*	0.84*	0.70*	0.49*	0.93*	0.47*	0.61*	0.55*	0.50*	0.50*	0.92*	0.82*
HW	0.97*		0.81*	0.80*	0.69*	0.53*	0.99*	0.48*	0.60*	0.51*	0.57*	0.52*	0.91*	0.79*
BL	0.61*	0.60*		0.81*	0.64*	0.78*	0.80*	0.37*	0.51*	0.49*	0.55*	0.48*	0.90*	0.83*
CD	0.83*	0.83*	0.57*		0.67*	0.40*	0.80*	0.45*	0.58*	0.63*	0.52*	0.47*	0.89*	0.76*
HL	0.57*	0.60*	0.38*	0.58*		0.48*	0.68*	0.60*	0.68*	0.50*	0.61*	0.63*	0.73*	0.64*
EL	0.38*	0.36*	0.25*	0.32*	0.23*		0.53*	0.67*	0.58*	0.32*	0.42*	0.60*	0.52*	0.55*
RH	0.97*	0.99*	0.60*	0.83*	0.60*	0.36*		0.48*	0.60*	0.51*	0.57*	0.52*	0.90*	0.78*
RW	0.55*	0.57*	0.38*	0.55*	0.56*	0.38*	0.56*		0.81*	0.58*	0.54*	0.78*	0.52*	0.51*
RL	0.33*	0.55*	0.25*	0.28*	0.32*	0.20*	0.34*	0.41*		0.62*	0.63*	0.84*	0.66*	0.62*
CBL	0.40*	0.44*	0.26*	0.38*	0.37*	0.18*	0.44*	0.42*	0.26*		0.61*	0.63*	0.60*	0.50*
CBC	0.45*	0.46*	0.35*	0.42*	0.38*	0.28*	0.47*	0.38*	0.35*	0.46*		0.56*	0.57*	0.54*
HDL	0.53*	0.56*	0.32*	0.57*	0.55*	0.26*	0.55*	0.61*	0.31*	0.48*	0.43*		0.56*	0.55*
BW	0.85*	0.84*	0.59*	0.76*	0.55*	0.36*	0.83*	0.52*	0.30*	0.35*	0.40*	0.46*		0.87*

* Significant at ($p<0.05$ and $p<0.0001$) level; HG= Heart Girth, BL=Body Length, WH= Wither Height, RH= Rump Height, CD=Chest Depth, HL=Horn length, EL= Ear Length, RW = Rump Width, RL=Rump Length, CBL=Cannon Bone Length, CBC=Cannon Bone Circumference, HDL= Head Length, BW=Body weight and SC = Scrotal Circumference;

4.11.4. Prediction of Body Weight of Goats from Other Linear Body Measurements

The results of multiple linear regression models for predicting the body weight of goats from other linear body measurements is presented in Table 29. The knowledge of live weight of animals is important in both livestock production and marketing practices and though the use of conventional weighing scales is the best way of determining live weight of an animal.Yet proper weight measurements are often difficult in villages due to lack of weighing scales. Thus in situations where no equipment for physical weighing of small ruminants are available, it is advisable to predict the body weight on the basis of body measurements using suitable prediction equations (Kassahunand Solomon, 2008). Multiple linear regression analysis was carried out to predict live body weight of an animal. The regression of body weight on independent variables, which have higher correlation with body weight, was done to set adequate model for the prediction of body weight separately for male and female. The result of stepwise multiple regression analysis showed that the most important variable to predict body weight was heart girth than the other variables in both sexes for does (71%) and bucks (85%).This is in agreement with the earlier results of Belay and Meseretu (2017), Yaekob *et al*., (2015), Alubel (2015), Bekalu (2014), Hulunim (2014), Ahmed (2013), and Belete (2013), as heart girth was selected first for prediction of live body weight of animals. The accuracy of functions used to predict live weight or growth characteristics from live animal measurements have enormous contribution on the improvement of livestock production and productivity Tesfaye (2008).

Only seven quantitative variables (HG, BL, CD, RW, SC, HW and RH) and (HG, CD, BL, HL, EL, HW and HDL) explained a total variability of 85% and 71% in males and females, respectively. However, the addition of BL (for male) and CD (for female) to chest girth in the first step improved the R2 value by 0.07 and 0.01 and decreased the MSE by 0.95 and 0.15 respectively. The inclusion of CD and RW (for male) and BL (for female) improve the R^2 by 0.01 and decreased the mean square error by 0.08 and 0.09 (for male) and 0.05 (for female). However the inclusion of other parameters did not improve the total variability of the dependent variable. This showed that heart girth (Model I) was the most reliable variable in predicting body weight than other LBMs both for male and female goats at farmer's level.

Stepwise regression procedure was carried out to generate models (equations) for prediction of body weight of both male and female goats separately from linear measurements. The regression equation for body weight was estimated as $Y= (- 27.12 + 0.76X$ (where X stands for HG), with R value of 0.71 for female and $Y= (- 45.12 + 1.01X$ (where X stands for HG), with R value of 0.85 for male goat in the present study. This finding showed that an increase of one cm of HG resulted in an increase of 0.76 and 1.01 kg of live body weight in female and male goats, respectively.

Even though the increment of $R^2$was small in each steps in the model, combination of more than one variable clearly indicated that weight could be estimated more accurately by combination of two or more variable. This may be decreasing the values of C (P), MSE which will ultimately increase the efficiency of the model. 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, live body weight estimation using heart girth alone would be better under extensive management conditions.

Table 29: Multiple regression analysis of live body weight on different body measurements of female and male goats in the study area

Models	Parameters								R^2	C(p)	RMSE
	Intercept	β1	β2	β3	β4	β5	β6	β7			
Model for female											
HG	-27.12	0.76							0.71	33.23	4.88
HG+CD	-26.21	0.63	0.27						0.72	16.99	4.73
HG+CD+BL	-26.87	0.60	0.07	0.24					0.72	9.76	4.66
HG+CD+BL+HL	-25.16	0.58	0.07	0.20	0.07				0.73	5.67	4.61
HG+CD+BL+HL+EL	-25.66	0.57	0.07	0.21	0.06	0.11			0.73	4.91	4.60
HG+CD+BL+HL+EL+HW	-25.91	0.45	0.14	0.07	0.19	0.06	0.12		0.73	4.40	4.58
HG+CD+BL+HL+EL+HW+HDL	-25.42	0.44	0.15	0.07	0.21	0.07	0.12	-0.11	0.73	4.22	4.57
Model for male											
HG	-45.30	1.01							0.85	109.53	2.06
HG+BL	-46.62	0.62	0.49						0.92	32.47	1.11
HG+BL+CD	-42.03	0.48	0.39	0.36					0.93	18.95	0.93
HG+BL+CD +RW	-41.67	0.48	0.40	0.31	0.20				0.94	12.13	0.84
HG+BL+CD+RW+SC	-37.41	0.40	0.34	0.32	0.16	0.17			0.95	10.50	0.80
HG+BL+CD+RW+SC+HW	-37.09	0.25	0.19	0.30	0.34	0.12	0.18		0.95	8.90	0.77
HG+BL+CD+RW+SC +HW +RH	-31.24	0.25	2.51	0.25	0.39	-2.32	0.11	0.19	0.95	4.42	0.70

HG = Heart girth; CD = Chest Depth; BL = Body length; HL=Horn Length; EL=Ear Length; WH = Wither Height; HDL= Head Length; RW=Rump width, SC=scrotum circumference RH = Rump Height; R2 = coefficient of determination, C (P) = the mallow's parameters, MSE = Mean square error

4.11.5. Multivariate analysis

Multivariate discriminate analysis was conducted using quantitative traits for does and bucks separately to determine assignment (%) of each individual animal and to distinguish significant discriminative traits; to obtain distances between sample populations and to observe the spatial distribution of sample populations (Aziz and Al-Hur, 2012; FAO, 2012).

4.11.5.1. Discriminate Analysis

The discriminate functions for the female and male sample populations are presented in Table 30. The correct classification ranged from 47.6 to 71.4% in the case of male population and 67.2 to 79.4% in the case of female population. Most female goat population were classified into their source population (79.4% for highland, 67.2% for midland, and 70.6% for lowland), whereas most individual male sampled goat population were 71.4%, 52.4% and 47.6% in highland, midland and lowland, respectively.

The highest correct classification percentages were calculated for highland followed by lowland for female goat population, while highland followed by midland agro-ecology of the study area was the correct classification percentages for male. In contrast lowland and midland had the least correct classification percentages for male and female sample populations, respectively. A total of 4and 2 male population of goat in highland were misclassified with midland and lowland by 19.0% and 9.5%, respectively.Out of the three goat population 33.3% and 14.3% of male goat population in highland and lowland were misclassified with midland. A total of 27 and 10 female goat populations in highland were misclassified as midland and lowland by 15.0% and 5.6%, respectively.

The proportion of individuals correctly reallocated is taken as measurement of the integrity of that population, whereas the number of misclassified individuals between studied population sources suggested close/overlapping of measurements between populations. This due to high geographical distance between their habitats as a result the probability of combination between the studied populations is very low.

Table 30: Number of Observation and Percent of Classification in Parenthesis for Sample Population by Sex Using K-Nearest Neighbor Meth

Sex	Agro-ecology	Highland		Midland		Lowland		Total	
		N	%	N	%	N	%	N	%
Male	Highland	15	71.4	4	19.0	2	9.5	21	100.0
	Midland	7	33.3	11	52.4	3	14.3	21	100.0
	Lowland	5	23.8	6	28.6	10	47.6	21	100.0
	Total	27	42.86	21	33.33	15	23.81	63	100.0
Female	Highland	143	79.4	27	15.0	10	5.6	180	100.0
	Midland	24	13.3	121	67.2	35	19.4	180	100.0
	Lowland	20	11.1	33	18.3	127	70.6	180	100.0
	Total	187	34.63	181	33.52	172	31.85	540	100.0

4.11.5.2. Canonical Discriminate Analysis

The canonical discriminate analysis was carried out to obtain Mahalanobis distances between sample populations and to observe the spatial distribution of sample populations on canonical variables by a means of graph. Pair-wise squared Mahalanobis distances between agro-ecology of the study area (Table 31) for male and female sample populations were significant ($p<0.0001$) except between midland and lowland for male population. This shows that the female population from each agro-ecology and male population between highland- midland and highland-lowland is distinct and has its own measurable differences from each agro-ecology. The shortest distance of male population across each agro-ecology as compared to the female one and the non-significance difference between midland and lowland is due to sample population. The shortest distance (18.17) and (2.97) was measured between midland and lowland while the longest distance (26.41) and (5.96) was measured between highland and lowland for male and female, respectively. The highest Mahalanobis distances was found between male goat population than the corresponding value of female goat population which is in agreement with Hulunim (2014) who reported that the higher squared Mahalanobis distance was found between bucks than does.

Table 31: Squared Mahalanobis Distance between Agro-Ecology for the Male (Above the Diagonal) and Female (Below the Diagonal) Sample Populations

Agro-ecology	Highland	midland	Lowland
Highland	**	18.8182	26.4097
Midland	3.1864	**	18.1659
Lowland	5.9452	2.9707	**

Spatial distributions of the three populations for each sex are presented in appendix Figure 3. The procedure of canonical discriminate analysis extracted two canonical variants for both female and male sample populations. The canonical analysis allowed extracting two canonical variants (CAN1, and CAN2) for both male and female. CAN 1 discriminated highland from lowland goat populations effectively on the left side, while in the right side keeping midland and lowland populations closer on the right. This indicated that midland goat populations were close to lowland both for male and female goat population in the study area. CAN (2) is not effective to separate three sampled goat population across all agro-ecology especially for lowland and midland goat population. The similarities between these populations of goats might be similarities in management system and genetically similar as well as agro-ecology of the two areas also more or less similar as compared to the highland one but they may have genetically different. In order to validate information from quantitative measurements on the two similar groups of populations, further molecular marker information for comparative genetic analysis is needed.

4.11.5.3. Principal Component Analysis (PCA)

In this study to perform PCA a total of 13 traits from 540 adult female and 14 traits from 63 adult male individuals' goat were carried out to study the linear relationships between characters. The PRINCOMP procedure was conducted separately for male and female to identify which characters of goats are more similar with each other by computing different principal component. Two principal components' (PC) were extracted that accounted for 77.83% and 63.70% of the total variation for buck and does (Table 32 and appendix Figure 4). The first two of these PC accounted for 66.59% and 54.32 % of the variance in the 14 traits for buck and 13 traits for doe, respectively.As presented Tables 32, all quantitative trait except head length, rump length, canon bone length, canon bone circumference and ear length showed that a higher value in the first component as compared to components two. However, the traits with higher value with component one have lower value in component two for both male and female goat population, respectively) were more related each other.

The correlation between the original traits and the first principal component were all positive (Table 32). Principal component one was most strongly influenced by all traits for both male and female goat; but there was strongly associated with body weight, heart girth, height at wither, rump height, chest depth, body length and scrotum circumference for male and body weight, heart girth, height at wither, chest depth and rump height for female. Principal component 2 was most strongly associated with head length, rump length, rump width, Canon bone length and Canon bone circumference for both male and female goat.

Table 32: Principal Component Analysis for Male and Female Goat population

Male goat	Component1	Component 2
Variance %	66.578	11.260
Cumulative %	66.578	77.838
HG	0.901	-0.316
WH	0.907	-0.294
BL	0.855	-0.333
CD	0.859	-0.268
HOL	0.813	0.101
EL	0.646	0.172
RH	0.906	-0.294
RL	0.692	0.574
RW	0.810	0.456
CBL	0.698	0.280
CBC	0.710	0.249
HDL	0.744	0.549
BW	0.941	-0.259
SC	0.869	-0.188

Female goat	Component1	Component 2
Variance %	54.315	9.388
Cumulative %	54.315	63.703
HG	0.924	-0.277
WH	0.936	-0.239
BL	0.660	-0.293
CD	0.865	-0.198
HOL	0.714	0.154
EL	0.446	0.000
RH	0.934	-0.240
RL	0.714	0.324
RW	0.452	0.440
CBL	0.548	0.469
CBC	0.593	0.383
HDL	0.691	0.354
BW	0.849	-0.285

5. SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary and Conclusion

The current study was aimed to generate information onphysical characteristics, production system and farmers' trait preference of indigenous goattype that help to design important breeding program in South Gondar Zone of Amhara National Regional State. The higher proportion of male household heads in highland (84.2%), midland (89.5%) and lowland (94.7%) agro-ecologies, respectively, may lead to inconsistent benefits from sale of goat population in the study area. Even if majority the farmers in the study area were at productive age group especially in highland but there were absence of educational person in most of goat keepers particularly in midland and lowland areas and as a result it leads to a negative impact for the adoption of technologies. Among different purpose of goat, income was the primary objectives of farmers rearing their goat flock in all three agro-ecology of the studied area. Natural pasture and river were the main source of feed and water for goat populations respectively. Regarding to trait preference of farmers, body conformation across all agro-ecology were ranked first while reproduction rate followed by adaptability in highland and coat color followed by reproduction rate in midland and lowland were ranked 2^{nd} and 3^{rd} respectively. Respondent in the study area ranked body conformation as a number one while coat color and litter size ranked as 2^{nd} and $3^{rd}$for selecting a breeding doe in all three agro-ecology respectively; whereas for breeding buck, body conformation ranked first followed by color and family history in highland and midland while in lowland area, coat color is the primary selection criteria for breeding buck followed by body conformation and family history. The study showed that disease was ranked as first constraint while feed shortage and predator ranked second and third in all three agro-ecology. The present study showed that there is a significant difference between agro-ecology for most reproductive performance except kidding interval and higher value of reproductive performance was recorded in the lowland one. The most dominant coat color pattern was plain, but patchy and spotted were also present in some extent. White dominant on red and red were the most frequent coat colors in highland and midland goat population in the study area while in lowland area white dominant on red and white coat color was the most frequent one. The body weight and most other linear body measurement result showed that the studied population in lowland was

generally better than highland and midland goat population. The least square means for the effect of sex had significant effect ($P<0.05$) on all quantitative variables except ear length, canon bone length, and rump length. Male goats were consistently higher than females in all significantly affected variables except for horn length. Based on the canonical discriminate analysis, result showed that highland and lowland goats were distantly related in morph metric characteristics while the least differentiation was reported between lowland and midland goats. Generally, the diversified functions of goats and constraints found in the present study across the study areas indicated the necessity to formulate holistic research-for-development strategies. Inbreeding in this study was high compared to the acceptable inbreeding value especially for highland and lowland goat population. Since the reason of goat keeping, management practices and agro-ecology varied across the study areas, the recommendations presented below need to be revised within the respective local contexts and implemented taking into account producers' interests.

5.2. Recommendation

i. Training should provide for goat owners to focus on economically important traits during selection and preference of trait especially for lowland area.

ii. Efforts should be implemented to identify major goat diseases, plan appropriate health control measures and introduce fast and efficient veterinary service.

iii. For adequate water supply especially for lowland and midland area, infrastructures should be developed and strengthen.

iv. For better reproductive performance especially for highland goats, feeding and housing system needed to be improved.

v. Training should be provided for farmers to be focus on practiced of communal grazing system, buy breeding buck from market instead of using only their own buck (born in the flock) and increased number of buck in the mixed flock and using control breeding to reduce inbreeding and increase genetic diversity.

vi. The difference and similarity between goat population in morphometric trait and adaptability (especially for highland and lowland goat population) should be supported by further study on characterization at molecular level under their production environment.

6. REFERENCES

Addisu, A., Solomon, M., Solomon, A., Fantahun, D., Wamatu, J., Thorpe, W. and Duncan, A.J., 2012. Characterization of the farming and livestock production systems and potential of feed-based interventions in Adama and ArsiNegelle Districts, Ethiopia EIAR, DebreZeit Agricultural Research Center, Ethiopia. PP15.

Ahmed, S., 2013. On-farm phenotypic and production system characterization of indigenous goats in Horro Guduru Wollega zone, western Ethiopia. M.Sc. Thesis Submitted to School of Graduate Studies, Haramaya University, Ethiopia

Alefe, T., 2014. Phenotypic Characterization of Indigenous Goat Types and Their Production System in Shabelle Zone, South Eastern Ethiopia. M.Sc. Thesis. School of Animal and Range Sciences, School of Graduate Studies. Haramaya University. Ethiopia.

Alemayehu, R., 1993. Characterization (phenotypic) of indigenous goats and goat husbandry practices in East and South East Ethiopia.M.Sc. Thesis, Alemaya University of Agriculture, Alemaya, Ethiopia. pp135.

Alubel, A., 2015. On-farm phenotypic characterization and performance evaluation of Abergelle and Central highland goat breeds as an input for designing community-based breeding program. M.Sc. Thesis Submitted to School of Graduate Studies, Haramaya University, Ethiopia.

Armstrong, J.B., 2006. Inbreeding: Why we will not do it? Accessed on June 13, 2010from http://www.parispoodles.com/Inbreeding.html.

Arse, G., Hundessa, F., Umeta, G., Muleta, M. and Debele, G., 2013. Assessment on challenges and opportunities of goat farming system in Adami Tulu, ArsiNegelle and Fantale districts of Oromia Regional State, Ethiopia. African Journal of Agricultural Research, 8(1), pp.26-31.

Assen, E. and Aklilu H., 2012. Sheep and goat production and utilization in different agro-ecological zones in Tigray, Ethiopia. Livestock Research for Rural Development. Volume 24, Article #16. http://www.lrrd.org/lrrd24/1/asse24016.htm

Banerjee, A.K., Animut, G. and Ermias, E., 2000. Selection and breeding strategies for increased productivity of goats in Ethiopia. The opportunities and challenges of enhancing goat production in east Africa, pp.70-79.

Belay, D., 2008. Growth, Reproductive, Performance and Carcass Characteristics of Abergelle and Central Highland Goat Types under Traditional and Slightly Improved Management in Sekota. M.Sc. Thesis Submitted to School of Graduate Studies, Haramaya University, Ethiopia. 73p.

Belay, Z and Meseretu, M., 2017. On Farm Phenotypic Characterization of Indigenous Goat Populations in Gamo-Gofa Zone South Western Ethiopia. Journal of Advanced Studies

in Agricultural, Biological and Environmental Sciences (JABE).Vol.4.Issue.3.2017 (July-Sept).

Belay, Z and Meseretu, M., 2018. Assessment of Traditional Goat Husbandry Practices in Gamo-Gofa Zone, Southwestern Ethiopia. Arba Minch University College of Agricultural Sciences. Arba Minch, Ethiopia. Global Veterinaria 20 (1): 11-18, 2018.

Belete, A., 2013. On farm phenotypic characterization of indigenous goat types and their production system in bale zone of Oromia region, Ethiopia. M.Sc. Thesis.School of Graduate Studies in Haramaya University. Haramaya, Ethiopia.

Belete, S., 2009. Production and marketing systems of small ruminants in Gomma district of Jimma zone, Western Ethiopia. M.Sc. Thesis, Hawassa University, Ethiopia.

Biratu, G.K., 2008.Agricultural Extension and Its Impact on Food Crop Diversity and the Livelihood of Farmers in Guduru, Eastern Wollega, Ethiopia. M.Sc. Thesis, Norwegian University of Life Sciences (UMB), Ås, Norway.

Cankaya, S., 2008. A comparative study of some estimation methods for parameters and effects of outliers in simple regression model for research on small ruminants OndokuzMayis University, Biometry and Genetics Unit, Kurupelit/Samsun, Turkey.

Cossins, N. J. and Upton M., 1987.The Borana pastoral system of southern Ethiopia. Agricultural Systems 25:199-218.

CSA (Central Statistics Agency). 2016. Agricultural sample survey. Volume II, Report on livestock and livestock characteristics.Statistical bulletin, 570, April 2013, Addis Ababa, Ethiopia. CSA (Central Statistics Agency).

Dadi, H., Duguma, G., Shelima, B., Fayera, T., Tadesse, M., Woldu, T. and Tucho, T.A., 2008. Non-genetic factors influencing post-weaning growth and reproductive performances of Arsi-Bale goats. Parity, 5(4.36), pp.2-94.

Dereje T, Mengistu U, Getachew A and Yoseph M, 2014.Perceptions of households on purpose of keeping, trait preference, and production constraints for selected goat types in Ethiopia. Tropical Animal Health and Production, 46:363–370.

Deribe, G., 2009.On-farm performance evaluation of indigenous sheep and goats in Alaba, southern Ethiopia. MSc. Thesis, Hawassa University, Ethiopia.

Duguma, G., Mirkena, T., Haile, A., Iñiguez, L., Okeyo, A.M., Tibbo, M., Rischkowsky, B., Sölkner, J. and Wurzinger, M., 2010. Participatory approaches to investigate breeding objectives of livestock keepers. Participatory definition of breeding objectives and implementation of community-based sheep breeding programs in Ethiopia, p.7.

Endashaw, A., 2007.Assessment on production system and marketing of goats at Dale district, SidamaZone. M.Sc. Thesis, Hawassa University, Ethiopia.

FAO (Food and Agricultural Organization of the United Nations), 2007.Global Plan of Action for Animal Genetic Resources and the Interlake Declaration.Rome (available at http://www.fao.org/docrep/010/a1404e/a1404e00.htm) (Accessed 07/ 01/ 2018).

FAO (Food and Agricultural Organization of the United Nations), 2012.Phenotypic characterization of animal genetic resources.FAO Animal Production and Health Guidelines No.11. Rome, Italy.

FAO (food and agricultural organization), 2011. Draft guidelines on phenotypic characterization of animal genetic resources. Commission on genetic resources for food and agriculture, thirteenth regular session

FAOSTAT, 2013. Agriculture organization of the United Nations. Statistical database.http://faostat3.fao.org/home/index.html#

FARM-Africa, 1996.Goat Types of Ethiopia and Eritrea.Physical description and management systems.Published jointly by FARM-Africa, London, UK and International Livestock Research Institute, Nairobi, Kenya. 76pp.

Galal, S., 2005.Biodiversity in goats.Small Ruminant Research. 60(1-2):pp75-81. Ain Shams University. Cairo, Egypt.

Gebrekiros, H., Kefelegn, K., Banerjee A.K. and Zinabu, W., 2016.On-Farm Phenotypic Characterization of Begait Goat and Their Production System in Western Zone of Tigray, Ethiopia. International Journal of Research and Innovations in Earth Science Volume 3, Issue 1, ISSN (Online): 2394-1375

Gebreyesus, G., 2010. Community based participatory characterization of the short-eared Somali goat population around Dire Dawa. Unpublished M.Sc. Thesis Submitted to the School of Graduate Studies of Haramaya University, Ethiopia129 p.

Getahun, L., 2008. Productive and economic performance of small ruminant production in production system of the highlands of Ethiopia. University of Hohenheim, Stuttgart-Hoheinheim, Germany.

Gimenez, D. and Rodning, S., 2007. Alabama Cooperative extension system reproductive management of Sheep and Goats.

Girma, A., 1996. Studies on Performance Potential of Somali Goats and their crosses with Anglo-Nubian: A Contribution to breed documentation and evaluation. Landwirtschaftlich-GärtnerischenFakultät der Humboldt, Universitätzu Berlin, 151.

Girma, A., 2008. Reproduction in Sheep and Goat. Sheep and Goat Production Handbook forEthiopia.60-79pp.

Girma, D., Misgana, D. and Feyisa, H., 2011. Effect of different factors on mortality rate of Arsi-Bale kids in Mid Rift Valley of Ethiopia. Global Veterinaria, 6(1), pp.56-60.

Grum, G., 2010. Community based participatory characterization of the short-eared Somali goat population around Dire Dawa. M.Sc. thesis, Submitted to the School of Graduate Studies of Haramaya University, Ethiopia129 p.

Gurmessa, U, G., Hundesa, F., Duguma, M. and Muleta, M., 2011. Analysis of goat production situation at ArsiNegele Woreda, Ethiopia. Journal of Stored Products and Postharvest Research, 2(8), pp.156-163.

Hailu, D., Mieso, G., Nigatu, A., Fufa, D. and Gamada, D., 2006. The effect of environmental factors on preweaning survival rate of Borana and Arsi-Bale kids. Small ruminant research, 66(1-3), pp.291-294.

Halima, H., Baum, M., Rischkowsky, B. and Tibbo, M., 2012. Phenotypic characterization of Ethiopian indigenous goat populations. African journal of Biotechnology, 11(73), pp.13838-13846.

Hulunim Gatew, 2014. On-farm phenotypic characterization and performance evaluation of Bati, Borena and Short eared Somali goat populations of Ethiopia. M.Sc. Thesissubmitted to the School of Animal and Range Sciences, School of Graduate Studies in Haramaya University. Haramaya, Ethiopia. Pp55-56.

IBC (Institute of Biodiversity Conservation), 2004. The State of Ethiopia's Farm animal Genetic Resources: Country Report. A Contribution to the First Report on the State of the World's Animal Genetic Resources. IBC, May 2004. Addis Ababa, Ethiopia.

Jainudeen, M.R., H. Wahid, E.S.E. Hafez, 2000. Sheep and goats. In: Hafez, E.S.E., Hafez, B. (Eds.), Reproduction in Farm Animals, seventh ed. Lippincott, Williams & Wilkins, Maryland, pp172–181.

Kassahun, A. and Solomon, A., 2008.Breeds of sheep and goats. pp 5-26. In: AlemuYami and R.C. Merkel (Eds.). Sheep and goat production handbook for Ethiopia. Ethiopian sheep and goat productivity improvement program, USAID.

Kassahun, A., Yibrah, Y. and Fletcher I., 1989. Productivity of purebred Adal and quarter bred Saanen x Adal goats in Ethiopia. In: R.T. Wilson and M. Azeb (eds), African small ruminant research and development, 510-523.

Kosgey, I.S. and Okeyo, A.M., 2007. Genetic improvement of small ruminants in low-input, smallholder production systems: Technical and infrastructural issues. Small Ruminant Research, 70(1), pp.76-88.

Kosgey, I.S., 2004. Breeding objectives and breeding strategies for small ruminant in the tropics. PhD Thesis, Animal Breeding and Genetics Group.Wageningen University, the Netherlands.

Lanari M.R, H. Taddeo, E .Domingo, M.P. Centeno, L. Gall, 2003.Phenotypic differentiation of exterior traits in local Criollo goat population in Patagonia (Argentina). ArchivTierzuchtDummerstorf. 46: pp 347–356.

Lebbie, H.B, 2004. Goats under household conditions. Small Ruminant Research (The Netherlands), 51(2), pp 131-136. ISSN 0921-448.

Mahlet, S., 2008. Reproduction in Arsi-Bale female goats and growth performances of Toggenburg x Arsi-Bale crosses. An MSc Thesis, Hawassa University, Ethiopia.

Markos, T., Jibril, Y., Woldemeskel, M., Dawo, F., Aragaw, K., Rege, J.E.O., 2004. Factors Affecting Hematological Profiles in Three Ethiopian Indigenous Goat Breeds. Intern J Appl Res Vet Med 2(4).

Mekasha, Y., 2007. Reproductive traits in Ethiopian male goats, with special reference to breed and nutrition.PhDdissertation.Department of Clinical Sciences, Faculty of Veterinary Medicine and Animal Sciences, Swedish University of Agricultural Science (SLU), Uppsala, Sweden. 56p

Mengistie, T., 2008.On-farm performances of Washera sheep at Yilmanadensa and Quarit districts of the Amhara National Regional State.MSc Thesis, Hawssa University, Ethiopia. pp: 62.

Morand-Fehr, P., Boutonnet, J.P., Devendra, C., Dubeuf, J.P., Haenlein, G.F.W., Holst, P., Mowlem, L. & Capote, J., 2004. Strategy for goat farming in the 21st century. Small Ruminant Research 51:pp175-183.

Mwacharo JM, Okeyo AM, Kamande GK, Rege JEO. 2006. The small east African shorthorn zebu cows in Kenya: I- Linear body measurements. Trop. Anim. Health Prod. J. 38:65–76. Sciences, Faculty of Natural & Agricultural Sciences, University of Pretoria, Pretoria 0002 South Africa.pp10.systems. FARM Africa, London (UK); ILRI, Nairobi (Kenya)

Nesamvuni, A.E., Mulaudzi, J., Ramanyimi, N.D. and Taylor, G.J., 2000. Estimation of body weight in Nguni-type cattle under communal management conditions. South African Journal of Animal Science, 30(4), pp.97-98.

Nigatu, A., 1994. Characterization of Indigenous Goat Types & husbandry Practices in Northern Ethiopia. MSc. Thesis, Alemaya University of Agriculture. Alemaya, Ethiopia.pp86.

Oluwatayo, I.B. and Oluwatayo, T.B., 2012. Small ruminants as a source of financial security: a case study of women in rural Southwest Nigeria. Institute for Money, Technology and Financial Inclusion (IMTFI), Working Paper, Ibadan. 21p.

Peacock, C. (2005). Goats- A pathway out of poverty. Small Ruminant Research 60:pp179-186.

Philipsson, J, Rege JEO, Okeyo AM., 2006. Sustainable breeding programmes for tropical farming systems. In: J. M. Ojango, B. Malmfors and A.M. Okeyo (eds.). AGTR - version 2, International Livestock Research Institute, Nairobi and Swedish University of Agricultural Sciences, Uppsala, Sweden.

Semakula, J., Mutetikka, D., Kugonza, R. D. and Mpairewe, D., 2010. Variability in Body Morphometric Measurements and Their Application in Predicting Live Body Weight of Mubende and Small East African Goat Breeds in Uganda. Middle-East Journal of Scientific Research 5 (2): pp98-105.

Siegmund-Schultze M., Legesse G., Abebe G. and Valle Zárate A. 2009. Bottleneck analysis of sheep production systems in southern Ethiopia: Comparison of reproductive and growth parameters. Options Mediterranean's, A no. 91, 2009 – Changes in sheep and goat farming systems at the beginning of the 21st century.

Sisay, L., 2009. Phenotypic Characterization of Indigenous Sheep Breeds in the Amhara National Regional State of Ethiopia. M.Sc. Thesis. Haramaya University, Ethiopia.

Solomon, A., 2014. Design of community based breeding programs for two indigenous goat breeds of Ethiopia. Doctoral Thesis. Universitat fur Bodenkultur Wien University of Natural Resources and Life Sciences, Vienna.Pp34-35.

Solomon, G., 2009. Goat breeds of Ethiopia. A guide for identification and utilization. Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP).

Solomon, G., Azage, T., Berhanu, G. and Dirk, H., 2010. Sheep and goat production and marketing systems in Ethiopia: Characteristics and strategies for improvement. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 23. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp58.

Solomon, G., Hans K., Jack J W., Olivier H., Ohan AM and Van A., 2008. Conservation priorities for Ethiopian sheep breeds combining threat status, breed merits and contributions to genetic diversity Genetics Selection Evolution, 40:pp433-447.

Tatek W, Hailu D, Mieso G and Dadi G., 2004.Productivity of Arsi Bale goat types under farmers' management condition: a case of ArsiNegelle. Proceedings of the 13th Annual Conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, 25-27 August 2004, 67-71

Tegegne F., Alemayehu, K. and Abegaz, S., 2013. Identification and phenotypic characterization of goat ecotypes in the Bench-Maji zone, southwestern Ethiopia. Animal Genetic Resources/Resources génétiques animals/Recourses genetics animals, 53, pp.19-26.

Tegegne, F., 2015.Characterization of goat production systems and trait preferences of goat keepers in Bench Maji zone, south western Ethiopia. African Journal of Agricultural Research. Vol. 11(30), pp. 2768-2774, 28 July, 2016.

Tesfaye, A., 2004. Genetic characterization of indigenous goat population of Ethiopia using microsatellite DNA markers. A Thesis submitted to the National Dairy Research Institute (Deemed University) Karnal (Haryana), India. pp258.

Tesfaye, K., Aynalem, H., Hailu, D. and Tesfaye, Al. 2012. Genetic and phenotypic parameter estimates for reproduction traits in indigenous Arsi-Bale goats. Tropical Animal Health Production 44:1007–1015

Tesfaye, T., 2009. Characterization of goat production systems and on- farm evaluation of the growth performance of grazing goats supplemented with different protein sources in Metemaworeda, Amhara region, Ethiopia. M.Sc. Thesis Haramaya university.pp108.

Thiruvenkadan, A.K. and Karunanithi, K. 2006. Characterization of Salem Black goats in their home tract. Animal Genetic Resources Information, 38: 67-75.

Tsedeke,k.k., 2007.Production and marketing systems of sheep and goats in Alaba, southern Ethiopia. M.Sc. Thesis Hawassa University, Ethiopia.

Tsegaye, T., 2009. Characterization of goat production systems and on- farm evaluation of the growth performance of grazing goats supplemented with different protein sources in Metemaworeda, Amhara region, Ethiopia. M.Sc. Thesis. Haramaya University.pp108.

Tsigabu, G., 2015. Phenotypic characterization of goat type and their husbandry practices in Nuer zone of Gambella people regional state, South Western Ethiopia. M.Sc. Thesis Submitted to School of Graduate Studies, Haramaya University, Ethiopia.

Wossenie, S., 2012. On-Farm Phenotypic Characterization of Hararghe Highland Sheep and their Production Practices in Eastern Hararghe Zone, Ethiopia. M.Sc. Thesis, Haramaya University.

Yadeta, N., 2016. Production and reproduction performances, producers' trait preferences and marketing system of small ruminants in Ada Barga and Ejere Districts of west Shoa Zone, Ethiopia. M.Sc. Thesis, Jimma University.

Yaekob, L., Kirmani, M. A. and Birhanu, B., 2015.Participatory Characterization of the Woyto-Guji Goat and Its Production Environment around Northern Omo, Ethiopia. The Journal of Agriculture and Natural Resources Sciences Journal homepage: http://www.journals.wsrpublishing.com/index.php/tjanrs.

Yoseph, M., 2007. Reproductive Traits in Ethiopian Male Goats.With special reference to breed and nutrition. A PhD. Dissertation Uppsala University.56p.

Zeleke, Z.M., 2007. Environmental influences on pre-weaning growth performances and mortality rates of extensively managed Somali goats in Eastern Ethiopia. Livestock Research for Rural Devel. 19(12).

Zewdu, E., 2008. Characterization of Bonga and Horro indigenous sheep breeds ofsmallholders for designing community based breeding strategies in Ethiopia. A MSc. thesissubmitted to the department of animal science, school of graduate studies, Haramaya University.33pp.

7. APPENDIX

Phenotypic Characterization of Indigenous Goat Types and farmer's trait preference in South Gondar Zone, Amhara National Region in Ethiopia

Appendix I. Questioner

Part I. Household Characteristics

1. District_____ PA _____ Date_____

1.1. Information about respondent and household head

Respondent	Sex	Age	Education level	Marital status

1.2. Household family size (number): Male_____Female_____Total_____

II) Farm characteristics and livestock holding (in number)

1. What is your major source of income? A. Livestock B. crop C. both

1.2. Land holding (in ha.)

Land holding	Own	Rented
Crops (including fallow land) land		
Grazing		

1.3. Trend in land holding A. Increasing B. Decreasing C. Stable

1.4. Composition of livestock

Species	Total no.
Goats	
Sheep	
Cattle	
Chicken	
Donkey	
Horse	
Mule	

Part II. Production and Management practices

2.1. Production system

	Production system			
	Crop livestock (mixed)	Agro pastoralists	Pastoralists	Others(specify)
Mark				

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

	Meat	Milk	Skin	Gift	Ceremony	Manure	Saving	Income
Mark								
Rank								

2.3. Trend in communal grazing area? A. Increasing B. Decreasing C. Stable

Reason_____

2.4. How is the goat flock herded during the day time? A. Male and female separated B. Kids are separated C. All classes of goats herded together D. Others (specify)

Reason_____

_____

2.5. Goat flock is herded

	Goat Separately	Together With cattle/	Together with Sheep	Together with Calves	All herded together
Mark					

2.6. Source of feed for your goat

Feed	Wet season	Rank	Dry season	rank
Natural pasture				
Crop residue				
Crop aftermath				
Feed left over				
Concentrate				

2.7. Grazing system of your goat flock

Feed	Wet season	Rank	Dry season	Rank
Free grazing				
Herded				
Herded and tethered				
Tethered only				

2.8. Do you give supplement feed for your goats? A. Yes B. No

2.9. Do you fatten your goat flock? A. yes B. No

2.10. If say yes what category of goat do you fatten?

	Young female	Older female	Young male	Older male	Castrated
Mark					
Rank					

2.10. What is the trend livestock population?

	Increased	Decreased	Same	Reason
A. Goat				
B. Cattle				
C. Sheep				
D. Chicken				

III .Watering and housing

1. What is your source of water?

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

2. Distance to nearest watering point

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

3. Frequency of watering and water quality

Frequency	Wet season	Dry season
Freely available		
Once a day		
twice a days		
Once in 2 days		
Once in 3 days		

HOUSING

1. Housing/enclosure for adult goats (Tick one or more boxes)

1. In family house	With roof	
2. Separate house		
3. Verenda		
4. Kraal	Without roof	
5.gatta		

Other (specify) _____

2. Are kids housed with adults? A.Yes B. No

If no, specify_____

3. Are goats housed together with other animals? A. Yes B. No

IV.HEALTH MANAGEMENT

1. What are the major goats diseases occur frequently in your area? List in order of importance

S. N	Name of disease	Rank
1		
2		
3		
4		
5		
6		
7		
8		
9		

1.1 What would you do when your goat sick?

Activity	Sales immediately	Slaughters immediately	Takes to veterinary center	Treat with treatments from local traders
Mark				

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

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

Veterinary service	Government	Private	Both	NGOs	Other
Mark					

1.4. Distance to nearest veterinary services

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

V. Reproductive performance of goat

Reproductive trait	Value
Average age at sexual maturity of male	
Average age at sexual maturity of female	
Age at first kidding	
Kidding interval	
Litter size	
Average reproductive life time	
Average number of kids per life time	

VI.BREEDING PRACTICES

1. Do you have breeding buck? A. Yes B. No

2. Reason (objective) for keeping buck(s)

Objective	Mating	Socio -cultural	Fattening	Other
Mark				

3. Breeding/mating system A. Controlled B. Uncontrolled

3.1. If uncontrolled, what is the reason?

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

4. What is your Source of buck(s?)

Source	Own buck (bred)	Own buck (bought)	Buck donated	Buck borrowed	Neighbor's buck	Communal buck
Mark						

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

6. If you yes for question no. 5 which traits do you consider in selecting breeding buck and doe?

Traits to select **doe**	Color	Body size/appearance	Kid survival	Family history	Age at first sexual maturity	Kidding interval	Litter size	Adaptability	Walk ability
Mark									
Rank									

Traits to select buck	Color	Body size	Fertility	Family history	Libido	Adaptability	Walk ability
Mark							
Rank							

6. Do you give special management for breeding buck? A. yes B. No

7. Do you allow another buck to mate your flock? A. Yes B. No

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

Rank them according to their importance (1, 2, 3… 1 for the most problem)

Problem	Late age at first kidding	Long kidding interval	Repeat breeding	Abortion	Dystocia	Long postpartum anoestrous period	Kid mortality	Low growth rate	Others (specify)
Rank									
Mark									

VII. CASTRATION

1. Do you castrate your buck? A. Yes B. No

2. If you castrate your buck, what are your reasons for castration?

	Control breeding	Improve fattening	Better price	Better temperament	Other
Mark					

3. Specify Castration method you used.

A. traditional B. modern

4. At what age do you castrate bucks? A. < 6months B. 6- 12 months C. > 12months

5. Do you give supplementary feed for castrated goat? A) Yes B) no

6. If your answer is yes, what types of supplement?

7. What are the main constraints for goat production? (Rank with significance)

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

1. What are the production features of goats that used for future breeding/trait preference?

Traits	Adaptability	Disease resistances	Milk yield	Reproduction rate	Feed shortage resistances	Coat color	Longevity	Others
Mark								
Rank								

Appendix II. 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							

- Would you state your trait and breed preference in justifiable manner?
- Social lows
- Herding
- Communal land use
- Traditional management system of goat in the area?
- Population trend of goat in the last years? If it's decreasing or increasing, why?
- What is your objective of goat breeding?
-How do you select your breeding goats for the next generation?
- If you face water and feed shortage for your goat what is your coping mechanism to cope up this problem.
-Major constraints of goat production in your area.
-What are your improving mechanisms of goat production?

Appendix III. Qualitative and quantitative descriptor list

Goat's physical description recording format and respective codes

Quantitative Data collection format

No.	Sex	Location	Age	Sc	Hg	Hw	Bl	Bw	Cd	Hol	El	Rh	Rl	Rw	Cbl	Cbc	Hdl
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

SC; Scrotal circumference **HG**=Heart Girth; **HW**= Height at Wither; **BL**=Live Body Length; **BW**=Body Weight; **PW**= Pelvic Width; **HL**= Horn Length; **EL**=Ear Length; **RH**= Rump Height, **CD**=Chest Depth, **RL**= Rump Length, **RW**= Rump Width; **FH**= Fore cannon bone length; **FC**= Fore canon Circumference, **HL**=head length and,
NB:- Live body weight in **Kg** and Linear body measurements in **cm**

Appendix Table 1: The Standard Breed Descriptor List for Goat Developed by FAO (2012).

Qualitative trait	Description and level
Location	1=Highland, 2=midland 3=Lowland
Sex	1=Male, 2=Female
Dentition class	1=1PPI, 2=2PPI, 3=3PPI, 4=4PPIand above
Coat color Pattern	1= plain 2= patchy 3= spotted
Coat color type	1= white 2= red 3 =black 4 = brown 5 = gray 6 = red with black 7=red + white 8 = black + white
Hair length	1=short 2 =medium 3=long
Hair type	1=smooth 2=glossy
Horn	1=presence 2=absence
Horn shape	1= straight 2 = curved 3 = spiral
Horn orientation	1 = obliquely upward2 = backward 3 polled
Ear orientation	1 = erect 2 = semi-pendulous 3= carried horizontally
Head profile	1 = straight 2 = concave 3 convex
Toggle	1 = absent 2 = present
Beard	1 = absent 2 = present
Ruff	1 = absent 2 = present
Wattle	= absent 2 = present
Back profile	1 straight 2 = slops up to rump 3 = dipped
Rump profile	1 flat 2 = sloping 3 = roof

Qualitative Data collection format

No.	Sex	Location	Age	Color	Co pan	HT	HL	HP	HS	HO	EO	HP	TG	BD	RF	WT	BP	RP
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

Co pan=coat color pattern, HT=hair type, HL=hair length, HP=horn presence or absence, HS=horn shape, HO=horn orientation, EO=ear orientation, HP=head profile, TG, BD, RF and WT= (the presence of toggle, beard, ruff and wattle respectively), BP=back profile and RP=rump profile.

Appendix IV.Secondary Data Collection Format

1. Region_____ Zone _____

2. District _____Total Kebele of District _____

3. Production system:

- Agro – pastoral

-mixed crop-livestock

4. Human population of the district: Male _____ Female _____Total_____

5. Climatic data:

Temperature (^{o}c): Minimum _____ Maximum _____

Annual rainfall (mm): Minimum _____ Maximum _____

6. Total area coverage of the district (ha) _____

7. Agro-ecology of the district _____

8. Major crops grown in the district _____, _____, _____, _____

9. Livestock population in the district:

- Cattle _____

- Goat _____

- Sheep _____

- Equine (horse, donkey and mule) _____

- Chicken_____

Others_____

_____

Appendix Table 2: Number of Breeding Male and Female of Goat in Mixed and Not Mixed Grazing in Highland Midland and Lowland

Not mixed					Mixed					overall
	Highland	midland	Lowland	overall		highland	Midland	lowland	Overall	
N	45	35	30	110	N	12	22	27	61	171
Nm	21	11	24	56	Nm	10	22	29	61	117
Nf	100	104	138	342	Nf	24	74	132	230	572
Total	121	115	162	398	Total	34	96	161	291	689

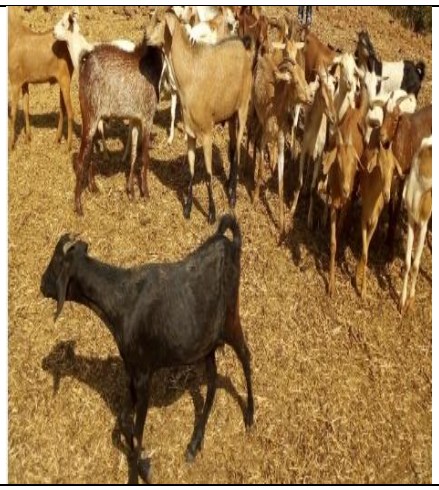
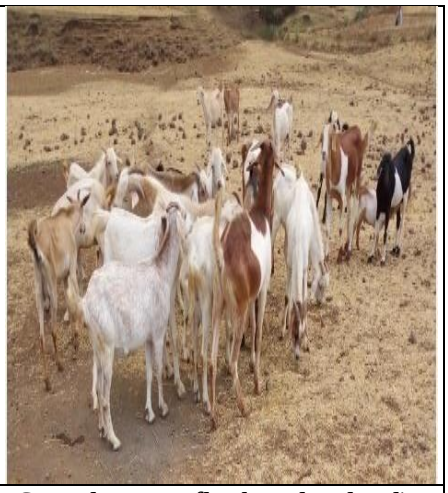
N=number of respondent, Nm= number of breeding male and Nf= number of breeding female

Appendix Table 3: ANOVA of Body Weight and Other Linear Body Measurement of Highland, Midland and Lowland Goats for the Effect of Agro-Ecology, Age, and Sex

Trait	Source	DF	Type III SS	Mean Square	F Value	Pr> F
HG	AGE	3	6161.3	2053.77	259.99	<.0001
	SEX	1	596.307	596.307	75.49	<.0001
	Agro-ecology	2	932.409	466.204	59.02	<.0001
	Error	596	4708.078	7.89946		
	Corrected Total	602	12109.82			
HW	AGE	3	6009.60954	2003.20318	265.6	<.0001
	SEX	1	569.760596	569.760596	75.54	<.0001
	Agro-ecology	2	365.251378	182.625689	24.21	<.0001
	Error	596	4495.13625	7.54217		
	Corrected Total	602	11097.068			
BL	AGE	3	4520.28064	1506.76021	92.22	<.0001
	SEX	1	599.590252	599.590252	36.7	<.0001
	Agro-ecology	2	1015.82594	507.91297	31.09	<.0001
	Error	596	9737.79744	16.33859		
	Corrected Total	602	15475.8508			
RH	AGE	3	5934.68155	1978.22718	255.76	<.0001
	SEX	1	563.567898	563.567898	72.86	<.0001
	Agro-ecology	2	380.177455	190.088728	24.58	<.0001
	Error	596	4609.81596	7.73459		
	Corrected Total	602	11149.2272			
CD	AGE	3	1884.30932	628.103106	167.85	<.0001
	SEX	1	518.236971	518.236971	138.49	<.0001
	Agro-ecology	2	62.031337	31.015668	8.29	0.0003
	Error	596	2230.24932	3.742029		
	Corrected Total	602	4421.98342			
HL	AGE	3	4123.47011	1374.49004	109.22	<.0001
	SEX	1	180.335266	180.335266	14.33	0.0002
	Agro-ecology	2	81.608592	40.804296	3.24	0.0657
	Error	583	7336.80105	12.58456		
	Corrected Total	589	11503.1			
EL	AGE	3	112.50488	37.5016267	19.96	<.0001
	SEX	1	3.2471546	3.2471546	1.73	0.1891
	Agro-ecology	2	104.958741	52.4793703	27.94	<.0001
	Error	596	1119.58254	1.878494		
	Corrected Total	602	1358.88889			

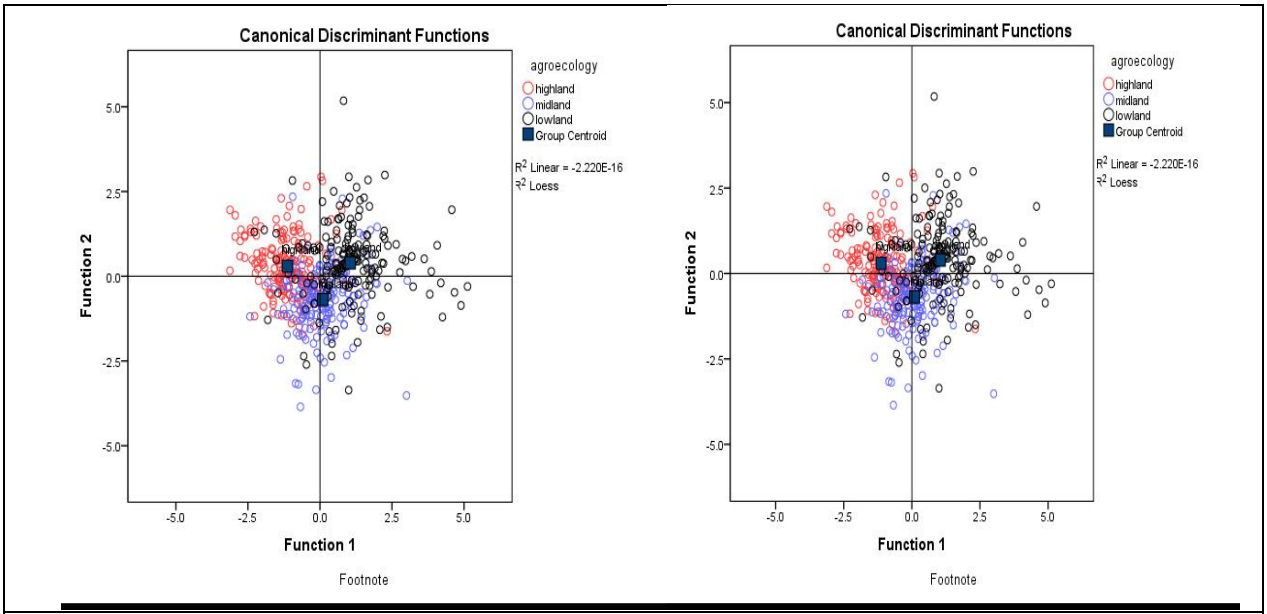
Appendix table 4 (Continued)

Trait	Source	DF	Type III SS	Mean Square	F Value	Pr> F
RW	AGE	3	500.669627	166.889876	60.45	<.0001
	SEX	1	33.6871986	33.6871986	12.2	0.0005
	Agro-ecology	2	113.420611	56.7103057	20.54	<.0001
	Error	596	1645.3938	2.760728		
	Corrected Total	602	2248.12272			
RL	AGE	3	634.593027	211.531009	27	<.0001
	SEX	1	4.3002577	4.3002577	0.55	0.459
	Agro-ecology	2	85.4473466	42.7236733	1.53	0.2153
	Error	596	4668.79116	7.833542		
	Corrected Total	602	5389.54561			
CBL	AGE	3	85.0845816	28.3615272	41.12	<.0001
	SEX	1	0.09463084	0.09463084	0.14	0.7112
	Agro-ecology	2	0.40905174	0.20452587	0.3	0.7435
	Error	596	411.115525	0.6897911		
	Corrected Total	602	499.462687			
CBC	AGE	3	84.8045067	28.2681689	45.59	<.0001
	SEX	1	9.16779416	9.16779416	14.78	0.0001
	Agro-ecology	2	25.0948413	12.5474207	20.24	<.0001
	Error	596	369.566353	0.6200778		
	Corrected Total	602	480.739635			
HDL	AGE	3	430.563353	143.521118	70.77	<.0001
	SEX	1	1.5191427	1.5191427	0.75	0.3871
	Agro-ecology	2	14.5343995	7.2671998	3.58	0.0284
	Error	596	1208.6875	2.027999		
	Corrected Total	602	1667.33665			
BW	AGE	3	4456.76689	1485.58897	196.97	<.0001
	SEX	1	559.904184	559.904184	74.24	<.0001
	Agro-ecology	2	1022.70779	511.353896	67.8	<.0001
	Error	596	4495.07785	7.54208		
	Corrected Total	602	10320.6567			
SC	AGE	3	300.303386	100.101129	63.68	<.0001
	SEX	0	0	.	.	.
	Agro-ecology	2	15.4752905	7.7376452	4.92	0.0107
	Error	57	89.6013762	1.571954		
	Corrected Total	62	439.079365			

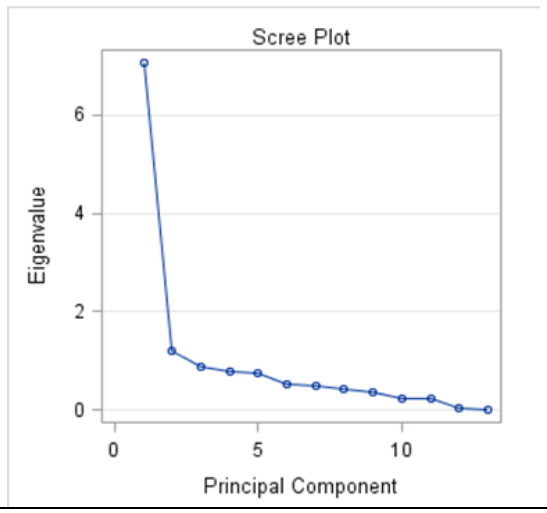
		
Sample goat flock in highland	Sample goat flock in midland	Sample goat flock in lowland)

Appendix figure 1: Sample goat flock structure in the study area

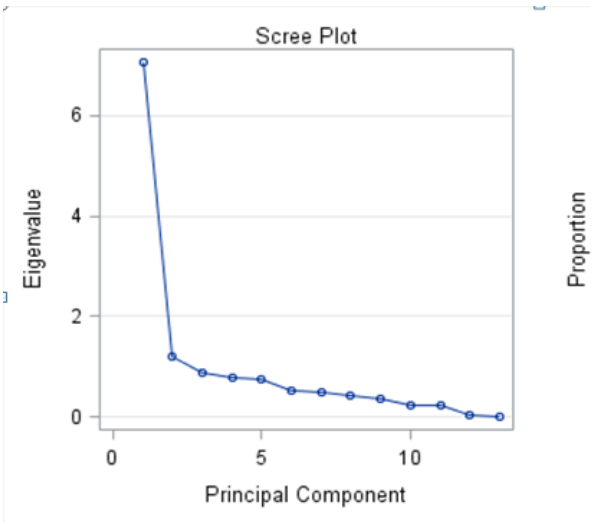
Appendix figure 2: Sample grazing of goat separately herded (left) and herded with cattle (to the right side) in the study area



Appendix figure 3: Spatial Distributions of Female (Left) and Male (Right) on the First Two Canonical Variants (CAN1 and CAN2)



Male goats



Female goats

Appendix figure 4:Principal Components by Scree Plot of Quantitative Measurements of Goat (Male in the Left Side and Female in the Right Side)