ON FARM PHENOTYPIC CHARACTERIZATION OF INDIGENOUS GOAT TYPES REARED IN BENA-TSEMAY AND DEBUB ARI DISTRICTS OF SOUTHERN REGIONAL STATE, ETHIOPIA

MSc Thesis

ZERIHUN FISEHA BOGALE

HAWASSA UNIVERSITY

College of Agriculture

Hawassa, Ethiopia

April, 2022

PHENOTYPIC CHARACTERIZATION OF INDIGENOUS GOAT TYPES REARED IN BENA-TSEMAY AND DEBUB ARI DISTRICTS OF SOUTHERN REGIONAL STATE, ETHIOPIA

ZERIHUN FISEHA BOGALE

ADVISOR: ABERRA MELESSE (Prof.)

CO- ADVISOR: SOLOMON ABEGAZ (PhD)

A Thesis Submitted to the School of Animal and Range Sciences,

HAWASSA UNIVERSITY

College of Agriculture

In Partial Fulfillment of the Requirements for the Degree of Master of Science In Animal and Range Sciences (Specialization: Animal Breeding and Genetics)

Hawassa, Ethiopia

April, 2022

HAWASSA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

ADVISOR'S APPROVAL SHEET

(SUBMISSION SHEET I)

This is to certify that the thesis entitled **''Phenotypic Characterization of Indigenous Goat Types Reared in Benatsemay and Debub Ari Districts of Southern Regional State, Ethiopia''** submitted in partial fulfillment of the requirements for the degree of Master in **Animal and Range Science** with specialization (**Animal Breeding and Genetics),** the research has been carried out by **Zerihun Fiseha Bogale ID. No GPAnBrR/0018/11,** under my/our supervision. Therefore I/we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

Submitted by:

Student : Zerihun fiseha	_____	_____
	Signature	Date
Major Advisor: Aberra Melesse (Prof.)	_____	_____
	Signature	Date
Co-advisor: Solomon Abegaz (phD.)		12/02/2022
	Signature	Date
School head:	_____	_____
	Signature	Date
SGS coordinator :	_____	_____
	Signature	Date

HAWASSA UNIVERISITY

SCHOOL OF GRADUATE STUDIES

EXAMINERS' APPROVAL SHEET II

We, the undersigned, members of the board of examiners of the final open defense by ZERIHUN FISEHA BOGALE, have read and evaluated his thesis entitled **''Phenotypic Characterization of Indigenous Goat Types Reared in Benatsemay and Debub Ari Districts of Southern Regional State, Ethiopia''** and examined the candidate. This is, there for, to certify that the thesis has been accepted in partial fulfillment of the requirements for the Degree of Master of science in Animal and range Science: (specialization: Animal Breeding and Genetics).

_____	_____	_____
Name of the Chairperson	Signature	Date
_____	_____	_____
Name of Major Advisor	Signature	Date
_____	_____	_____
Name of Internal Examiner-I	Signature	Date
_____	_____	_____
Name of Internal Examiner-II	Signature	Date
_____	_____	_____
Name of External Examiner	Signature	Date
_____	_____	_____
SGS Approval	Signature	Date

DEDICATION

I dedicate this thesis manuscript to my honored father Mr. FISEHA BOGALE, my mother Mrs. LIYOU SHAWUL, my beloved wife, Mrs. TENAYE BOGELE, my daughter FILSETA ZERIHUN and my son DAGIMAW ZERIHUN affectionately. Without their love, encouragement and moral support I would not be successful.

STATEMENT OF AUTHOR

First, I declare that this dissertation is my bona fide 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 an MSc degree at the Hawassa University. I truly declare that this thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Name: Zerihun Fiseha Bogale **Signature**: ----------

Place: College of Agriculture, Hawassa University, Hawassa

Date of Submission: ----------

ACKNOWLEDGEMENT

First and foremost, I would like to thank the Almighty God for granting me hope, love, patience, blessing and also for his commitment and protection to me and my families throughout my study. For His unlimited mercy I would like to praise Him! I would like to express my genuine and sincere appreciation to my major advisor, Prof.Aberra Melesse, who advised me starting from proposal preparation, research work and the final write-up and shaping of the Thesis. No words to mention for his treatment, very kind approach, excellent cooperation and unreserved efforts. Special thanks and appreciations also go to Dr. Solomon Abegaz, my co-advisor, for his useful advice and sharing me his unlimited knowledge towards my thesis research. I want to express my sincere gratitude to Mr. Addisu Jima, He sacrificed his golden time and helped me during data analysis. I would like to thank the Gates foundation project for offering all necessary funds during my study. My heartfelt gratitude goes to the Head and staff members of School of Animal and Range Sciences of Hawassa University for their contribution in learning, teaching process and mainly I would like to appreciate Dr. Mestawat Taye for her effort, positive altitude and care for others. I also like to extend my heartfelt thanks, respect and deepest love to all the member of my lovely family, mainly my wife Mrs. Tenaye Bogale, and my daughters: Filseta Zerihun, Tizita Zerihun and my son Dagimaw Zerihun for their endless love and moral support throughout my study. I also would like to appreciate all the managers and staff members of south livestock and fishery resource bureau (BOLF) for their financial, material and moral support during the study especially Mr. Eyasu Terefe and Mr.Teklu Tesema for their effort and positive altitude. Finally I would like to thank all in one way or the other that contributed to the success of this work.

LIST OF ABBREVIATIONS OR ACRONYMS

1PPI	One Pair of Permanent Incisors
2PPI	Two Pair of Permanent Incisors
3PPI	Three Pair of Permanent Incisors
4PPI	Four Pair of Permanent Incisors
ANOVA	Analysis of Variance
BL	Body Length
BCS	Body Condition Score
BWt	Body Weight
CC	Cannon Bone Circumference
CCPP	Contagious Caprine Pleuro Pneumonia
CD	Chest Depth
CW	Chest Width
DBnT	Distance Between Teats
DMY	Daily Milk Yield
ErL	Ear Length
HG	Heart Girth
HL	Horn Length
HLt	Head Length
HtW	Height at Wither
HW	Head Width
PAs	Peasant Associations

LIST OF ABBREVIATIONS OR ACRONYMS (CONTINUED)

PG	Punch Girth
PPR	Pest des Petit Ruminants
RHt	Rump Height
RL	Rump Length
RW	Rump Width
SC	Scrotum Circumference
SE	Standard Error
SPSS	Statistical Package for Social Sciences
StHt	Sternum Height
TDFg	Teat Distance from Ground
TD	Teat Diameter
TL	Teat Length
UC	Udder Circumference
UL	Udder Length
UW	Udder Width

TABLE OF CONTENTS

LIST OF TABLES

TABLE **PAGE**

LIST OF TABLES (CONTINUED)

TABLE **PAGE**

LIST OF TABLES (CONTINUED)

TABLE **PAGE**

LIST OF FIGURES

FIGURE **PAGE**

LIST OF TABLES IN APPENDIX

TABLE IN APPENDIX PAGE

LIST OF TABLES IN APPENDIX (CONTINUED)

TABLE IN APPENDIX **PAGE**

LIST OF FIGURES IN APPENDIX

FIGURE IN APPENDIX PAGE

PHENOTYPIC CHARACTERIZATION OF INDIGENOUS GOAT TYPES REARED IN BENA-TSEMAY AND DEBUB ARI DISTRICTS OF SOUTHERN REGIONAL STATE, ETHIOPIA

By Zerihun Fiseha

Major-Advisor: Aberra Melesse (Prof.)

Co- advisor: Solomon Abegaz (PhD)

ABSTRACT

*The study was conducted to physically characterize indigenous goats' population in Debub Ari and Bena-Tsemay districts (Debub Omo zone). A total of 180 households were identified by using multi-stage (purposive and systematic) sampling techniques for characterization of the survey study. 630 mature goats were sampled randomly for the phenotypic characterization. The average (±SD**)** goat flock size per house hold was 14.97±7.4 for Bena-Tsemay district which was significantly (P<0.01) higher than the 9.07±6.3 heads/household for Debub Ari district. Saving was primary purpose of male goats rearing both in Debub Ari and Bena-Tsemay districts. Similarly respondents in Debub Ari keep female goats primarily for asset (saving) with the index value of 0.53 whereas respondents in Bena-Tsemay district keep female goats for income source with the index value of 0.53. The major criteria considered for selecting breeding bucks and does in both districts were physical appearance and body conformation. Natural pasture was the main feed source and rivers, pond and rain water were main water source for goats. The age at puberty of male goats was 10.19±1.17, and 11.71±0.81 months while for females it was 9.92±0.93 and 11.45±1.04 months in Debub Ari and Bena-Tsemay, respectively. The average kidding interval for Debub Ari and Bena-Tsemay goat was 8.57±0.62 and 8.09±0.65 months, respectively. Disease and feed shortage were the major production constraints in studied districts. 52.38% of goats in Debub Ari and 60% of goats in Bena-Tsemay had patchy coat color pattern. Among the sampled goat population, brown coat color was dominant one on both sexes. Majority of female and male goats were horned and had horizontally carried ear orientation both in Debub Ari and bena-Tsemay districts. Fully matured (4ppi) female goats (30.46± 0.58, 25.15±0.16) and male goats (34.43±0.35, 33.33±0.81) had average body weight (kg) in Debub Ari and Bena-Tsemay district respectively. Positive correlation (P<0.01) were observed among most of the different body measurements for female and male goats population. Paunch girth (52.3%) and chest girth (77.3%) had high coefficient of determination (R^2) for female and male respectively to estimate live body weight from others linear body measurements. The result revealed that the goats' populations were related with woyito-guji goats' type and more suitable for meat than milk production but it needs genotypic characterization to classify the goats' breed clearly.*

***Key words**: Debub omo zone; Districts; Indigenous goats; Morphological traits.*

1. INTRODUCTION

1.1. Background and Justification

Agriculture is the major economic activity in Ethiopia, in which livestock sector plays a significant role in the economic, social and cultural development of the farming community. The country is endowed with diverse agro ecologies suitable for diverse livestock resources and natural resources. These potentials make the country prominent repository for animal genetic diversity. According to CSA (2021) Ethiopia has 70.00, 42.90, 52.50, 2.15, 10.80, 0.38, 7.70 and 57.00 million heads of cattle, sheep, goats, horse, donkey, mule, camels and chickens, respectively.

Small ruminant in general and goat production in particular, contributes significantly to the national and household economy in Ethiopia. Goat production is one of the integral parts of livestock farming activities of the country. With respect to their originality, almost all of the goats are indigenous/native breeds, which account about 99.9 % (CSA, 2021).

The majority of the goat population is found in large flocks in the arid and semi-arid lowlands where pastoralists in the south, east and west keep them for milk production, for meat production and for sale. Goats in the highlands are widely distributed in the mixed crop-livestock production systems with very small flock size as a means of cash earnings and meat (Solomon, 2014). Traditional livestock breeds, unlike modern commercial breeds, play multiple roles. Some of the roles of indigenous goat breeds in Ethiopia include: milk, meat and part of the cultural heritage of the communities keeping them. They have multiple values and special merits like adaptation to their unique environment and have different production potentials such as twinning percentage and growth (ESGPIP, 2008). Goats also fulfill various functions such as generating cash income, serving as household security, accumulating capital,

and fulfilling cultural obligations (Dhaba *et al.,* 2012; Gebreyesus, 2012; Misbah, 2013). The small body size, broad feeding habits, adaptation to unfavorable environmental conditions and their short reproductive cycle provide goats with a comparative advantage over other species to suit the circumstances of especially resource-poor livestock keepers (Gurmesa *et al.,* 2011).

The milk production potential of Ethiopian indigenous goats has not been adequately studied in the past and most of the studies are done on-station. Research results indicated that the goat production accounts for 16.7% of milk consumed in the country (Tsedeke, 2007) and daily milk yield (DMY) of indigenous Ethiopian goats ranged between 0.28 kg to 1.13 kg under improved management (MOA, 1999; Mestawet *et al.,* 2012). However, there is a good potential to increase the DMY to about 1 kg through improved management system and relatively higher DMY is produced from the lowland goats as compared to the highland goats (Dereje *et al.,* 2015).

Research results reported by Belete (2009) indigenous Ethiopian goats produce about eight million quality premium skin per annum. For instance, Bati goat type is renowned for its high quality skin worldwide (Mahmoud, 2010). According to the author, the skin is thicker, highly flexible and with clean inner surfaces, and excellent for producing high quality suede leather. No recognized use of fiber has been reported from Ethiopian goats though some goat breeds (e.g. Arsi-Bale goats of Bale highlands) are known to have long hair (Solomon, 2014). Despite the large population of goats, Ethiopian indigenous goats are genetically less productive as compared to temperate breeds (Mohammed *et al.,* 2012). The average carcass weight of Ethiopian goats is about 10 kg, which is the second lowest in sub-Saharan Africa (Amha, 2008). Factors like slaughtering goats at immature body weight, poor nutrition, prevalence of

diseases, lack of appropriate breeding strategies and poor understanding of the production system contributes for low meat yield (FAO, 2008; Tesfaye, 2009).

Phenotypic and genetic characteristic information is a prerequisite to sustainable breed improvement, utilization, and conservation (FAO, 2012). The characterization of local genetic resource based on morphological trait plays a very fundamental role in the classification of animals based on size and shape in turn which to some extent reasonable economic indicator (Okpeku *et al.,* 2011) and are the first step towards the use of the available animal genetic resources (AnGRs) (Lanari et al., 2003). Knowledge of the adapted goat genetic resources is a pre-requisite for designing appropriate breeding and utilization programs.

Morphometric measurements have been used to evaluate the characteristics of various breeds of animals, and could provide first-hand information on the suitability of animals for selection (Martins *et al.*, 2009; Yakubu, 2010) and for further characterization studies using modern molecular methods.

The previous research by FARM Africa(1996) on phenotypic characterization indicated that there are about 13 goat types in Ethiopia while, a genetic study that used microsatellite markers showed only eight distinctively different types of goats in Ethiopia (Tesfaye, 2004). However, the current molecular study on the domestic goats by Getinet (2016) did not support the former classifications of the indigenous goat populations. After detailed analysis of the goat population based on production systems, agro-ecologies, goat families, admixture and phylogenetic network analyses the author classified the 12 Ethiopian goat populations in to six goat types. However, according to FAO (2007) changes in population type and structure need

to be documented regularly for all breeds at intervals of about five years for cattle, buffalo, sheep and goats.

The Southern Nations, Nationalities and people Regional State (SNNPRS) of Ethiopia has approximately 4.82 million goat population with its great variation in climate and topography representing a good reservoir of goat genotypes (CSA, 2019/20). The current study area, Debub Omo zone is characterized by diverse agro-ecological settings and predominantly categorized under arid area where goats play increasingly significant roles for communities that who keep them. There is a long tradition of small ruminant production and huge goat resources in the zone. However, despite having huge benefits for the society goat's phenotypic traits and documented information particularly on goat phenotypic characterization in the study area is lacking. To conserve and utilizes our animal's resources effectively, it is necessary to characterize indigenous goat populations under different agro ecology of the country. Therefore, the study was initiated with the following objectives:

1.2. Objective

1.2.1. General Objective

The General objective of this study was to characterize indigenous goat population in selected districts of the Debub Omo zone.

1.2.2. Specific Objectives

- To characterize indigenous goats' types based on their morphological (qualitative and quantitative) traits.

- To describe goats husbandry practices and assess major constraints of goat production in study area.
- To analyze goat breeding objectives and selection criteria of farmers /pastoralists/ in the selected districts
- To develop prediction equation for estimation of body weights from linear body measurements for indigenous goats types in the study area.

1.3. Problem Statement

Ethiopia is endowed with huge livestock genetic resources and Goat production is ancient and widely practiced in the country. The previous research implementation on characterization of indigenous goat populations was impressive but, there are goat populations still not well characterized and productivity or output per goat is low due to number of limitations like genotype, feed, diseases, institutional, environmental, infrastructural, knowledge gap of the farmers to adapt technology and lack of attention to improve local breeds. This condition has a great influence in the goat production and productivity. The absence of adequate information on the characteristics of breeds potentially leads to wrong decision and genetic erosion through cross breeding and breeds replacement.

1.4. Significance of the Study

This study was designed to characterize indigenous goat populations reared under farmers' management in the study area. The quantitative and qualitative data (morphological traits) which had been collected from the study area was analyzed and used to generate baseline information on goat populations (type) of the study area. Identification, characterization and documentation of the breeds or strains and the type of environment in which they are kept,

description of the breed characteristics, their adaptation as well as production potentials in those environments are the prerequisite for genetic improvement work. Thus characterizing this goat genetic resource is essential for efficient utilization and conservation of genetic resources as well as to plan different developmental strategies like community-based genetic improvement program.

2. LITERATURE REVIEW

2.1. Origin and Domestication of Goat

Goats (Capra hircus) were among the first domesticated animals, adapted from the wild-type Capra aegagrus (Zeder and Hasse, 2000). Archeological studies show that goat was the earliest ruminant and probably the first animal domesticated by a man after the dog (Hole, 1996; Uerpmann, 1996). Goat is a member of the Bovidae family and closely related to the sheep as both are in the goat-antelope subfamily caprine. According to Hirst Kris (2008) Goats were domesticated from the wild version of Capra aegagrus about 10,000-11,000 years ago, by Neolithic farmers in the Near East and there are nearly 500 breeds of goats and 600-700 million goats in the world, living in climates ranging from high altitude mountains to deserts (Galal, 2005). It is disseminated all over the world because of their great adaptability to varying environmental conditions and different nutritional regimes under which they were evolved and subsequently maintained (Mahmoud, 2010).

African goats could be grouped into three main families which are Dwarf goats of West and Central Africa, Savannah goats of sub-Saharan Africa and Nubian type goats of North Africa (Wilson, 1991). The ancestors of Ethiopian goats are closely associated with the one migrated from the Middle East and North Africa (Kassahun and Solomon, 2008). It is assumed that the first wave of goats entered Ethiopia from the north between 2000 and 3000 B.C (Rege and Lebbie, 2000).

2.2. Ethiopian Indigenous Goat Distribution and Classification

Ethiopia has long been recognized as a source of large diversity of farm animal genetic resources in which an estimated 50.50 million heads of goats are reared (CSA,19/20). A domestic animal population may be regarded as a breed if the animals fulfill the criteria of

being subjected to a common utilization pattern; sharing a common habitat/distribution area; representing largely a closed gene pool and being regarded as distinct by their breeders in general (FAO, 2012).

In developed countries breeds are defined in terms of a set of phenotypic standards, the use of breed herd books and the existence of formalized breed societies that are often supported by legislation where as in developing countries livestock-keeping communities and governments apply the term more loosely and identify breeds more with geographic localities, ethnic identities and the traditions of their owners than with their phenotypic attributes (FAO, 2012).

Goat breeds found in Ethiopia have been identified and classified based on their differences in physical characteristics and genetic make-up (Solomon, 2009). Based on physical description, Ethiopian goat population has been classified into 13 goat types (Farm-Africa 1996). These are Afar, Abergele, Anglo-Nubian, Arsi-Bale, Begayit (Barka), Central Highland, Hararghe Highland, Kaffa, Long-eared Somali, Small-eared Somali, Western Highland, Western Lowland, and Woyto-Guji. Tesfaye (2004) has classified indigenous goat types of Ethiopia in to 8 distinct genetic entities using genetic DNA markers, these are Arsi-Bale, Gumuz, Keffa, Woyto-Guji, Abergele, Afar, Highland goats (previously separated as Central and North West Highland) and the goats from the previously known Hararghe, Southeastern Bale and Southern Sidamo provinces (Hararghe Highland, Short-eared Somali and Long-eared Somali goats). These goat populations are found in various agro-ecologies.

Based on differences in physical characteristics, four families and 12 breeds of goats have been identified in Ethiopia. The families and breeds are named after their geographical

location, the ethnic communities maintaining them, or based on some identifying physical features (Table 1).

Table 1. Ethiopian Indigenous Goat Breeds, Distribution, and their Production System

Family	Breed/Type	Distribution/Location	Common names/Local names	Production System
Nubian	Nubian	North-west Ethiopia	(Wegera) Shukria, Langae, Hassen	Pastoral
Rift valley	Afar	Afar Region	Adal, Danakil	Pastoral
	Abergele	Along the Tekeze River, Northern Wollo, Gondar	-	Mixed farming, agro-pastoral
	Arsi-Bale	Highlands of Arsi, Bale and East Shewa	Gishe, Sidama	Mixed farming to agro-pastoral
	Woyto-Guji	North and South Omo, Gamu Gofa and Eastern Sidamo (Guji)	Woyto, Guji, Konso.	Pastoral to mixed farming
Somali	Hararghe Highland	Highlands of Eastern and Western Hararghe	Kotu-Oromo	Mixed farming
	Short-eared Somali	Northern and Eastern parts of Ogaden and around Dire Dawa	Issa-Somali, Ogaden, Modugh, Denghier, Agal, Habib, Bimal	Pastoral
	Long-eared Somali	Throughout the Ogaden, lowlands of Bale, Borana, and Southern Sidamo	Large-White Somali, Digodi, Degheir, Melebo, Boran Somali, Benadir, Gigwain, Ogaden	Pastoral

Table 1, (continued)

Family	Breed	Distribution	Common name	Production system
Small East Africa	Central high land	Northern Ethiopia (NorthGonder, Wollo,Tigray)	Brown Goat	Mixed farming
	Western high land	High lands of Western Ethiopia (South Gonder, Gojam,Wellega,and Western shoa)	Agew	Mixed farming
	Western low land	Lowlands of Western Ethiopia (Metekel, Asossa, and Gambela	Gumuz	Agro-pastoral
	Keffa	Keffa, part of South Shewa, Kembata, and Hadiya	-	Mixed farming

Source: FARM-Africa, 1996; DAGRIS, 2007; Solomon Gizaw, 2009

2.3. Goat Production Systems in Ethiopia

In Ethiopia, there are various factors that should be considered to categorize small ruminant production systems. According to Solomon *et al.*, (2010) goats are maintained under two broad production systems which are mixed crop-livestock and pastoral and agro-pastoral production system. Based on the prevalent agricultural activity, Getahun (2008) reported four production system categories; annual crop-based, perennial crop-based, cattle-based, and small ruminant dominated systems. Solomon *et al.*, (2008) put the prevailing production

systems into three major categories which are highland sheep–barley, mixed crop-livestock, and pastoral and agro-pastoral production systems. The authors also stated that ranching, urban and peri-urban (landless) sheep and goat production systems are the other production systems that are not practiced widely in the country but have a future.

2.3.1. Mixed crop and livestock

A mixed crop-livestock production system is prevalent in humid, sub-humid and highland agro-ecological zones. Crop-based mixed farming systems often comprise some goats, with very small flock sizes, as a way to generate cash and produce meat (Tesfaye, 2004). Major feed sources include natural pastures, crop residues, industrial by-products, and tree legumes in cut and carry system (Kidus, 2010; Dereje *et al.,* 2013; Dhaba *et al.,* 2012; Tegegne *et al.,* 2013). In some areas, grazing is under tethering while in others it is either free or herded and goats graze and browse on communal land (Deribe, 2009; Tegegne *et al.,* 2013). In most cases, goats are housed with the family (Endeshaw, 2007; Deribe, 2009; Kidus, 2010) or in a separate housing (Belete, 2009; Kidus, 2010; Dhaba *et al.*, 2012).

In this production system goats are kept by smallholders and graze together with sheep and/or other livestock such as cattle. These mixed herds usually freely graze on communal pastures and seasonally on fallow crop land with no extra-supplement and receive minimum health care. However, due to the increasing population pressure in areas with this production system, free grazing is becoming limited and goats are now tethered, reflecting the challenge of procuring sufficient feed in this system (FARM-AFRICA, 1996). Furthermore, in highland agro ecology, as in central Ethiopia, the increased human population has led to decreased farm size and a gradual shift from keeping large cattle to small ruminants, mainly goat and sheep (Peacock, 2005).

2.3.2. Pastoral and agro-pastoral

In pastoral and agro-pastoral systems, which are found in arid and semi-arid agro-ecological zones, goats are kept by nearly all pastoralists, freely grazing or browsing in the rangelands (Solomon *et al.,* 2010). Pastoral systems are associated with agro-ecological zones that are too dry to sustain crop production. These are characterized by little or no crop agriculture and high mobility in search of grazing and water. Correspondingly, the agro-pastoral system is characterized by less integration with crop production as compared to the crop-livestock production systems (Solomon *et al.,* 2008). Most goats are kept under extensive systems in the Ethiopian lowlands where the main production system is pastoral or agro-pastoral. Flock sizes can be very large (>150 in some pastoral and agro-pastoral areas (Gebreyesus, 2012; Misbah, 2013). Feeding is predominantly on rangeland-based pastoral systems, with periodic use of crop residues in agro-pastoral areas. Water availability is usually a limiting factor, with more adapted breeds such as the Short and long-eared Somali breeds requiring less frequent watering. Thorny enclosures are common in pastoral areas with pens made for the kids (Gebreyesus, 2012).

2.3.3. Urban and peri-urban

Despite there being goat production in towns all over the country this system has received little research attention. No reliable quantitative data is available on urban and peri-urban goat production but it is not uncommon to observe goats in urban areas including the capital Addis Ababa (Solomon *et al.,* 2008). With the expansion of khat (Catha edulis) in almost all parts of the country, goats frequently serve as ‘cleaners' of the leftovers. The population and contribution of goats in urban and peri-urban areas need to be quantified and associated value chains studied. The environmental impacts of these production systems also need to be investigated.

2.4. Methods of Animal Genetic Resources Characterization

Basic decision making in livestock development and breeding program requires a good understanding of breed characteristics (FAO, 2007). Breed characterization includes all activities related with the description of the origin, development, structure, population, quantitative and qualitative characteristics of the breeds in defined management and climatic conditions (Gizaw *et al.,* 2011). Describing and classifying of livestock breeds and species at molecular level by measuring frequencies of genotypes and alleles, degrees of polymorphism, allelic diversity (observed and expected hetrozygosity) and genetic distances activities are also another complementary breed characterization (Solomon, 2014). So that breeds can be characterized by both phenotypic and advanced-molecular level.

2.4.1. Phenotypic characterization

Phenotypic characterization is the process of identifying distinct populations and describing their external and production characteristics within a given production environments and geographical distributions; taking into consideration the social and economic factors that affect (FAO, 2015). The external characteristics for breeds descriptors are (coat color, ear type and shape, horn shape and type), linear body measurements (such as height at wither, heart girth, body length, ear length), production traits (body weight, milk yield) and reproductive traits (such as age at first kidding, litter size) (FAO, 2012). Phenotypic characterization provides a crude estimate of the average of the functional variants of genes carried by a given individual or population (FAO, 2007) and is comparatively easy and cheap means of breed characterization but phenotypic characters are highly influenced by environmental effects. Therefore, it should be supported by molecular characterization (Gizaw *et al.,* 2011).

2.4.2. Molecular (Genetic) characterization

Phenotypic characterization provides a crude estimate of the average of the functional variants of genes carried by a given individual or population. Molecular (genetic) characterization, by

itself or in conjunction with other data (phenotypic traits or geo-referenced data), provides reliable information to assess the amount of genetic diversity. Information about the genetic make-up of populations also helps decision making for conservation activities (Boettcher *et al.*, 2010). Protein polymorphisms were the first molecular markers used in livestock. With the development of Polymerase Chain Reaction (PCR) and sequencing technologies associated with automatic and/or semi-automatic large-scale screening system, several molecular markers have been widely used for genetic diversity and phylogenetic analyses in livestock breeds or populations (Charoensook *et al.*, 2013). A number of molecular markers are available to detect polymorphisms at the DNA level. The most popular markers in genetic diversity studies are simple sequence repeats (SSR) or microsatellites, restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD), amplified fragment length polymorphism (AFLP), single nucleotide polymorphism (SNP) and mitochondrial DNA (mt DNA) analysis (Charoensook *et al.*, 2013). The Food and Agricultural Organization of United Nations has proposed a global program for the management of genetic resources using a molecular methodology for breed characterization. However, in Ethiopia, only limited goat genetic characterization activities (Tesfaye, 2004; Halima et al., 2012b; Getinet, 2016) had been conducted on some goat breeds using microsatellite markers.

2.5. Performance of indigenous goats

Evaluation of the performance of economically important traits of the goat is very useful inputs for a breeding program plan. The most important traits of livestock (goat) are broadly classified into two categories: production and reproductive traits (Solomon, 2014).

2.5.1. Growth performance

To increase economic return from goat meat, production requires improvements in market weight of kids and mature goats. Growth performance may be separated in pre-weaning (birth weight, weaning weight and pre-weaning growth rate) and post-weaning (six months weight, yearling weight and mature weight) (Solomon, 2014). The growth performance of goats is affected by many genetic and non-genetic factors. The early stage of growth performance of kids is largely influenced by genotype and the milk yield of the does. Parity, type of birth, sex, season and year of birth also influence the growth performance of goats (Bedhane *et al.*, 2013; Derbie and Taye, 2013 quoted in Solomon, 2014). Kids which are heavier at birth are usually singles or are those produced by does with larger body sizes and good feeding conditions (Devendra and McLeroy, 1988). Kids born as singles and twins had significantly higher birth weight than kids born as triplets (Saddul *et al.,* 1999). Most of Ethiopia goats' adult body weight range from 25-40 kg (Peacock, 1996). Birth weight, weaning weight and pre- weaning average daily gain performance of some Ethiopian goat breeds are presented in table 2.

Table 2. Birth, weaning, weight and pre- weaning average daily gain of some Ethiopian goat types under different management condition.

Goat type	Management type	Bwt (kg)	Wt (kg)	PWADG(g/day)	Reference
Abergelle	Intensive	2.4-2.6	6.0-8.9	33-55	Birhane and Eirk ,2006
Arsi –Bale	Intensive	2.45	9.2	71.76	Mehlet, 2008
Arsi –Bale	Traditional	2.28	8.39	72.21	Tatek et al., 2004
Arsi –Bale	Traditional	2.52	9.56	NA	Endashaw,2007
Keffa	Traditional	2.78	9.0	NA	Belete, 2009
Somali	Station	3.19	11.67	61.25	Zeleke, 2007
Togenberg x Arsi – Bale	Station	2.57	9.43	NA	Girma,2002

Bwt= Birth weight; Wt=Weaning weight; PWADG=Pre-weaning average daily gain; NA=Not available

2.5.2. Reproductive performance

Reproductive performance is an important criterion when evaluating the structure of the strength and weakness of the breeds in particular production environments. Mukasa Mugerwa *et al*., (2002) stated that reproduction failure is the first indicator of decreased flock productivity. Litter size, age at first kidding and kidding interval are economically important reproductive traits and their values of some of Ethiopian goat breeds under different management conditions are summarized in Table 3.

Table 3. Reproductive performance of some of Ethiopian goat breeds

Goat type	AAFK(months)	KI(months)	Litter size	References
Arsi-Bale(Halaba)	12.1	6.9	1.75	Tsedeke, 2007
Arsi-Bale	13	8.07	NA	Samuel, 2005
Arsi–Bale(Loka Abaya)	14.8±0.3	6±0.2	2.07	Endeshawu, 2007
Keffa	12.5	7.9	1.7	Belete, 2009
Unspecified (Metema)	13.6±2.44	8.4±1.37	NA	Tesfaye, 2009

AAFK=Age at first kidding; KI=Kidding interval; NA=Not available

2.6. Goat breeding objectives and selection criteria for farmers in Ethiopia

2.6.1. Goat breeding objectives of farmers

Farmers breeding management decision is determined by the merit of livestock species and breed, breeding objectives and the production environment (Solomon *et al*., 2010). Defining breeding objectives involves identifying breeding objective traits, deriving their relative importance and constructing the aggregate genotype that can subsequently be translated into a selection index (Kosgey, 2004). Breeding objectives are affected by many factors and have to consider the needs and priorities of the animal owners or producers, the consumers of animal products, the food industry, and increasingly also the general public. Lack of participation of farmers in defining the breeding objective was the main reason for the failure of many livestock improvement programs in the tropics (Wurzinger *et al.,* 2011). The report of Tegegn et al., (2013) shows that the breeding objectives of goats in Benchi maji zone were to improve growth of goats and increase income. The report of Judith (2006) indicates that the Abergelle meat and dairy goat is stated to have a live weight of 18-20 kg at 8 months or to provide an

equivalent 8-9 kg carcass. The Central Highlands meat goat is stated to reach 25-30 kg within 1 year or an equivalent 11-13.5 carcass. Ethiopian goats in the lowlands are highly valued and reared mainly for milk and meat production (Kassahun and Solomon, 2008).

2.6.2. Goat selection criteria and trait preferences of farmers

Farmers have their own criteria for selection of breeding goat. Farmers in different production systems may have different trait preferences and they may also follow as diverse strategies as the agro-environments within which they perform (Solomon *et al.,* 2010). Understanding farmers' trait preferences provide insights into which traits are particularly important in their agro-ecosystem and how these can be incorporated into the design of sustainable breeding programs. Selection of breeding stock by farmers is by using their indigenous knowledge. They depended on information about the potential of buck or doe and growth performance, information from relatives (ancestor) and assessment of young buck and or doe. There were no records on the performance of individuals and their pedigree. Identification was mainly by phenotypic appearance. Lack of animal records and identification has very serious implications, as no effective selection and breeding programs can be applied in the absence of records (Jimmy *et al*., 2010). Belete (2013) reported selection criteria of farmers in Bale zone for the breeding buck are appearance, color, character, growth, prolificacy, testicular characteristics, better sexual ability and pedigree (family) history while for breeding does are appearance, color, better milk yield, mothering ability, kid survival and growth, short Kidding interval and twinning ability.

2.7. Socio-Economic Importance of Goat

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 the

size of land-holding, suggesting that small ruminants have importance for landless people especially for rural women (Oluwatayo and Oluwatayo, 2012). In some cultural settings, women are not entitled to own land. For instance, African rural women (like Nigeria, Kenya, and Tanzania) have limited access to household's land and receive limited land use rights from their husbands (Quisumbing *et al*., 2001). As a result, crop production provides seasonal employment; hence, rearing of small ruminants would provide an employment opportunity and income throughout the year. In Ethiopia, livestock in general goats, in particular, plays a very important role in the lives of households. They have a great role in the economy of the farming community of the country. Sale of goats and goat products by farming communities is the major source of cash for the purchase of clothes, grains, and other essential household commodities. In the country, the purpose of keeping goats is to generate income, for labor, wage payment followed by food crop purchase, input purchase, school fee and as means of tax in that order (Deribe, 2009; Tesfaye, 2009).

2.8 Goat production constraints and opportunities in Ethiopia

2.8.1. Goat production constraints

Goat production and productivity in Ethiopia are generally low which is as a result of a combination of low reproduction rate, high mortality rate and slow growth rate (Solomon *et al*., 2010). They are said to be late in age at first kidding, low fertility, prolificacy and weaning rate and mature body weight (Dhaba *et al*., 2012). The average carcass weight of Ethiopian goats is 10 kg, which is the second lowest in sub-Saharan Africa (Adane and Girma, 2008) and indigenous goats are genetically less productive as compared to temperate breeds (Mohammed *et al*., 2012). Long distance traveling for feed and water searching; seasonal feed and water shortages, both in quality and quantity; diseases prevalence and parasites

infestation, particularly for early mortality on young stocks; poor veterinary services; and traditional goat management system is not market oriented, underdeveloped marketing information and infrastructure system, and poor financial facility (Berhanu *et al*., 2006; Solomon *et al*., 2010). Thus, the adoption and use of improved livestock technologies is very limited throughout the country. Performance recording is also another important tool to suggest the breeding policy for a given area. However, recording in general is hardly practiced in any livestock like goat species in the country, to identify the performance and management gaps (Tibbo, 2006). Thorough monitoring of the productive, reproductive and economic performance of small ruminants and their existing level of integration with crop production and other livestock keeping is required to capture a full picture of their contribution and there by verifying possible intervention areas (Getahun, 2008). The research approach has not also invited the end users for active participation. Improvements were too slow due to lack of identifying the actual on-farm situations and weighing the socioeconomic and cultural benefits of the animals for the poor farmers (Deribe, 2009).

2.8.2. Opportunities

According to Tesfaye (2009) the opportunities of goat production in the Metema district of Amhara region was enough grazing (communal as well as individual) land that was not utilized for growing food crops. If this grazing land is properly managed, it could be a good source of good quality feed to boost goat production in the area.

At the world market, the demand for mutton and goat meat have been increasing due to an increase in income and increased population hence there is a growing demand for goats in both the domestic and export markets. Young male flocks have huge demand by the export

abattoirs. With the increased competitiveness in the market, farmers are looking for the alternative ways of breeding and fattening to increase their income.

According to Fikru and Gebeyew (2015) modest interventions on the existing flock impediments, such as minimizing flock loss through diseases and parasites control and proper feeding during dry seasons could potentially boost the flock performances. The local goat flocks demonstrate remarkable response to the local fattening management practices and possess desirable physical characteristics adding high aesthetic value. The local feeding management system entirely depended on natural pastures of spicy herbs drawn the preference of urban consumers like the present "organic agricultural products". High demand of the small ruminants in the local market as a result of population increase, urbanization, and increase in income (even within a district) can be considered as an opportunity for the small ruminant producers.

Nowadays, many abattoirs flourish in the country; so agents and assemblers purchase small ruminant even at farm gate. Several development partners involved in higher learning, research and development are currently committed to sheep and goat development. These could facilitate entry of intervention (inputs, technology and recommendation). Small holder farmers are aware of the current high market values and demand for goats. The support of IPMS under ILRI is sharing a good experience of community-based goat Improvement program with full participation of the beneficiaries (Tesfaye, 2009). At federal government level, there is pastoral standing committee which works on improving life pastoral communities. There are also many Non-Governmental Organizations (NGO) that are working on improving living and livelihood through improving the production and productivity of their animals. Government is also working to solve the challenges (Arse *et al.,* 2012).

3. MATERIALS AND METHODS

3.1. Description of the Study Areas

3.1.1. Debub Omo Zone

This study was conducted in Bena-Tsemay and Debub Ari districts of Debub Omo zone which is found in Southern Nation, Nationalities and Peoples Regional State (SNNPRS) and situated in the South western part between 4° 27′-60° 26′N latitude and 34° 57′-37° 49′E longitude. Map of the study area is indicated in Figure 1. Debub Omo zone is named after the Omo River, a river that flows south in to Lake Turkana on western side. Jinka, the capital of Debub Omo zone, is 750 km from the capital city of the country (Addis Ababa) and 530 km from Hawassa. Debub Omo zone has a total area of about 2,241,731.598 ha. Out of this, about 11.63% is cultivated, 37.4% is fertile and can be cultivable, 13.01% is grazing land, 16.25% of the area is covered by trees and bushes, and the other 21.72% is covered with grasses and shrubs which can be used for grazing. The traditional agro-ecology classification of the Zone was; Dega, Woinadega, Kola and Bereha cover 0.5, 5.1, 60, and 34.4 percent respectively. Rainfall pattern in the area is bimodal. The mean annual rainfall ranges between 400 and 1600 mm. The mean annual temperature ranges between 10^0_c and >27°c. maize, sorghum, barley, wheat, teff, godore, millet, cassava, haricot bean and field peas are some of the major crops grown in the area. Debub Omo zone has ten districts of which six (Malie, Bena-Tsemay, Hamer, Nyangatom, Salamago, and Dasenech) districts are categorized under pastoral areas.

According to CSA (2007) census the zone has a total population of 573,435, of whom 286,607 are men and 286,828 women. Cattle are the most important animals that play a great role in the livelihood of pastoralists. Cattle have various uses in the life of pastoralists such as a source of food in day to day life commonly milk, meat, butter, and sometimes blood during

the time of starvation (drought). In addition, they are major source of income (selling as live animal or selling their products). Goats are next to cattle in terms of their importance in pastoralist's livelihood. Livestock are core to pastoral livelihoods and pastoral identity, and livestock and livestock products contribute significantly as a food source and are usually the main source of income in pastoral livelihoods. Sheep, goats, cattle, camels, and donkeys are the predominant holdings (Judith and Steven, 2008). Bena-Tsemay and Debub Ari districts were selected purposively because of their potential for goat production and they have unique agro ecologies.

3.1.2. Bena-Tsemay district

Bena-Tsemay is one of the ten districts in Debub Omo Zone of Southern Nations, Nationalities, and Peoples' Regional state of Ethiopia. It is named after Banna and Tsamay people who live at this district and has 33 rural Peasant associations (Pas). The district is located between 04°59' and 05°58' N latitude and 36°12' and 37°30' E longitude. The district is characterized by semi-arid and arid climatic conditions, with altitudinal variation of 500 to 1800 meters above sea level (m.a.s.l) and mean annual rain fall averaging from 350-838mm in bimodal distribution. The main rain occurring in March to May and a short rain occur in September to October. The mean annual temperature ranges between 10^0c and greater than 35^0C. The administrative center is Key Afer. The livestock commodities of the district include cattle, sheep, goats' poultry and equines. The district has a high potential for goat production. The major crops grown in the district are sorghum, maize, pigeon pea, haricot bean, cassava, sunflower, small millet and sesame. (DLFRO, 2020).

3.1.3. Debub Ari district

Debub Ari district is one of the ten districts in Debub Omo Zone, Southern Nations, Nationalities and Peoples Regional state (SNNPRS), with an estimated area of 1,520 km^2 and is located at 5^0.67'-6^0.19' N and 36^0.30'-36^0.73'E. The altitude of the district ranges between 500m a.s.l and 3000 m a.s.l. The traditional agro ecologies Dega, woina-dega and kola cover 30, 65 and 5 percent respectively of the total areas. The district has a rain fall pattern of bimodal type Belg and meher. Belg rain ranges from February – April and Meher from July – September. The mean annual rainfall ranges between 601- 1600 mm. The annual temperature ranges between 10^0C and greater than 27.5°C. The district has different livestock species of which about 202,018 are cattle, 108,167 sheep, 52,160 goats, 14,113 equines, 117,519 chickens and more than 15,000 bee families. Maize, sorghum, barley, wheat, teff and coffee are the major crops grown in the area. The Ari ethnic group lives in the district with mixed /crop livestock/ farming system. Regarding the land use, the proportion of cultivated land, grazing land, forest land, cultivable land, non-cultivable land and others is 17, 15.08, 22.43, 8.3, 15.36 and 21.81 percent respectively (DLFRO, 2020).

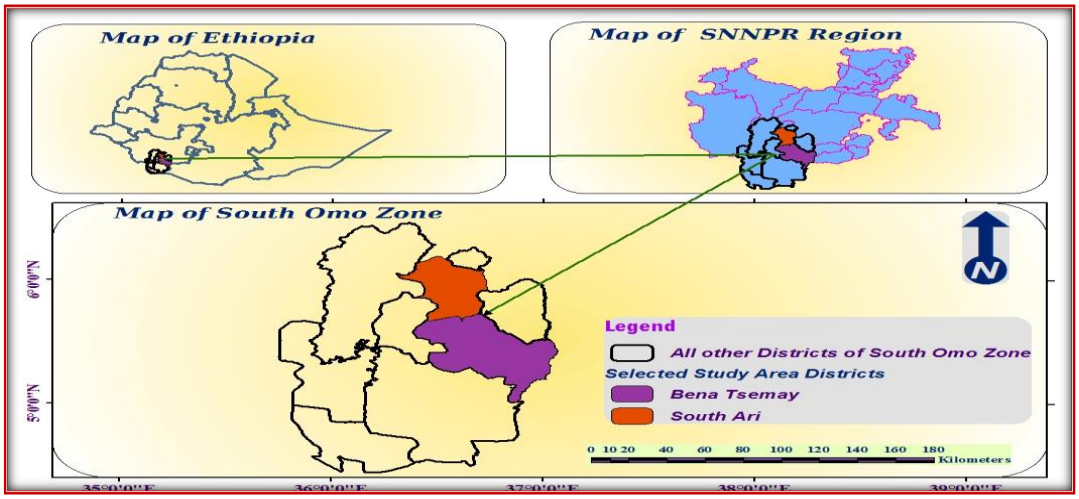

Figure 1.Geographical Location of the Study Area (Source: Ethio- Gis data, 2022)

3.2 Sampling procedures

Prior to formal survey, actual research and selection of PAs and HHs, participatory meeting and discussion with zonal and district livestock staffs, development agents, local farmers, village leaders and socially respected individuals who had known to have better knowledge was conducted to identify the present and past socio-economic status of the study area; the districts' range of agro-ecological conditions; the existing farming systems; about the origin, concentration and distribution of the local goat population**..** The two districts; Benatsemay district with 33 PAs and Debub Ari with 37 PAs were selected purposively based on goat population potential, agro-ecology representations and accessibility of infrastructure. From each districts three kebeles (peasant associations) were selected purposively based on relatively large goat population and agro-ecology representations (lowland or <1500m.a.s.l, mid altitude or 1500-2500m.a.s.l and high land or >2500m.a.s.l). During selecting sample goats from six peasant associations of the districts, castrated goats, pregnant doe, buck kids, doe kids, were avoided to enhance accuracy for body weight and leaner body measurements (LBMS) and to represent the adult goat population. For morphological characterization bucks and does whose age is one and above years were sampled from each Pas following the phenotypic descriptor of FAO (2012). Measurements were taken early in the morning to avoid the effect of feeding and watering on the animal's body weight and when they are on normal standing position during same season (FAO,2012). The age of the animals was estimated by recall and dentition methods as follows: no pair of permanent incisor (0PPI), one pair of permanent incisor (1PPI), two pair of permanent incisor (2PPI), three pair of permanent incisor (3PPI) and four pair of permanent incisors (4PPI) to represent age 0-1 year, 1-2 years, 2-3 years, 3-4 years and more than 4 years, respectively based on (FAO, 2012) for tropical goat breeds.

3.3. Sample size determination for households and goats

Sample size of households were determined by using multi-stage (purposive and systematic) sampling techniques based on the number of goat flock (those who had at least three mature goats) from different villages.180 households 30 households from each peasant association were interviewed, by imitating other researcher's work of small ruminant phenotypic characterization. The sample size of goats also were determined by the formula given by Cochran's (1997) as FAO (2012) recommended for phenotypic characterization of livestock for simple random sampling.

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

n = sample size
Z = standard normal deviation (1.96 for 95% confidence level)
P = 0.15 (estimated population variability proportion, 15%)
q = 1-P i.e. (0.85)
e = level of precision (0.05)

Based on the formula a total head of 588 goats (196 heads from each agro-ecology) were selected. In order to increase the accuracy adding up to 10% of the sample size on this calculated sample is recommended and 7% of the sample size was added in this calculated sample (588*7/100 =41.16, 588+41.16 =629.16) and a total of 630 goats were used for collecting data of qualitative and quantitative traits. Based on FAO (2012), from the total sample size 83.5% (526) were female and the remaining 16.5 % (104) were male goats

3.4. Data Types and Collection Methods for Phenotypic Characterization

Semi-structured questionnaire, group discussion, field measurements and secondary information sources were used to gather qualitative and quantitative data on goats' production system and husbandry practices.

3.4.1. Questionnaire and group discussion

Semi structured questionnaires were prepared, translated in to Amharic language and interviewed by local language. After pre-tested on selected respondents, administered to collect information on the existing socio-economic characters (sex, age, education level, major cash income source, farming activities, main food sources of respondents, livestock possession, goat flock structure, economic benefit of goats (objectives of goat production), feed sources and browsing methods, water source and watering method, housing, fattening and castration practices, sources and typical feature of goats, breeding practices and possession of bucks, ability of farmers to identify sire of kids, response to inbreeding in the flock, purpose of keeping breeding bucks, selection criteria of goats, coat color preference of farmers, reproductive performance of goats, common disease of goats, disposal and marketing age of goat and major goat production constraints were collected from each selected respondent or flock owners via interview. Organized group discussion were held with clan or village leaders, district agricultural experts (extension agents), goats owners and elderly female and male member of the society who are known to have better knowledge on the present and past social and economic status of the area. Discussions were focused on the origin and history of the goats' population, special characteristics of the goats in the area, chain of goats market and exchange of goat with neighbor zones and districts, current status and major constraints of goat production system, and social bylaws on communal interest like communal gazing land, watering point and utilization of bucks for breeding. Discussions were held using a prepared check list. Information on the description of the goat population was recorded from direct counting of qualitative characters and measurements of quantitative characters from all members of the sampled goats.

3.4.2. Field measurements

A rapid survey procedure in which sample flocks owners are observed only once were employed to record both qualitative and quantitative data. During a single visit to a sampling site qualitative and quantitative measurements were collected from matured goats of both sexes. Data on the assessment of qualitative characters and quantitative (morphometric) traits were obtained from a total of 630 goats (105 goats from each peasant association) of either sexes or age categories from 180 households (30 households from each peasant association). For the assessment of the quantitative (morphometric) traits, only those bucks and does aged one year and above were considered for the purpose of uniformed comparison.

Qualitative characters: Data on coat color pattern, coat color type, hair coat type, horn shape, horn orientation, ear orientation, head profile, back profile, rump profile, body condition, presence and absence of wattle, beard and ruff were observed and recorded for bucks and does separately. Body condition score (BCS) was assessed subjectively and scored using the 5 point cale (1= very thin, 2 = thin, 3= average, 4 = fat and 5 = obese) for both of the sexes according to Hassamo *et al.* (1986).

Quantitative morphometric characters: Data of rump height (RHt), sternum height (StHt), height at wither (HtW), chest depth (CD), chest width (CW) and teat distance from ground (TDFg) was taken by using wooden stick calibrated in centimeters (cm). Body length (BL), rump length (RL), rump width (RW), paunch girth (PG), heart girth (HG), ear length (ErL), horn length (HL), head length (HLt), head width (HW) and cannon bone circumference (CC) was collected using tailors measuring tape while body weight (BWt) was measured using suspended spring balance and recorded for both bucks and does while teat length (TLL), teat length right (TLR), teat diameter left (TDL), teat diameter right (TDR), udder length (UL),

udder width (UW), udder circumference (UC) and distance between teat (DBnT) were measured by tailors measuring tape and recorded for milking does only. Scrotum circumference (SC) measurement also taken and recorded for bucks. All measurements were taken early morning prior to supply of feed and by the same personnel in each district keeping the goats in an up-right plane during measurement. Castrated bucks, pregnant does and kids were avoided from sampling because of the effect of castration and pregnancy on some of the body parameters.

Table 4. Methods used for assessing linear body measurement

Measurement	Technique for measurement
Body length(BL)	The distance from the point of shoulder to the pin bone.
Heart girth (HG)	Measured by taking the measurements of the circumference of the chest; behind the forelegs
Chest depth (CD)	From withers to the bottom brisket surface, just behind the elbow
Chest width (CW)	The widest point of shoulders
Ear length (ErL)	Taken from the base to the tip of the ear.
Fore canon circumference (CC)	The circumference of the lower part fore cannon bone or the smallest circumference of the foreleg.
Height at withers (HtW)	Measured as a distance from the surface of the platform to the withers of the animal.
Height at rump (RHt)	Measured as a distance from the surface of the platform to the rump of the animal.
Rump length (RL)	Measured as the distance from the hip (tuber coxae) to the pin (tuber ischi)
Rump width (RW)	The horizontal distance between the extreme lateral points of the hook bone (tuber coxae) of the pelvis)
Head length (HLt)	The length from the middle of the top head to the end of the nose.
Head width (HW)	The width of the front head from the base of left and right ear.
Horn length (HL)	Measured from root of horn to the tip along the outer curvature.

Table 4. (continued)

Measurement	Technique for measurement
Scrotum circumference (SC)	Surrounding distance taken from half way of scrotum.
Sternum height(StHt)	Measured from flat ground surface to the sternum
Paunch girth (PG)	Circumference of the belly at the center
Distance between teats (DBnT)	Length between two teats
Teat distance from ground (TDFg)	Measured from flat ground surface to the tip of teat
Teat length (TL)	Length of the teat measured from the base of the teat to the end of the teat
Teat diameter (TD)	Circumference taken from half way of teat
Udder circumference (UC)	Surrounding distance of udder above teats
Udder length (UL)	Distance from end point of teat to mammary attachment
Udder width (UW)	Horizontal distance of udder

Data was collected by the researcher with the assistance of enumerators. Quantitative data was collected by using tailors measuring tapes and wooden sticks calibrated in centimeters(cm) after restraining and holding the animals in an unforced position and weight measurement was taken by using weighing scale (50 Kg spring balance), and for qualitative data; coding sheets and guides for enumerators, color charts, pictorial body conformation guides, and Digital Cameras were used.

3.5. Data Management and Statistical Analysis

All data gathered during the study period, coded and recorded in computer (Excel) and was checked for any error for farther analysis. Preliminary data analysis like homogeneity test, normality test and outliers test was employed before conducting the main data analysis for quantitative data. Quantitative and qualitative data generated from field survey and on–farm

linear body measurements were analyzed using statistical analysis system (SAS, ver. 9.1, 2008). Data collected on quantitative traits was subjected to General linear model procedure (GLM) procedures by fitting age, sex and district as independent factors (effects). When F-test declared significant for each variable, means were compared using Duncan multiple range test. The least-square means (LSM) with their corresponding standard errors were calculated for sex, age and location. The qualitative traits were analyzed using non-parametric tests (Chi-square test). Index (having three, four, five and six) ranking levels were calculated for ranking data.

For categorical survey data, interactions (interaction of sex by age group, interaction of sex by location, interaction of age by location, interaction of age group, sex and location), correlation between body weight and body measurements, step wise multiple regression analysis to estimate body weight from other linear body measurements were analyzed by using statistical package for social sciences (SPSS version, 21). Some morph metrical indices of 4ppi goats' also was calculated to assess the function of goats.

For quantitative data the following models was used:

1. **Model 1**

The model for analysis of adult body weight and linear body measurements (LBMs) except scrotum circumference, teat length, teat diameter, udder length, udder width, udder circumference, distance between teats and teat distance from ground was as follows:

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

Where:

$\mathbf{y_{ijk}}$ = observations (of body weight, body length, chest girth, chest depth, chest width, ear length, cannon bone circumference, height at withers, height at rump, rump length, rump width , head length, head width, horn length, sternum height, paunch girth)in the i^{th} age group, j^{th} sex and k^{th} district

μ = overall mean

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

$\mathbf{S_j}$= the effect of j^{th} sex (j = female or male)

$\mathbf{D_k}$= the effect of k^{th} district (K =Benatsemay and Debub Ari)

Ai*Sj = interaction due to age and sex

Ai*Dk = interaction due to age and district

Sj*Dk = interaction due to sex and district

Ai*Sj*Dk = interaction due to age, sex and district

$\mathbf{e_{ijk}}$ = random residual error

Model 2

Model used for analysis of scrotum circumference, teat length, teat diameter, udder length, udder width, udder circumference, distance between teats and teat distance from ground was

$yik= \mu + Ai + Dk + eik$

Where:

yik= observation (of scrotum circumference**,** teat length, teat diameter, udder length, udder width, udder circumference, distance between teats and teat distance from ground) in the ith age group and kth district

μ = overall mean

Ai= the effect of ith age group (i=1PPI, 2PP, 3PPI and 4PPI)

Dk = the effect of kth district (k= Benatsemay and Debubi Ari)

eik= random residual error

model 3

A stepwise regression mode was used for the estimation of body weight from linear body measurements. To this effect, the following models were used:

For male

$$\mathbf{Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + e_j}$$

Where:

$\mathbf{Y_j}$ = the dependent variable (body weight)

$\boldsymbol{\alpha}$ = the intercept

$\mathbf{X_1 \ldots, X_5}$ independent (explanatory) variables [body length (BL), paunch girth (PG), heart girth(HG), cannon bone circumference (CC) and Scrotal circumference (SC)]

$\boldsymbol{\beta_1 \ldots, \beta_5}$ are regression coefficients of the variables $\mathbf{X_1 \ldots, X_5}$

$\mathbf{e_j}$ = random residual error

For Female:

$$\mathbf{Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + e_j}$$

Where:

$\mathbf{Y_j}$ = the dependent variable (body weight)

$\boldsymbol{\alpha}$ = the intercept

$\mathbf{X_1 \ldots, X_5}$ =are independent (explanatory) variables [body length (BL), rump height (RHt), paunch girth (PG), chest width (CW) and distance between teats (DBnT)]

$\boldsymbol{\beta_1 \ldots, \beta_5}$ =are regression coefficients of the variable $\mathbf{X_1 \ldots, X_5}$

$\mathbf{e_j}$ = random residual error

Index was calculated as= sum of (6 X number of household ranked first + 5 X number of household ranked second + 4 X number of household ranked third+3 X number of household ranked fourth+2 X number of house hold ranked fifth+1 X number of house hold ranked sixth) given for each trait divided by sum of (6 X number of household ranked first + 5 X number of household ranked second + 4 X number of household ranked third+ 3 X number of house hold ranked fourth +2 X house hold ranked fifth + 1 X house hold ranked sixth) for all traits of selection criteria of breeding does in a production system and others .

Structural Indices calculations

About six indices were calculated from the morphometric traits for bucks/does of 4PPI (4-5 years old) to assess the type and function of the bucks and does.(Table 5)

The following indices were calculated from the mean values of body measurements for 4ppi male and female goats.

Table 5. Some structural indices calculations

Indices	Formula	Description
Body index	(Body length /Chest girth)*100	When this measure is greater than 90, the animal is longiline; between 86 and 88 it is medigline, and less than 85, it is brevigline;
Proportionality index	(Height at withers/ Body length)*100	A value less than 100 shows the predominance of the body length on body height indicating that body tends to be rectangular, which is the characteristic of meat breeds however, a value greater than 100 indicates characteristic of dairy breeds.
Compact index	(Body weight / Height at wither)*10	Meat type animals have values above 3.15. Values close to 2.60 indicates that animals are more suitable for milk. Dual purpose animals have values close to 2.75.
Transverse pelvic index	(Rump width/Rump height)*100	Largely exceeding 33= meat type
Longitudinal pelvic index	(Rumplength /Rump height)*100	Not exceeding 37 are suitable indicators for meat animals
Dactyl thorax index	(Cannon bone circumference/ Chest girth)*100	It classify animals as large format, medium format, or small format, being less than 10 in animals with dairy phenotype and greater than 11 in those with meat phenotype.

4. RESULT AND DISCUSSION

4.1. General house hold information

A total of one hundred eighty households (90 small holder farmers from Crop- livestock (Debub Ari) district or three peasant associations and 90 pastoralists from Pastoral (Bena-Tsemay) district or three peasant associations, 30 households from each peasant association [PA]) were interviewed for the household survey. Sex proportion, age structure, marital status, educational back ground and major cash income source of respondents are presented in Table 6 and Table 7.

Table 6. Sex proportion, age structure and marital status by districts

Factors and level	Production system				X^2	p-value
	Crop- livestock		Pastoral			
	N	%	N	%		
Sex proportion					0.04	0.844
Male	75	83.33	74	82.22		
Female	15	16.67	16	17.78		
Age in (yrs)					12.32	0.015
<30	12	13.33	25	27.78		
31-40	45	50.00	47	52.22		
41-50	26	28.89	10	11.11		
51-60	4	4.44	6	6.67		
>60	3	3.33	2	2.22		

N = number of observation; %=Percentage of respondents (households); crop- livestock represents Debub Ari district; pastoral represents Bena-Tsemay district

Table 7. Educational background and major cash income sources by districts

	Production system				Test	
	Crop- livestock		Pastoral		X^2	P-value
Factors and level	N	%	N	%		
Marital status					7.15	0.067
Married	82	91.11	77	85.56		
Single	3	3.33	-			
Divorced	1	1.11	5	5.56		
Widowed	4	4.44	8	8.89		
Educational background					0.0615	0.996
Illiterate	54	60.00	54	60.00		
First cycle(1-4)	19	21.11	18	20.00		
Second cycle (5-8)	14	15.56	15	16.67		
Secondary school (9-12)	3	3.33	3	3.33		
Major cash income source					95.29	0.001
Only crop	17	18.89	-	-		
Only livestock	-	-	60	66.67		
Crop & live stock	72	80.00	30	33.33		
Petty trade	1	1.11	-	-		

N = number of observation; %=Percentage of respondents (households); crop- livestock represent= Debub Ari district; pastoral represent= Bena-Tsemay district

The survey revealed that the majority of the households in both production systems were headed by males which accounted for 83.3% in crop-livestock (Debub Ari) and 82.2% in pastoral production system (Bena-Tsemay). There were no statistically significant difference in sex proportion between the districts (P= 0.844) in (Table 5) .The remaining proportions of the households were headed by females. Majority of female headed household in this particular study would indicate either the husband has died or they have divorced. In both

districts the largest proportion of house hold (Debub Ari 50 % and Bena-Tsemay 52%) were 31-40 years old and from the total respondents 91.1% and 85.6% were married respectively. Interviewed households in the study area have different educational backgrounds. Different studies in different part of Ethiopia (Lishan, 2007; Tesfaye, 2009; Tesfaye, 2010; Grum, 2010) reported that majority of goat owners were unable to read and write. Similarly, the largest proportions of household heads in both districts (60%) were illiterate. The proportion of house hold heads in grade 1-4 in Debub Ari and Bena-Tsemay were 21% and 20% respectively. The proportion of in grade 5-8 in Debub Ari district was 15.6%, whereas in Bena-Tsemay district was 16.7 %. In both district 3.3% were in grade 9-12. These observations are in close accordance with the reports of Ntume *et al*., (2015) who have indicated that illiteracy can be one of the major hurdles in scientific developments. There were no significant differences between the districts in the case of educational level ($p=0.99$) therefore it is mandatory to consider upgrading of the education status of pastoralists for the successfulness of goat breeding strategies and other development interventions. In Debub Ari distirict about 80% of household's income was from both crop and livestock production whereas in Bena-Tsemay district in 66.7% of pastoralist households income was from livestock production. There were significant differences ($p<0.001$) between the districts in the case of income source. Azage *et al.*, (2009) reported that pastoralists derive over 90% of their cash income from livestock.

4.2. **Farming Activities**

In the mixed crop-livestock production system (Debub Ari area) the major crops such as Maize, sorghum, teff and cassava are growing during the short and long rain seasons of the year and these crops are major feed sources in the study areas (Table 8). Similar findings

were also reported by Grum (2010) that the two most cultivated crops in the rural PAs of Dire Dawa Administration council were maize and sorghum. Cattle, goat, sheep and donkey are major livestock species reared in the area. Both livestock and crop have vital role in each and every living process of the farmers. Over 60% of Ethiopian land area is semi-arid lowland, dominated by a livestock economy (IFAD, 2009). Due to low and highly variable rainfall conditions as well as extreme temperature, crop cultivation is limited in Bena-Tsemay areas. As a result, majority of the sampled households mainly depend on livestock production. There were significance difference ($P<0.001$) of food source between two district .In Debub Ari 98.9% food source comes from maize, whereas in Bena-Tsemay 55.6% food source comes from maize and 27.8% from sorghum.

Table 8. Main food sources of the study areas

	Production system				**Test**	
	Crop- livestock		Pastoral		X^2	P-value
Factors and level	N	%	N	%		
					51.94	0.001
Maize	89	98.9	50	55.6		
Sorghum	-	-	25	27.8		
Cassava	0	-	5	5.6		
Maize and sorghum	1	1.1	0	-		
Maize and teff	0	-	10	11.1		

4.3. Herd size and species composition

The average livestock possessions in the study areas are presented in Table 9. The largest average number of livestock possessed by the two districts was goat, chicken, followed by cattle. Because of the fact that this study involved farmers and pastoralists who owned goat, as a major criterion, all respondent (100%) across the study area had goats. However, the proportion of farmers and pastoralists who owned cattle was 87.8% and 94.4% in Debub Ari

and Bena-Tsemay, respectively. According to Nega *et al.*, (2009) the probability of keeping livestock is strongly correlated with agro-climatic conditions. In the present study, households in the lowland areas keep goats as the primary animal because of their ability to survive in a harsh environment. Solomon *et al*., (2010) stated that flock sizes vary with the production system and the environment. Likewise in this study, average goat flock size per household showed significant deviation (P<0.001) between Debub Ari and Bena-Tsemay districts. The average holding of goats in Debub Ari and Bena-Tsemay was 9.07±0.67, 14.97±0.79 respectively, was lower than the average holding of 34.23± .54 reported for Siti goat (Grum, 2010)), and comparable to 7.79 ± 4.54 reported for Bati goat (Getachew *et al.,* 2006). The average number of pack animals (donkeys and others) was the lowest in the studied areas. Even though they are too few in number, there were camels in Bena-Tsemay district.

Table 9. Average (±SE) livestock species composition in Debub Ari and Bena-Tsemay.

Parameter	Debub Ari(90)	BenaTsemay(90)	Over all(180)	P-value
	Mean ±SE	MEAN±SE	MEAN±SE	
Cattle	4.23±0.44	6.67±0.54	5.45±0.36	0.001
Sheep	0.63±0.17	2.46±0.37	1.54±0.21	0.001
Goat	9.07±0.67	14.97±0.79	12.02±0.56	0.001
Chicken	7.66±0.61	5.69±0.44	6.67±0.38	0.01
Donkey	0.24±0.05	0.14±0.04	0.19±0.03	0.114
Camel	0.00±0.00	0.01±0.01	0.01±0.01	0.319
Bee hives	1.11±0.29	0.67±0.22	0.89±0.19	0.231

SE= Standard error

4.4. Goats Flock Structure

The proportion of different classes of animals reflects the management decisions of the producers which in turn are determined by their production objectives (Solomon *et al.*, 2010**).** In this study, as compared to other age groups breeding does made a major share followed by replacement does and female kids (Figure 2). The overall mean goats flock size was higher

for Bena-Tsemay district followed by Debubi Ari district In Bena-Tsemay district, breeding does accounted for the largest number (5.34±2.63) followed by replacement does (2.42±1.58), female kids (2.40±1.07), male kids (2.27±1.21), castrates (1.89±.95) and breeding bucks (1.59±.72). In Debub Ari district as well, the largest number of goat category in a flock was breeding does (3.69±2.33). Followed by male kids (1.87±1.01), replacement does (1.83±1.19), female kids (1.70±0.93), castrates (1.59±0.73) and breeding bucks (1.55±0.77). This result is in agreement with findings of (Tsedeke, 2007) and (Tsegaye, 2009). However, the number of breeding bucks in a flock was generally small. In fact the proportion of breeding buck and doe can determine the production of kids in a flock.

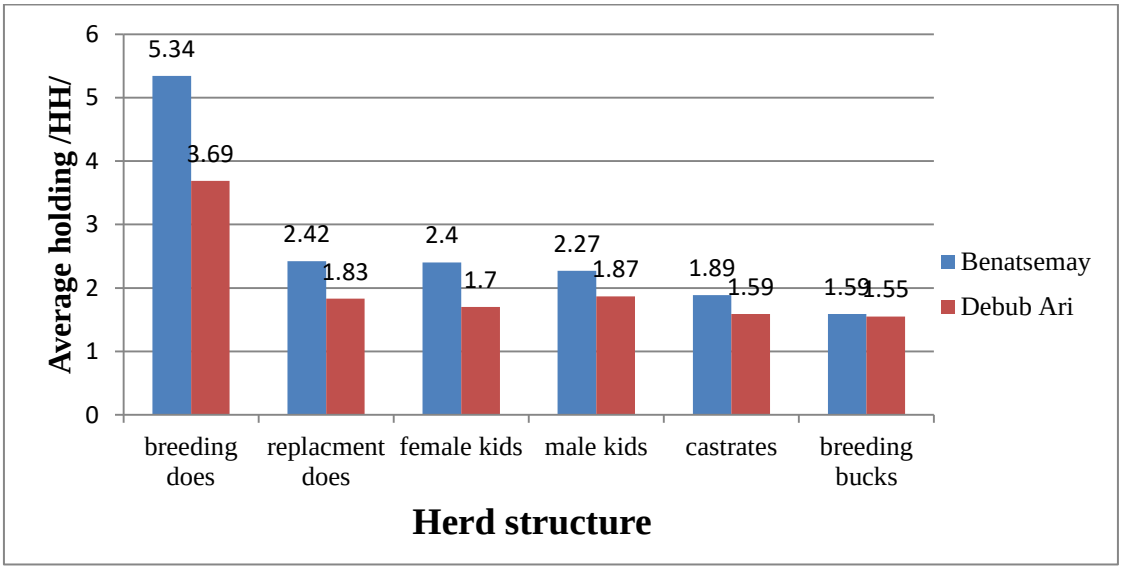

Figure 2.**Goat flock structures in Debub Ari and Bena-Tsemay districts.**

4.5. Purpose of goat keeping

4.5.1. Purpose of keeping male goats

Indigenous goat breeds have a wide range of functions that differ from place to place. In present study the purpose of keeping male goats by farmers and pastoralists in the study areas is presented in Table 10. The primary purpose of keeping male goats in Debub Ari district was

reported to be for saving (to be used as an asset) with an index value of 0.38, followed by income generation index value of 0.33. However, keeping male goats for meat purpose in Debub Ari district stands last index=0.03.

Table 10. Purpose of keeping male goats as ranked by respondents in the study areas

Purpose of keeping male goat by district	Index
Debub Ari district	
• For meat	0.03
• For breeding(mating)	0.26
• As an asset (saving)	0.38
• As income source	0.33
Benatsemay District	
• For meat	0.05
• For breeding(mating)	0.12
• As an asset (saving)	0.45
• As income source	0.38

Similar to Debub Ari, in Bena-Tsemay, for saving (to be used as an asset), income generation, breeding and meat production were the major purpose of goat production with an index values of 0.45, 0.38, 0.12 and 0.05 respectively.In general, this study showed that farmers and pastoralists in both Debub Ari and Bena-Tsemay districts keep goats for multipurpose functions. The rearing of goats for diverse purposes are in close accordance with the observations of (Tesfaye *et al.*, 2012) who reported that goat plays the multifarious roles among the agrarian communities .

4.5.2. Purpose of keeping female Goats

The purposes of keeping female goats by farmers and pastoralists in the study area are presented in Table 11. The primary purposes of keeping female goats in Debub Ari district were for saving (to be used as an asset), income generation, meat and milk with index value of 0.52 ,0.35, 0.08 and 0.05 respectively. They also use for gift and bride price. On the other hand, the primary purpose of keeping female goats in Bena-Tsemay pastoralists were income

generation, saving, milk and meat with index value of 0.53, 0.21, 0.09 and 0.07 respectively. In addition goats were kept gift purpose.

The primary purpose reported in Bena-Tsemay pastoralists is in agreement with Tesfaye (2009), Dhaba *et al*., (2012) and Solomon *et al.*, (2013) who reported that goats are kept primarily for income generation. This might be because small ruminants are easier to sell when compared to those of the bovines which may be attributed to the fact that the price of a small ruminant is significantly lower than that of the cattle. The observations are in close accordance with study of (Endeshaw, 2007). It could also be because small ruminants grow faster than those of cattle and hence income generation from the sale of a buck or doe can meet immediate family requirements.

Table 11. Purpose of keeping female goats in the study area as ranked by respondent

Purpose of keeping female goat by district	Index
Debub Ari district	
• For meat	0.08
• For milk	0.05
• As an asset (saving)	0.52
• As income source	0.35
Bena-Tsemay District	
• For meat	0.07
• For milk	0.09
• As an asset (saving)	0.31
• As income source	0.53

4.6. Feed sources and Browsing methods

4.6.1. Feed sources

Goat production in communal land browsing condition, highly dependent on rangeland resources (Homann *et al.,* 2007). In line with this statement, natural bushes and shrubs were the major feed source in rainy and dry seasons in both Debub Ari and Bena-Tsemay districts. Feed resources commonly used by farmers and pastoralists in the study area during rainy and

dry seasons are presented in Table 12 and 13. The quantity and quality of feed resources available for animals primarily depends upon the climatic and seasonal factors (Zewdu, 2008). In this study, natural pasture (bushes and shrubs), crop residues (maize and sorghum), trees leaves and crop after math are the common feed resources used in the study area. Even though the use of crop residues were moderate in the study area, farmers or pastoralists in Debub Ari and Bena-Tsemay use crop residues (maize and sorghum) both in rainy and dry season. In general, natural pasture, crop residues, and tree leaves serve as feed sources during both the rainy and dry season in Debub Ari and Bena-Tsemay districts.(Figure 3)

Seasonal feed shortage is among the major constraints that limit goat's production in the study area as reported by 92.22% and 100% of the respondents in Debub Ari and Bena-Tsemay districts, respectively. Similarly, feed shortage was reported to be a major production constraint in many parts of the country (Abebe, 1999; Samuel, 2005; Tesfay 2008). The Period of critical feed shortage in the study area ranges from January to February. This period covers dry season, where most of the natural pasture lands are covered by non-edible (thorny plants). To manage feed shortage farmers and pastoralists provide supplements like tree leaves and crop residues.

Figure 3. Debub Ari goats, browsing in natural bushes

Table 12. Feed resources commonly used during rainy season in the study area

Types of feed sources	Debub Ari	BenaTsemay			
	Rainy season N(%)		Over all N(%)	X^2	p-value
Natural bush/ pasture/	71(78.88)	78(86.67)	149(82.78)	4.96	0.84
Natural pasture ,crop residues and tree leaves	11(12.22)	3(3.33)	14(7.78)		
Natural pasture and tree leaves	8(8.89)	9(10.00)	17(9.44)		

N=Number of respondents

Table 13. Feed resources commonly used during dry season in the study area

Types of feed sources	Debub Ari	BenaTsemay			
	Dry season N(%)		Over all N(%)	X^2	p-value
Natural bush/ pasture/	65(72.22)	66(73.33)	131(72.8)	11.32	0.01
Natural pasture ,crop residues and tree leaves	11(12.22)	6(6.67)	17(9.44)		
Natural pasture and tree leaves	8(8.89)	18(20.00)	26(14.44)		
Natural pasture and crop after math	6(6.67)	0	6(3.33)		

N=Number of respondents

4.6.2. Browsing method practiced in the study area

Herding was the most important feeding management in Debub Ari district during both rainy and dry season as opposed to free roaming in Bena-Tsemay district (Table 14 and 15) because most of the arable lands are covered by crops and decreasing trend of communal browsing land. In Debub Ari tethering was also important practices during rainy season to avoids crop damage, protect the stock against theft, ease of protecting from predation and proper utilization of the limited grazing land. Such reasons were reported earlier in other (Dejen, 2010; Zewdu, 2008) and similar areas (Workneh, 1992).

Table 14. Browsing method practiced during dry season in the study area

	Debub Ari	BenaTsemay	Over all		
Browsing methods	Dry season				
	N(%)		N(%)	X^2	p-value
Free grazing	20(22.22)	87(96.67)	107(59.44)	107.23	0.001
Herding	58(64.44)	3(3.33)	61(33.89)		
Tethering	12(13.33)	0(0.00)	12(13.33)		

N=Number of respondents

Table 15. Browsing method practiced during rainy season in the study area

	Debub Ari	BenaTsemay	Over all		
Browsing methods	Rainy season				
	N(%)		N(%)	X^2	p-value
Free grazing	0(0.00)	69(76.67)	69(38.33)	122.22	0.001
Herding	53(58.89)	21(23.33)	74(41.11)		
Tethering	37(41.11)	0(0.00)	37(20.55)		

N=Number of respondents

4.7. Water sources and watering

According to respondents (Table 16), river was the major water source during dry season for Debub Ari district (82.2%), whereas pond was the major water source (54.4%) for Bena-Tsemay district. Similarly, river was the major water source during rainy season in Debub Ari district (55.5%), while in Bena-Tsemay rain water (flood) (47.8%) was the main water source during rainy season (Table 17). During dry season,(61%) respondents' in Debub Ari district allowed their flock to take water as they needed (free access) and 34.4% respondents' allowed their flock to take water once a day , where as in Bena-Tsemay district (100%) respondents allowed their flock to take water once in two days. During wet season 98% respondents in Debub Ari and only 45.6% respondents of Bena-Tsemay allowed their flock to take water as they needed. 54.4 % respondents of Bena-Tsemay allowed their flock access to water only once a day. The availability of water was not consistent particularly in the dry season. According to Urge (2007), Short-eared Somali goats deprived of water for about three days in

dry season that resulted in about 22% milk yield reduction as compared to goats with water access every day. Therefore, watering is an important management component, which is often not addressed (Homann *et al.*, 2007).

Table 16. Water sources in the study area during dry season

	Debub Ari	BenaTsemay	Over all		
	Dry season				
Water sources	N(%)		N(%)	X^2	p-value
Water well	0(0.00)	3(3.33)	3(1.67)	168.54	0.001
Pond	0(0.00)	49(54.44)	49(27.22)		
River	74(82.22)	1(1.11)	75(41.67)		
Spring	12(13.33)	0(0.00)	12(6.67)		
Pipe water	2(2.22)	31(34.44)	33(18.33)		
Water well and pond	0(0.00)	6(6.67)	6(3.33)		
River, spring and rain water	1(1.11)	0(0.00)	1(0.55)		
River and spring	1(1.11)	0(0.00)	1(0.55)		

N.B. More than one response was possible, N= number of respondents

Table 17. Water sources in the study area during rainy season

	Debub Ari	BenaTsemay	Over all		
	rainy season				
Water sources	N(%)		N(%)	X^2	p-value
Pond	0(0.00)	21(23.33)	21(11.67)	114.56	0.001
River	50(55.56)	3(3.33)	53(29.44)		
Spring	11(12.22)	0(0.00)	11(6.11)		
Rain water(flood)	7(7.78)	43(47.78)	50(27.78)		
Pipe water	2(2.22)	0(0.00)	2(1.11)		
River , spring and rain water	2(2.22)	0(0.00)	2(1.11)		
River and rain water	15(16.67)	15(16.67)	30(16.67)		
Spring and rain water	2(2.22)	0(0.00)	2(1.11)		
River and spring	1(1.11)	0(0.00)	1(0.55)		
Pond and rain water	0(0.00)	8(8.89)	8(4.44)		

N.B. More than one response was possible, N= number of respondents

4.8. Housing

In the study area, goats are housed in different ways (Table 18). The majority of the respondents (64.4%) in Debub Ari district housed their goats in the roofed and separate goat houses and followed by below granary house. Unlike Debub Ari district the majority of the respondents (88.9%) in Bena-Tsemay district indicated that goats are kept in traditional

enclosure (kraal). Adjoining family house (veranda) was also reported by some respondents in both districts. The proportions of respondents using separate kid's house are too small in number, 3.3% in Debub Ari district and 6.7% in Bena-Tsemay district. Some of the housing systems are indicated in Figure 4.

Table 18. House types for goats in the study area

	Debub Ari	Benatsemay	Over all		
House types	N(%)	N(%)	N(%)	X^2	p-value
Roofed and with family	2(2.22)	0(0.00)	2(1.11)	117.63	0.001
Roofed and separated	58(64.44)	0(0.00)	58(32.22)		
Traditional enclosure (kraal)	12(13.33)	80(88.89)	92(51.11)		
Below granary	15(16.67)	4(4.44)	19(10.56)		
Adjoining family house (veranda)	3(3.33)	6(6.67)	9(5.00)		

N= number of respondents

Figure 4. Below granary house from Debub Ari (on the left) and picture of traditional enclosure (kraal) from Benatsemay (on the right)

4.9. Fattening and castration goats

4.9.1 Fattening

Goats fattening were practiced by 55.6% respondents in Debub Ari district and 31% respondents in Bena-Tsemay district. Commonly older male and female goats were kept for fattening purpose in the study areas. Natural pasture (browsing), crop residues, salt and tree leaves were the major feed resources used for fattening in both districts. However, sometimes concentrate and improved forge were also used in Debub Ari district. Fattening was usually

practiced following the end of the main rainy season and in the beginning of dry season coinciding with the availability of good quality and quantity natural pasture, better forage production and aim to specific market (holiday market). Some farmers also reported that they perform fattening activity twice a year, during the time when the quantity and quality of available feed resource is high.

4.9.2. Castration

About (60%) and (95.6%) of the respondents from Debub Ari and Bena-Tsemay districts castrate their goats respectively. All respondents in Debub Ari district used traditional castration method to castrate their goat by crashing the vas deference using stone. The majority of respondents from Bena-Tsemay district indicated that castration is done by owners following traditional castration method. However, about 4.4% respondents from Bena-Tsemay district indicated that castration is done by veterinarians. Average castration age in Debub Ari and Bena-Tsemay districts was 26 and 31 months, respectively. Some respondents believed that castration at early age affect the growth of the goats. Castration was primarily practiced to improve the fattening potential and minimize flock disturbance (unwanted mating) in both districts. Fattened goats are sold with premium price.

4.10. Source and Current status of Debub Ari and Bena-Tsemay goat types

It is not clear when goats were first introduced to Ethiopia; they appeared in East Africa by 4000-3500 years BP (Marshall, 2000). Indigenous goat breeds/types/ are widely distributed and are found in all agro-ecologies of Ethiopia and it appears they have evolved through a process of natural selection (Galal, 2005) that favored adaptation and survival rather than production. In this study, focal group members (key informants) believed that Debub Ari goats were kept for long time by their ancestors and transferred to the current generation. On the

other hand, key informant in Bena-Tsemay believed that the Bena-Tsenay goats entered in to the Bena-Tsemay district from Borena, specific place (Kore). They also heard from elders that their goats was known for their twining rate, but currently their potential for prolificacy reduced due to climate change and the associated feed shortage. A comprehensive phenotypic characterization of Ethiopian goats was done by Farm Africa (FARM Africa, 1996), which classified indigenous goats based on some phenotypic aspects, their geographic location and the ethnic communities who keep them. Based on this information, Debub Omo goats can be categorized under Woyto-Guji goat population. Group members also indicated that the goat populations of Bena-Tsemay are currently at a decreasing trend because of the recurrent drought and high distribution of goat's diseases and different parasites. The respondents also believed that, today goat populations of Bena-Tsemay are distributed up to Hammer area (neighboring district). Aggressiveness is the special characteristics of the goats which is most liked by pastoralists because they can easily escape from predators and thieves. During crop production the owners of crop have responsibility to protect their crop from animal's damage during day time whereas during night the owner of animal (goats) has responsibility to look after his animals to protect crop damage. This is one of social bylaw of the Mokecha and others peasant association of Bena-Tsemay districts.

4. 11.Typical Features of Debub Ari and Bena-Tsemay goat Types

For both Debub Ari and Bena-Tsemay, resistance to disease and hot climatic condition is considered as special merits of the goat types. The coat color is dominated by brown, black and light brown (Figure 5) and coat color pattern is dominated by patchy. Majority of the goats in both districts have smooth hair type and straight horn shape. Their ear orientation was

dominated by carried horizontally. Only 13% and 9.2% goats have wattle in Debub Ari and Bena-Tsemay Districts, respectively.

Figure 5.**Goats from Debub Ari (on the left) Goats from Bena-Tsemay (on the right)**

4.12. Breeding Practices and possession of bucks

In both Debub Ari and Bena-Tsemay districts, mating was random with generally uncontrolled manner. Uncontrolled mating was observed to be a result of communal grazing and watering point in the study area. Most of the households in Debub Ari (65.5%) and Bena-Tsemay (97.8%) owned breeding bucks. Quite substantial number of respondents in Debub Ari (34.5%) and some numbers in Bena-Tsemay (2.3%) did not own bucks. These respondents receive bucks service from their neighbors.

4.13. Ability of the respondents to identify sire of the kids and response to inbreeding in the flock

All goats owners in Bena-Tsemay district were not able to identify sire of a new born kids while only 20% respondents in Debub Ari district were able to identify the sire of a new born kids by relating the kids with the colour and appearance/conformation/ of a buck. About 96.7 % respondents in Debub Ari and 100 % in Bena-Tsemay, responded that they allowed mating of goats with relatives. The proportion of respondents who were aware about the disadvantage

of inbreeding in both districts was negligible, except in Debub Ari district the proportion was 3.3%.

4.14. Purpose of Keeping Bucks

Asset (saving) were The major Purpose with different index values of keeping breeding bucks in Debub Ari and Bena-Tsemay districts (Table 19)

Table 19. Purpose of keeping breeding bucks by district

Debub Ari district	**Index**
• For mating	0.40
• For socio cultural	0.18
• As an asset (saving)	0.42
Bena-Tsemay District	
• For mating	0.29
• For socio cultural	0.25
• As an asset (saving)	0.46

4.15. Selection criteria for breeding goats

4.15.1. Selection criteria for breeding bucks

Appearance and body conformation were major selection criteria for breeding bucks both in Debub Ari and Bena-Tsemay districts with different index value (Table 20). The observations are in close agreement with Tegeng *et al.,* (2013) Bucks in Bench Maji zone are also selected based on body size.

Table 20. Selection criteria for selecting breeding buck as ranked by goat's owners in the study area

District	Selection criteria	Index
Debub Ari	Appearance and conformation	0.33
	Age	0.30
	Fast growth	0.20
	Coat colour	0.11
	Libido/mating interest /	0.05
Bena-Tsemay	Appearance and conformation	0.34
	Fast growth	0.33
	Age	0.17
	Coat color	0.15
	Libido/mating interest/	0.01

4.15. 2. Selection criteria for breeding does

Selection criteria for selecting breeding does as ranked by respondents, appearance and body conformation were major selection criteria for breeding does both in Debub Ari and Bena-Tsemay districts with different index value (Table 21). This observation was similar to the observation of Grum *et al.,* (2013) from Dire Dawa area where goat keepers select their doe based on body conformation. The result is in contradiction with Tekleyohannes *et al.,* (2012) who reported that goats in some pastoral areas of South Omo are selected highly for adaptation traits such as tolerance to drought and resistance to diseases as opposed to growth performance trait.

Table 21. A selection criterion for selecting breeding does as ranked by goats' owner in the study area

District	Selection criteria	Index
Debub Ari	Appearance/Body conformation /	0.27
	Age	0.24
	Mothering ability	0.17
	Fast growth rate	0.14
	Litter size	0.11
	Coat colour	0.07
Benatsemay	Appearance/Body conformation /	0.33
	Fast growth rate	0.31
	Age	0.19
	Mothering ability	0.14
	Litter size	0.02
	Coat colour	0.01

4.16. Effective Population Size and Level of Inbreeding for Debub Ari and Bena-Tsemay goat flock

Increased level of inbreeding and decreased genetic diversity may be the result of the utilization of breeding buck/s born within the flock, small flock's size, uncontrolled mating and lack of awareness about inbreeding which may lead to accumulation of inbreeding and decreased genetic diversity (Falconer and Mackay, 1996; Jaitner *et al.,* 2001; Kosgey, 2004). However, communal herding practiced by goats' owners allows breeding females to mix with males from other flocks and this can minimize the risk of inbreeding (Jaitner *et al.,* 2001) by increasing the effective population size. In this study effective population size (Ne) and the rate of inbreeding coefficient (ΔF) calculated for Debub Ari and Bena-Tsemay goat flock considering the existing flock size are presented in Table 22. Under random mating and when goat flocks of different smallholders (pastoralists) were not mixed, Ne and ΔF for Debub Ari

goats were 4.36 and 0.11, respectively. For Bena-Tsemy district, Ne was 4.9 and ΔF was 0.10. In both cases the level of inbreeding was higher than the maximum acceptable level of 0.063(Armstrong, 2006).

Table 22. Effective population size and level of inbreeding when flocks of goats are not mixed in Debub Ari and Bena-Tsemay District.

District	When flocks are not mixed			
	N_m	N_f	N_e	ΔF
Debub Ari	1.55	3.68	4.36	0.11
Bena-Tsemay	1.59	5.34	4.9	0.10

Nm= number of male; Nf= number of female; N_e = effective population size; ΔF = coefficient of inbreeding.

4.17. Coat Color Preferences of goats

Respondents in Debub Ari (92.2%) and Bena-Tsemay (94.4%) prefer a particular coat color, but they have low preference for black coat colour. In Debub Ari district 25.3% respondents preferred white, 20.5% preferred black with white spotted, 26.5% preferred red and 25.3% preferred brown coat colored goats and others (2.4%) preferred other colors. Whereas in Bena-Tsemay district about 23.5% respondents preferred white, 36.5% preferred brown, 29.4% preferred light red and others (10.58%) preferred other different coat color types. Preference of respondents for a particular coat color might be associated with belief, market demand and socio-cultural practices. 90.4% of respondents in Debub Ari and 87.1% of respondents in Bena-Tsemay do not prefer black coat color. 93.97% respondents in Debub Ari district and 67.1% respondents in Bena-Tsemay district believed that black coat colored goats had less market value. In general, this study showed that black colored goats were less preferred by majority of respondents in both districts.

4.18. Reproductive Performances

A successful livestock production program should be based up on good reproductive performance of animals. Certainly, there is no milk if birth does not occur, no meat and fiber if survival cannot be ensured (Tesfaye, 2008). Poor reproductive performances of Ethiopian goats can be associated with genetic factors, poor management, seasonal fluctuations in feed resources and diseases (Mukasa-Mugerwa *et al*., 2002). In the current study, reproductive performances of Debub Ari and Bena-Tsemay goats were summarized in Table 23. Age at sexual maturity (puberty) was 9.92±0.93 and 11.45±1.04 months for females and 10.19±1.17 and 11.71±0.81 months for males in Debub Ari and Bena-Tsemay, respectively. The average age at puberty was different (P<0.001) for both sexes between two districts being shorter in Debub Ari district. The variation might be because due to the difference of feed availability and agro ecology.

Table 23. Reproductive performance of Debub Ari and Bena-Tsemay goats

Characters	Debub Ari(90)	Benatsemay (90)	Over all(180)	P-value
	Mean ±SD	MEAN±SD	MEAN±SD	
Age at puberty of female (month)	9.92±0.93	11.45±1.04	10.69±1.25	0.001
Age at first kidding (month)	14.92±0.93	16.47±1.04	15.69±1.25	0.001
Age at puberty of male (month)	10.19±1.17	11.71±0.81	10.95±1.26	0.001
Kidding interval (month)	8.57±0.62	8.09±0.65	8.33±0.68	0.001
Reproductive life span of female (yrs)	5.67±0.81	5.27±0.72	5.47±0.79	0.001
Life span kid crop (number)	9.33±0.1.39	7.97±0.81	8.65±1.33	0.001

Age at first kidding can be defined as the age at which does give birth for the first time. Age at first kidding is influenced by many factors such as genetic makeup of an individual, physical environment, nutrition and time of birth (Alexander *et al*., 1999). In this study the average age at first kidding of Debub Ari and Bena-Tsemay goats were 14.92±0.93 and 16.47±1.04 months, respectively (Table 23). Average age at first kidding was statistically significant (P<0.001) higher in Bena-Tsemay district. The result obtained in this study is much longer

compared to the values reported by Getahun (2008) who indicated that average age at first kidding of Keffa and Adilo goats were 12.5 months. However it is comparable with local goats found in central Tigray (Assen and Aklilu, 2012). They reported that average age at first kidding of central Tigray goats were 15 months. It is also comparable with the figures reported for other African indigenous goats such as the red Sokoto goat in Nigeria (14.6 months) and Malawi goats (15.6 months) under village management conditions (Karua,1989). In this study (twining rates) for goats' population of Debub Ari and Bena-Tsemay, based on data taken from goat owners were about 25.5% and 11% respectively. According to Tsedeke (2007) twining rate of Arsi – Bale goats were between 18 and 36%. In few cases, twining rates as high as 41 to 50% have been reported for local goats in Hawassa Zuria (Markos, 2000).

The average kidding interval for Debub Ari and Bena_Tsemay ($P<0.001$) goats was 8.57±0.62 and 8.09±0.65 months, respectively (Table 23). The result was not far from the average kidding interval (8 months) reported by Assen and Aklilu (2012) for Abergelle and other local goats kept under traditional systems in Tigray. The value was shorter than the report of Berhane and Eik (2006) who reported 11 and 14 months of kidding interval for Abergelle and Begait goats.

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 Debub Ari and Bena-Tsemay does were 5.67±0.81 and 5.27±0.72 years, respectively.

The results of this study shows that on average a doe can produce 9.53±1.88 (Debub Ari) and 7.97±0.81 (Bena-Tsemay) kids in her life time. The Debub Ari does can produce large ($P<0.001$) number of kids than the Bena-Tsemay district. Without any argument life time kid

crop is very important trait to improve goat's productivity and profitability. This will provide a base for selection of better replacement stock.

4.19. Disease

It is well documented that disease control is very basic for genetic improvement of livestock (Solomon, 2007). Healthy goats with normal physiological function and structure that enable the goats to attain highest production are vital. Existing health problems of study area were identified and ranked by the respondents, the local name of diseases have translated to their veterinary equivalents with the support of animals health workers (Table 24). In this study CCPP, PPR, internal and external parasite, were the most frequently reported diseases of goats in both Debub Ari and Bena-Tsemay districts (Table 24). Majority (53.3%) of respondents in Debub Ari and 23.33% respondents in Bena-Tsemay districts use modern veterinary service regularly to treat their goats (Figure 6).

Figure 6. Bena-Tsemay goats being sprayed at Aldula kebele animal health clinic for tick's infestation

About 45.6% respondents in Debub Ari and 74.4% respondents in Bena-Tsemay districts use modern veterinary service occasionally. Small number of respondents (1.11% in Debub Ari 2.2% in Bena-Tsemay districts) never uses modern goats' treatment. However about 67.8 %

respondents in Debub Ari and 46.7 % respondents in Bena-Tsemay districts use traditional treatment occasionally. About 3.3% respondents in Debub Ari and 2.22% respondents in Bena-Tsemay use traditional treatment regularly. 28.9% and 51.11% respondents never use traditional treatment in Debub Ari and Bena-Tsemay districts, respectively.

Table 24. List of major and economically important diseases and parasites reported by respondents in the study districts

Districts	Common name of the disease	Local name of the disease	Index
Debub Ari	Indo parasite / liver fluke/	Gosra	0.38
	CCPP	*Shompo*	0.33
	Exto parasite / ticks/	*Soya*	0.21
	PPR	-	0.08
Bena-Tsemay	Exto parasite /ticks/	Soya	0.45
	CCPP	Shompo	0.34
	Indo parasite	Gosra	0.17
	PPR	-	0.04

4.20. Goat Disposal and Marketing Age

The average market and culling age of goat in Debub Ari and Bena-Tsemay are presented in Table 25. The average market age of male goat in Debub Ari and Bena-Tsemay was 1.72±0.62 and 2.27 ±0.49 years, respectively. Similarly, females reached market age at 1.55 ±0.57 and 2.05 ±0.43 years in Debub Ari and Bena-Tsemay, respectively. This shows that male goats reached for market at older age than female goats; however, male goats are marketed first than females any time whenever there is serious money shortage.

Most of the selling times and buying process of goats were carried out in big nearby markets on market days of the week. However, it is not uncommon to sell goats any day of the week mostly to local traders and to lesser extent to consumers and other farmers/pastoralists/. Upon collection of goats from farmers/pastoralists/, local traders in turn sell goats to traders from nearby zones, who ultimately truck/trek goats to the nearby cities, mainly to Jinka and konso. In accordance with the reports of Endeshaw (2007) and Belete (2009) in Ethiopia and Kosgay (2004) in Kenya, in the local markets informal goat marketing practice (eye ball price setting) was noted. In the current study, sometimes the process of marketing goats takes place without the participation of local traders in which case farmers/pastoralists/ specially sells male goats directly to the main traders at Alduba and Luka market. The traders come from different parts of the country and use weighing scale to weigh the goats and the price is depend on live weight of goats. In contrast to local traders, main traders use car transportations to truck the goats to meat processing and exporting center.

Though shortage of capital force farmers/ pastoralists/ to sell their goats any time of the year, they usually prefer to sell their goats in particular time of the year especially during local holidays and festivals (E.g. Ethiopian New Year, Christmas, Epiphany, Easter, Meskel et*c*) because of high demand and better price. However, respondents in both districts stressed that long distance trekking of goats due to inadequate transportation facilities, fluctuation of market price of goats and lack of market information system are the major problems that challenge goats marketing.

The average market age of male goats in Debub Ari and Bena- Tsemay district due to money needs was 4.50±0.81 and 4.40±0.59 years, respectively. In Debub Ari and bena-Tsemay districts females culled (due to old age) at the 7.26±0.76 years old and 7.41±0.72 years old

respectively. Mostly culling of breeding bucks was accomplished to fulfill immediate need of cash and when the animals faced health problem. When farmers/ pastoralists/ need instant money they give priority to sell their goats. In Debubi Ari district 33.3%, 30%, 16.7%, 11.11%, 7.8% and 1.1% respondents sell old bucks, castrated bucks, old does, both old does and old bucks, male goats less than six month and female goats less than six months first, respectively. Similarly in Bena-Tsemay district 33.3%, 26.7%, 23.3%, 6.7%, 4.4%, 3.3%, 1.1% and 1.1% respondents sell old bucks, old bucks and old does, old does, castrated males, male goats between six month and one years old, male goats less than six month old, breeding does and female goats between six month and one years old first, respectively.

Table 25. Marketing and culling age of goats (mean ± SD) in the study area (in years)

Parameter	Debub Ari(90)	Benatsemay (90)	Over all(180)	P-value
	Mean ±SD	MEAN±SD	MEAN±SD	
Average marketing age (males)	1.72±0.62	2.27±0.49	1.99±0.62	0.001
Average marketing age (females)	1.55±0.57	2.05±0.43	1.80±0.56	0.001
Average culling age (males)	4.50±0.81	4.40±0.59	4.45±0.71	0.346
Average culling age (females)	7.26±0.76	7.41±0.72	7.33±0.74	0.160

90 and 180 = number of respondents

4. 21. Constraints of goats Production in the study area

Identifying the obstacles of goat's production is a base to solve the problem and to improve goat's genetic resource and productivity. Major constraints challenging goat production in the study area are presented in Table 26. This study demonstrated that disease and feed shortage are the major constraints challenging goat's production in both Debub Ari and Bena-Tsemay districts. In Debub Ari disease accounted for the lions share (index value=0.39) followed by feed shortage (index value=0.36), recurrent drought (index value= 0.19) and labor shortage

(index value=0.06) as limiting factor of goat production. In Bena-Tsemay, however, feed shortage and disease were the major constraints with the index value of 0.31 and 0.31, respectively followed by water scarcity (index value=0.25) and the recurrent drought (index value= 0.13) that has been killed many animals in this district. The major constraints of goat rearing found in this study were similar with the constraints listed by Solomon *et al*., (2010) though their importance varied between the study areas, During focus group discussion in Debub Ari district some respondents mentioned that predator (monkey) which was killed many kids at goats' browsing area (in the bushes) , but it was not a major concern in Bena-Tsemay district.

Table 26. Major constraints of goat production in the study area

District	Constraints	Index
Debub Ari	Disease	0.39
	Feed shortage	0.36
	Recurrent drought	0.19
	Labor shortage	0.06
Bena-Tsemay	Feed shortage	0.31
	Disease	0.31
	Water scarcity	0.25
	Recurrent drought	0.13

4.22. Qualitative Characteristics of Debub Ari and Bena-Tsemay goat

Phenotypic characteristics of a breed include qualitative, Quantitative and economic traits (FAO, 2012). These characteristics are important in breed identification, classification, genetic improvement (selection) implementation and sustainable utilization and conservation of Animal Genetic Resources (Salako and Ngere, 2002).

The frequency and percentage of qualitative traits of Debub Ari and Bena-Tsemay goat populations for both bucks and does are presented in table 27. The observed overall coat color patterns for both sexes were patchy(52.38%), plain(42.54%) and spotted(5.08%) for Debub Ari district and patchy(60.00%), plain(39.05%) and spotted(0.95%) for Bena-Tsemay district goat populations. Similarly, Bekalu (2014) reported that about 44.5% of goat population in West Gojam zone had patchy coat color pattern. In contrast to this result, Ahmed (2013) reported that majority (75.49%) of goat population in Horro Guduru Wollega zone had plain coat color pattern. About 93% plain patchy color was also reported in Bati, South Wollo and Shewa Robit and Ankober areas Tesfaye *et al*., (2006).

Goat populations found in the study area had a wide range of coat color types (Table.27) and (Figure 7and 8). This result is comparable with FARM Africa (1996) who reported that the dominant coat color type of Central Highland goat was reddish-brown. On the contrary Hailu *et al*., (2019) reported that (21.4%) of goat population in Minjar shenkora district had white coat color. In studied area different coat colors also were observed with small and varied frequencies. Similarly Halima *et al*., (2012a) and Grum (2010) reported wide range of coat colors for different Ethiopian goat populations. The variability in coat color may be due to the indiscriminate crossing existing among indigenous goat populations (Hagan *et al.*, 2012). The respondents also indicated that coat color was an important criterion for selection of the bucks and does.

The majority of both sexes in Debub Ari female (50.20%) and male (46.67%) as well as in Bena-Tsemay female (55.72%) and male (56.82%) goats had smooth hair type. The result was comparable with (Hailu *et al.,* 2019) goat population in Berehet (79.5%), in Basona-worena, (67.6%) and in Minjar Shenkora (69.5) had smooth hair coat type .

In this study the majority of Debub Ari (female 87.45% and male 90%) and Bena-Tsemay (female 93.73% and male 95.45%) goat populations were horned. The presence of horn were in line with the previous studies by FARM Africa (1996) and Alubel (2015) who reported that the majority (90.38%) of Abergelle and Central Highland goats were horned. 79.08 % of the sampled female and similar percent of male goats (79.80%) had straight horn shape. This result is comparable with Hulunim (2014) reported that the dominant horn shape in Bati indigenous goats was straight (96.7%).

75.20% (female), 73.33 % (male) goats in Debub Ari district and 81.55% (female) and 72.73% (male) goats in Bena-Tsemay district had upward horn orientation. Most of the Debub Ari goats female (88.24%) and males (70.45%), as well as Bena-Tsemay goats, female (67.16%) and males (80.00%) had horizontal ear orientation, which may be associated with alertness to protect them against predators and also long ears can help in dissipating heat from the animals (Cote *et al.*, 2013). The presence of horizontal orientation of the ears has also been reported for several Ethiopian goat breeds (Halima *et al.*, 2012b; Tsegaye *et al.*, 2013 and Alayu *et al.*, 2014). Among total sampled goats population, 52.69% in Debub Ari district and 55.56% in Bena-Tsemay district had straight and concave head profile respectively. About 62.73% female and 72.12% male goat's population had straight back profile, similarly 65.97% female and male goats (72.12%) had sloping rump profile. However, only 9.88% females and 17.31% males, had wattle. Studies by Odubote (1994) and Adedeji (2012) indicate that among the West African dwarf goats those with wattles had significantly lower rectal temperature and respiration rate indicating that goats with wattle are able to tolerate the hot and humid climate and hence could be associated with thermo regulatory function of the tropically adapted animals.16.35% females and 93.27% males were bearded and small number of females

(1.52%) and 88.46% males had ruff. The result indicated that the presence of beard was more frequent in males. Similar results were also reported by Dereje *et al*., (2013) for Hararghe high land goats. According to Hagan *et al*.,(2012) in addition to the thermoregulatory functions, the presence of wattle and beard associated with reproduction traits such as higher prolificacy, higher milk yield, higher litter size and fertility. 60.65 females and 72.12% males had average body condition. As the result from the current study indicated that Debub Ari and Bena-Tsemay districts goats had difference in qualitative characters ($P<0.05$) except wattle and ruff (Table.27), which might be resulted due to geographical differences.

Table 27. Frequency (N) and percentage in brackets for each qualitative trait by goat population.

		Debub Ari			BenaTsema			Chi-square test	
		Female=255	Male=60	Total=315	Female=27	Male=44	Total=315	By districts	
Traits	Class level	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	X^2	p-values
Coat color pattern	Plain	107(41.96)	27(45.00)	134(42.54)	105(38.75)	18(40.91)	123(39.05	10.99	0.004
	Patchy	137(53.73)	28(46.67)	165(52.38)	163(60.15)	26(59.09)	189(60)		
	Spotted	11(4.31)	5(8.33)	16(5.08)	3(1.11)	-	3(0.95)		
Coat Color type	Black	48(18.82)	9(15.00)	57(18.09)	29(10.70)	8(18.18)	37(11.75)	43.70	0.001
	Brown	51(20.00)	12(20.00)	63(20.00)	84(31.00)	9(20.45)	93(29.52)		
	Light brown	26(10.20)	6(10.00)	32(10.12)	40(14.76)	6(13.64)	46(14.60)		
	Dark brown	10(3.92)	-	10(3.17)	29(10.70)	2(4.55)	31(9.84)		
	Red	8(3.14)	3(5.00)	11(3.49)	8(2.95)	2(4.55)	10(3.17)		
	Light red	13(5.10)	6(10.00)	19(6.03)	9(3.32)	-	9(2.85)		
	Dark red	5(1.96)	2(3.33)	7(2.22)	3(1.11)	-	3(0.95)		
	Fawn	7(2.75)	2(3.33)	9(2.85)	1(0.37)	3(6.82)	4(1.27)		
	Gray	15(5.88)	4(6.67)	19(6.03)	7(2.58)	2(4.55)	9(2.86)		
	White	24(9.14)	4(6.67)	28(8.88)	30(11.07)	4(9.09)	34(10.79)		
	Creamy white	29(11.37)	8(13.33)	37(11.74)	24(8.86)	6(13.64)	30(9.52)		
	Mixture of black ,gray and white	4(1.57)	1(1.67)	5(1.58)	4(1.48)	-	4(1.27)		
	Brown with patch	6(2.35)	2(3.33)	8(2.54)	3(1.11)	-	3(0.95)		
	Brown with dark patch	4(1.57)	-	4(1.26)	-	-	-		
	White with small light patch	5(1.96)	1(1.67)	6(1.90)	-	2(4.55)	2(0.63)		

Table 27. (Continued)

		Debub Ari			Benatsemay			Chi-square test	
		Female=255	Male=60	Total=315	Female=271	Male=44	Total=315	By districts	
Traits	Class level	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	X^2	p-values
Hair type	Glossy	90(35.29)	25(41.67)	115(36.51)	77(28.41)	11(25.00)	88(27.93)	18.19	0.001
	Smooth	128(50.20)	28(46.67)	156(49.52)	151(55.72)	25(56.82)	176(55.87)		
	Straight	1(0.39)	1(1.67)	2(0.63)	5(1.85)	3(6.82)	8(2.53)		
	Curly rough	11(4.31)	5(8.33)	16(5.08)	3(1.11)	1(2.27)	4(1.27)		
	Dull	25(9.80)	1(1.67)	26(8.25)	35(12.92)	4(9.09)	39(12.38)		
Horn shape	Scars	31(12.16)	6(10.00	37(11.75)	17(6.27)	2(4.55)	19(6.03)	8.13	0.043
	Straight	191(74.90)	46(76.67	237(75.24)	225(83.03)	37(84.09)	262(85.17)		
	Curved	29(11.37)	7(11.67)	36(11.43)	26(9.59)	2(4.55)	28(8.89)		
	Spiral	4(1.57)	1(1.67)	5(1.59)	3(1.11)	3(6.82)	6(1.90)		
Horn orientation	Lateral	1(0.39)	-	1(0.32)	2(0.74)	3(6.82)	5(1.59)	10.19	0.04
	Obliqual	13(5.12)	3(5.00)	16(5.08)	18(6.640)	1(2.27)	19(6.03)		
	Upward	191(75.20)	44(73.33)	235(74.60)	221(81.55)	32(72.73)	253(80.32)		
	Back ward	18(7.09)	7(11.67)	25(7.95)	13(4.80)	6(13.64)	19(6.03)		
	Polled	31(12.20)	6(10.00)	37(11.75)	17(6.27)	2(4.55)	19(6.03)		
Ear orientation	Erect	2(0.78)	1(1.67	3(0.95)	4(1.48)	2(4.55)	6(1.90)	32.47	0.001
	horizontal	225(88.24)	48(80.00)	273(86.67)	182(67.16)	31(70.45)	213(67.61)		
	Pendulous	4(1.57)	-	4(1.27)	10(3.69)	-	10(3.17)		
	Semi pendulous	24(9.41)	11(18.33)	35(11.11)	75(27.68)	11(25.00)	86(27.30)		
Head profile	Straight	143(56.08)	23(38.33)	166(52.69)	106(39.11)	15(34.09)	121(38.41)	13.04	0.0015
	Concave	108(42.35)	28(46.67)	136(43.17)	155(57.20)	20(45.45)	175(55.56)		
	Convex	4(1.57)	9(15.00)	13(4.13)	10(3.69)	9(20.45)	19(6.03)		

Table 27. (Continued)

		Debub Ari			BenaTsemay			Chi-square test	
		Female=255	Male=60	Total=315	Female=271	Male=44	Total=315	By districts	
Traits	Class level	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	X^2	p-values
Back profile	Straight	171(67.06)	42(70.00)	213(67.62)	159(58.67)	33(75.00)	192(60.95)	33.55	0.001
	Slop up toward the rump	65(25.49)	13(21.67)	78(24.76)	46(16.97)	7(15.91)	53(16.83)		
	Slop down from wither	13(5.10)	4(6.67)	17(5.39)	26(9.59)	2(4.55)	28(8.89)		
	Curved	6(2.35)	1(1.67)	7(2.22)	40(14.76)	2(4.55)	42(13.33)		
Rump profile	Flat	56(21.96)	16(26.67)	72(22.86)	15(5.54)	3(6.82)	18(5.71	74.53	0.001
	Slopping	178(69.80)	41(68.33)	219(69.52)	169(62.36)	34(77.27)	203(64.44)		
	Roofy	21(8.24)	3(5.00)	24(7.62)	87(32.10)	7(15.91)	94(29.84)		
Wattle	Present	28(10.98)	13(21.67)	41(13.02)	24(8.86)	5(11.36)	29(9.21)	2.31	0.128
	Absent	227(89.02)	47(78.33)	274(86.98)	247(91.14)	39(88.64)	286(90.79)		
Bearded	Present	60(23.53)	53(88.33)	113(35.87)	26(9.59)	44(100.00)	70(22.22)	14.24	0.002
	Absent	195(76.47)	7(11.67)	202(64.13)	245(90.41)	-	245(77.78)		
Ruff	Present	5(1.96)	50(83.33)	55(17.46)	3(1.11)	42(95.45)	45(14.29)	1.18	0.275
	Absent	250(98.04)	10(16.67)	260(82.54)	268(98.89)	2(4.55)	270(85.71)		
Body condition	Very thin	-	-	-	17(6.27)	-	17(5.39)	76.22	0.001
	Thin	32(12.55)	4(6.67)	36(11.43)	90(33.21)	8(18.18)	98(31.11)		
	Average	170(66.67)	42(70.00)	212(67.30)	149(54.98)	33(75.00)	182(57.78)		
	Fat	53(20.78)	14(23.33)	67(21.27)	15(5.54)	3(6.82)	18(5.71)		

Figure 7. A picture of goat flock taken from Debub Ari district

Figure 8. A picture of goat flock taken from Bena-Tsemay district

4.23. Morphometric/Quantitative/ measurements of goats in the two districts

Quantitative characteristics are those that can be measured in some units. Knowledge of these quantitative characteristics is important to implement genetic improvement (selection), appreciate variations among goat populations so as to facilitate their sustainable use and estimate live body weight from simple and more easily measurable variable as well as market value in terms of cost of animals. Least square mean and associated standard error (LSM±SE) of body weight and other linear body measurements of goat by sex, age groups, study site (location), interaction of sex by age group, interaction of sex by location, interaction of age by location, interaction of age group, sex and location, indices , correlation between body weight and other body measurements and step wise multiple regression analysis of live weight on different body measurements were presented in tables 28, and 29, 30,31,32,33, 34, 35, 36, 37 and 38 respectively.

4.23.1. Effect of sex

In the current study sex had significant ($p<0.05$) effect on the rump height (RHt), sternum height (StHt), height at wither (HtW), chest width (CW), ear length (ErL), horn length (HL), head length (HLt), head width (HW), cannon bone circumference (CC) chest depth (CD) and rump length (RL) and body weight (BWt) . Bucks had higher values than does (Table 27). Sex had no significant effect ($P>0.05$) on body length (BL), rump width (RW), paunch girth (PG) and heart girth (HG). The current study result showed that, the average weight of does was 22.85±0.24kg that of bucks was 25.48±0.60kg but fully matured (4PPI) does had (30.46±0.58 and 25.15±0.16) and bucks (34.43±0.35 and 33.33±0.81) average body weight (kg) in Dubub Ari and Bena-Tsemay districts respectively. The average body weight reported in the current study was comparable with indigenous goat breed of Ethiopia, the average live body weight

for Gumuz, Agew goats, Begia-Medir goats, Bati goat, Abergelle goats, and Central Abergelle goats was 34.6, 31.5, 32.5, 29.9 and 28.1 and 27.9 kg, respectively (Halima *et al.*, 2012b). According the east Africa goat size classification method, body size of the goat breeds is categorized into three groups: small (20-30 kg), medium (30-45 kg) and large (45-60 kg) (Kiwuwa, 1992) in this sense the Debub Omo goats can be grouped under medium goat breed.

The overall traits based coefficient of variation due to sex difference ranged 7.06 to 29.43% for rump height and horn length respectively. The sex effect (R^2) values ranged from 0.00038 for punch girth to 0.21 for chest width. Traits with low overall R^2 with the corresponding high coefficient of variation (CV) values such as horn length in the present study reflected that the heterogeneity was within the sex of goats. While the reverse (high over all R^2 and low CV values such as rump height indicated heterogeneity between sexes of goats. Therefore, the variation in this study attributed to within sex differences.

Table 28. Least square mean (± SE) body weight (kg), and other body measurements (cm) of Debub Ari and Bena-Tsemay goat types by sex

Effects		**BL**		**RHt**		**RL**		**RW**		**PG**		**HG**
Sex	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Female	526	59.54±0.22	526	60.92±0.18	526	15.83±0.08	526	12.06±0.06	526	76.20±0.34	526	66.74±0.24
Male	104	60.35±0.54	104	62.58±0.42	104	16.24±0.22	104	12.20±0.18	104	76.60±0.75	104	67.62±0.58
Over all	630	59.67±0.20	630	61.19±0.17	630	15.89±0.07	630	12.08±0.06	630	76.27±0.31	630	66.88±0.22
P-value		0.142		0.001		0.048		0.395		0.625		0.141
C V		8.59		7.06		12.19		12.77		10.09		8.31
R^2		0.003		0.019		0.006		0.0012		0.00038		0.00345
Effects		**StHt**		**HtW**		**CD**		**CW**		**ErL**		**HL**
Sex	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Female	526	36.97±0.14	526	61.08±0.19	526	28.04±0.09	526	15.71±0.08	526	12.26±0.09	486	7.99±0.12
Male	104	38.51±0.29	104	63.18±0.45	104	28.51±0.25	104	16.53±0.19	104	13.07±0.17	98	9.54±0.24
Over all	630	37.23±0.13	630	61.42±0.18	630	28.12±0.09	630	15.84±0.07	630	12.39±0.08	584	8.25±0.10
P-value		0.001		0.001		0.054		0.001		0.001		0.001
C V		8.35		7.39		8.08		12.29		16.71		29.43
R^2		0.0325		0.029		0.0058		0.21		0.022		0.05
Effects		**HLt**		**HW**		**CC**		**BWt**				
Sex	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE				
Female	526	17.41±0.05	526	11.93±0.05	526	7.34±0.03	526	22.85±0.24				
Male	104	17.96±0.12	104	12.61±0.11	104	7.91±0.09	104	25.48±0.60				
Over all	630	17.50±0.05	630	12.04±0.05	630	7.43±0.03	630	23.28±0.23				
P-value		0.001		0.001		0.001		0.001				
C V		7.47		9.39		10.14		23.83				
R^2		0.03		0.059		0.07		0.028				

BL = Body length; RHt = Rump height ; RL = Rump length ; RW = Rump width; PG = Paunch girth; HG= Heart girth; StHt= Sternum height ; HtW= Height at wither ; CD= Chest depth; CW= Chest width; ErLL= Ear length ; HL Horn length ; HLt= Head length ; HW = Head width ; CC=Canon bone circumference; BWt=Body weight; N= number; CV=coefficient of variation within sex; R^2= effects between sexes.

4.23.2. Effect of age group

Age group exerted strong effect on body length (BL), rump height (RHt), rump length (RL), rump width (RW), paunch girth (PG), heart girth (HG), sternum height (StHt), height at wither (HtW), chest depth (CD), chest width (CW), horn length (HL), head length (HLt), head width (HW), cannon bone circumference (CC),body weight (BWt), scrotal circumference (SC), teat length (TL), teat diameter (TD), udder width (UW) and udder circumference (UC) were significantly ($p<0.001$) affected by age group (table 28). Similarly ear length (ErL) and udder length (UL) were affected ($P<0.01$) by age group. Distance between teat (DBnT) and teat distance from ground (TDFg) were not affected ($p> 0.05$) by age group. As reported earlier, the size and shape of the animal increases until the animal reach its optimum growth point or until maturity (Yoseph, 2007). Dentition group 3PPI and 4PPI had higher values than those between 1ppi and 2PPi dentition groups. The significant difference ($p<0.001$) among the four age groups on body measurements (BL, RHt, RL, RW, PG, HG, StHt, HtW, CD, CW, HL, HLt, HW, CC, BWt, SC, TL, TD, UW, and UC) shows that those measurements were highly dependent on age. The finding of this result of body weight and other body measurements is in agreement with the report of Zewdu (2008) who reported that matured body weight of the animal almost fully attains at older age. As age increased the size of scrotal circumference also increased. The matured (age group 4) goat had higher ($p<0.001$) scrotal circumference than the other age groups. The scrotal circumference of matured (4PPi) Debubi Ari and Bena-Tsemay goats was 23.77± 0.64cm.

Table 29. Least square mean (± SE) body weight (kg) and other body measurements (cm) of Debub Ari and Bena-Tsemay goat types by age.

Effect & level		**BL**		**RHt**		**RL**		**RW**		**PG**
Age group	N	LSM ±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
1ppi	125	53.51±0.31	125	56.78±0.32	125	14.17±0.16	125	10.50±0.15	125	69.71±0.38
2ppi	184	58.19±0.22	184	60.03±0.25	184	15.51±0.11	184	11.92±0.09	184	74.86±0.43
3ppi	221	62.24±0.26	221	63.02±0.24	221	16.67±0.11	221	12.65±0.07	221	78.53±0.50
4ppi	100	64.43±0.35	100	64.81±0.31	100	17.05±0.15	100	13.10±0.12	100	80.04±0.79
Over all	630	59.67±0.21	630	61.19±0.17	630	15.89±0.08	630	12.08±0.06	630	76.27±0.31
P-value		0.001		0.001		0.001		0.001		0.001
CV		5.87		5.55		10.40		10.49		8.6
R^2		0.54		0.39		0.28		0.33		0.27

BL = Body length; RHt = Rump height; RL = Rump length; RW = Rump width; PG = Paunch girth; CV=coefficient of Variation within age; R2= effects between ages.

Table 29 continued (Age)

Effect & level		**HG**		**StHt**		**HtW**		**CD**		**CW**
Age group	N	LSM ±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
1ppi	125	61.06±0.30	125	34.60±0.26	125	56.38±0.37	125	26.13±0.20	125	14.56±0.14
2ppi	184	65.51±0.30	184	36.36±0.20	184	60.52±0.25	184	27.66±0.14	184	15.48±0.12
3ppi	221	69.16±0.32	221	38.36±0.17	221	63.29±0.22	221	28.79±0.12	221	16.17±0.13
4ppi	100	71.63±0.45	100	39.63±0.24	100	65.24±0.35	100	29.96±0.18	100	17.37±0.18
Over all	630	66.88±0.22	630	37.23±0.13	630	61.42±0.18	630	28.12±0.09	630	15.84±0.08
P-value		0.001		0.001		0.001		0.001		0.001
CV		6.40		7.13		5.74		6.79		11.2
R^2		0.41		0.29		0.42		0.29		0.20

HG= Heart girth; StHt= Sternum height; HtW= Height at wither; CD= Chest depth; CW= Chest width; CV=coefficient of Variation within age ; R2= effects between ages.

Table 29 continued (Age)

Effect & level		**ErL**		**HL**		**HLt**		**HW**		**CC**
Age group	N	LSM ±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
1ppi	125	12.11±0.22	118	6.54±0.18	125	16.55±0.09	125	11.24±0.10	125	6.98±0.05
2ppi	184	12.55±0.17	168	7.64±0.15	184	17.28±0.08	184	11.78±0.08	184	7.29±0.05
3ppi	221	12.61±0.16	206	9.27±0.17	221	17.80±0.07	221	12.37±0.06	221	7.57±0.05
4ppi	100	13.33±0.22	92	9.36±0.24	100	18.30±0.10	100	12.77±0.09	100	7.95±0.06
Over all	630	12.63±0.09	584	8.25±0.10	630	17.50±0.04	630	12.04±0.05	630	7.43±0.03
P-value		0.01		0.001		0.001		0.001		0.001
CV		15.03		26.91		6.53		8.65		9.69
R^2		0.03		0.21		0.26		0.20		0.15

ErL= Ear length ; HL Horn length ; HLt= Head length ; HW = Head width ; CC=Cannon bone circumference; CV=coefficient of Variation within age; R2= effects between ages.

Table 29 continued (Age)

Effect & level		**BWt**		**SC**		**TL**		**TD**		**UL**
Age group	N	LSM ±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
1ppi	125	18.12±0.25	28	21.07±0.39	10	2.55±0.14	10	1.58±0.12	10	10.40±0.91
2ppi	184	21.61±0.27	42	22.19±0.37	85	2.71±0.03	85	1.71±0.03	85	10.34±0.19
3ppi	221	25.42±0.37	25	23.34±0.35	153	2.67±0.04	153	1.71±0.03	153	10.07±0.17
4ppi	100	28.43±0.57	9	23.77±0.64	75	2.91±0.05	75	1.87±0.03	75	11.08±0.25
Over all	630	23.28±0.23	104	22.30±0.22	323	2.73±0.02	323	1.74±0.02	323	10.38±0.12
P-value		0.001		0.001		0.001		0.001		0.01
CV		19.17		9.76		14.87		19.65		19.71
R^2		0.37		0.18		0.06		0.05		0.04

BWt=Body weight; SC= scrotum circumference; TL=teat length; TD= teat diameter; UL= udder length; CV=coefficient of Variation within age; R2= effects between ages.

Table 29 continued (Age)

Effect & level		**UW**		**UC**		**DBnT**		**TDFg**
Age group	N	LSM ±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
1ppi	10	7.65±0.74	10	21.00±1.51	10	5.20±0.33	10	31.44±0.98
2ppi	85	7.62±0.13	85	20.64±0.37	85	5.03±0.06	85	30.83±0.27
3ppi	153	7.49±0.13	153	20.67±0.31	153	5.09±0.06	153	31.09±0.18
4ppi	75	8.42±0.17	75	22.89±0.49	75	5.32±0.08	75	30.61±0.22
Over all	323	7.74±0.08	323	21.19±0.23	323	5.13±0.41	323	30.92±0.13
P-value		0.001		0.001		0.08		0.52
CV		19.08		17.33		14.35		7.48
R^2		0.06		0.05		0.02		0.01

UW=udder width; UC= udder circumference; DBnT=distance between teat; TDFg= teat distance from ground; CV=coefficient of Variation within age; R2= effects between ages.

4.23.3. Effect of location (district)

Location was found to influence ($P<0.05$) body weight, body length, rump height, rump length, rump width, paunch girth, heart girth, sternum height, height at wither, chest width, ear length, horn length, head length, head width, cannon bone circumference, scrotum circumference, teat length, teat diameter, udder length, udder width, udder circumference, distance between teat and teat distance from ground (Table 30) whereas chest depth was not influenced ($P>0.05$) by location. Except horn length and teat distance from ground Debub Ari district goats had higher value than Bena-Tsemay district goats. The reason may be difference of feed and water availability between two locations during data collection. In addition to this there was higher tick's infestation load in Bena-Tsemay district.

Table 30. Least square mean (± SE) body weight (kg) and other body measurements (cm) of Debub Ari and Bena-Tsemay goat types by location

Effect & level		**BL**		**RHt**		**RL**		**RW**
Location	N	LSM ±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Debub Ari	315	60.99±0.32	315	62.81±0.25	315	16.15±0.12	315	12.41±0.09
Bena-Tsemay	315	58.36±0.23	315	59.57±0.19	315	15.64±0.09	315	11.76±0.08
Over all	630	59.67±0.20	630	61.19±0.17	630	15.89±0.07	630	12.08±0.06
P-value		0.001		0.001		0.001		0.001
CV		8.34		6.62		12.12		12.49
R^2		0.07		0.14		0.02		0.04
Location		**PG**		**HG**		**StHt**		**HtW**
Debub Ari	315	78.79±0.43	315	68.18±0.32	315	38.08±0.19	315	62.50±0.29
Bena-Tsemay	315	73.74±0.39	315	65.58±0.29	315	36.38±0.15	315	60.34±0.21
Over all	630	76.27±0.31	630	66.88±0.22	630	37.23±0.12	630	61.42±0.18
P-value		0.001		0.001		0.001		0.001
CV		9.53		8.09		8.17		7.29
R^2		0.11		0.05		0.07		0.06

BL = Body length; RHt = Rump height; RL = Rump length; RW = Rump width; PG = Paunch girth; HG= heart girth; StHt= sternum height; HtW= height at withers; CV=coefficient of Variation within location; R2= effects between locations.

Table 30 continued (location)

Effect & level		**CD**		**CW**		**ErL**		**HL**	**BWt**
Location	N	LSM ±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	LSM±SE
Debub Ari	315	28.26±0.13	315	16.56±0.11	315	13.29±0.07	287	8.01±0.13	25.29±0.34
Bena-Tsemay	315	27.97±0.12	315	15.13±0.08	315	11.53±0.14	297	8.49±0.15	21.29±0.27
Over all	630	28.12±0.09	630	15.84±0.07	630	12.39±0.09	584	8.25±0.10	23.28±0.23
P-value		0.107		0.001		0.001		0.01	0.001
CV		8.09		11.58		15.54		30.00	22.67
R^2		0.01		0.13		0.15		0.01	0.12
Location		**HLt**		**HW**		**CC**		**SC**	
Debub Ari	315	17.95±0.07	315	12.33±0.07	315	7.74±0.04	60	22.74±0.26	
Bena-Tsemay	315	17.05±0.06	315	11.74±0.06	315	7.12±0.04	44	21.69±0.39	
Over all	630	17.50±0.05	630	12.04±0.05	630	7.43±0.03	104	22.30±0.23	
P-value		0.001		0.001		0.001		0.01	
CV		7.19		9.34		9.69		10.33	
R^2		0.10		0.07		0.15		0.06	

CD= Chest depth; CW= Chest width; ErL=ear length; HL= horn length; BWt=body weight; HLt = head length; HW=head width; CC= cannon bone circumference; SC= scrotum circumference; CV=coefficient of Variation within location; R2= effects between locations.

Table 30 continued (location)

Effect & level		**TL**		**TD**		**UL**		**UW**
Location	N	LSM ±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Debub Ari	157	2.85±0.03	157	1.91±0.02	157	11.20±0.15	157	8.34±0.12
Bena-Tsemay	166	2.63±0.03	166	1.59±0.02	166	9.62±0.15	166	7.18±0.11
Over all	323	2.74±0.02	323	1.75±0.02	323	10.39±0.12	323	7.74±0.08
P-value		0.001		0.001		0.001		0.001
CV		14.79		17.81		18.52		18.16
R^2		0.07		0.21		0.14		0.14
Location		**UC**		**DBnT**		**TDFg**		
Debub Ari	157	22.66±0.29	157	5.43±0.06	157	30.13±0.13		
Bena-Tsemay	166	19.82±0.31	166	4.86±0.05	166	31.67±0.20		
Over all	323	21.19±0.23	323	5.14±0.04	323	30.92±0.13		
P-value		0.001		0.001		0.001		
CV		16.64		13.35		7.05		
R^2		0.12		0.15		0.12		

TL = teat length; TD = teat diameter; UL = udder length; UW = udder width; UC = udder circumference; DBnT= distance between teat; TDFg= teat distance from ground; CV=coefficient of Variation within location; R2= effects between locations.

4.23.4. Interaction of Sex by age group

The interaction between sex and age group significantly ($p<0.05$) affected, body length, rump height, rump length, height at wither, chest width and head width (Table 31). The remaining parameters of body measurements body weight, rump width, paunch girth, heart girth, sternum height, chest depth, ear length, horn length, head length and cannon bone circumference were not affected ($P>0.05$) by the sex-age interaction effect. The value of body length for female goats in age group1, age group 2, age group 3 and age group 4 were 52.56±0.34cm, 58.01±0.28 cm, 62.03±0.24 cm and 63.94±0.35 cm, respectively and the values for males in the same age groups were 56.66±0.62cm, 58.83±0.52cm, 63.84±0.67cm and 69.44±1.12cm respectively. Both females and males in age group 1(1ppi), age group 2(2ppi), group 3(3ppi) and age group 4(4ppi) had the different ($p<0.05$) body measurement value.

Table 31. Least square mean (± SE) body weight (kg) and other body measurements (cm) of Debub Ari and Bena-Tsemay goat types sex by age interaction

Effects		BWt	BL	RHt	RL	RW	PG
	N	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
P-value		0.144	0.001	0.01	0.04	0.06	0.51
Female, 1PPI	96	17.47±0.44	52.56±0.34	55.71±0.31[b]	13.82±0.17	10.25±0.13	69.08±0.66
Male, 1PPI	29	20.26±0.79	56.66±0.62	60.31±0.59	15.35±0.30	11.35±0.23	71.79±0.21
Female, 2PPI	143	20.81±0.36	58.01±0.28	59.52±0.27	15.48±0.14	11.87±0.11	74.65±0.54
Male,2PPI	41	24.58±0.68	58.83±0.52	61.81±0.50	15.63±0.25	12.09±0.19	75.61±1.02
Female, 3PPI	196	24.79±0.31	62.03±0.24	62.85±0.13	16.56±0.12	12.62±0.08	78.15±0.46
Male, 3PPI	25	30.31±0.87	63.84±0.67	64.40±0.64	17.56±0.32	12.88±0.25	81.56±1.31
Female, 4PPI	91	27.93±0.45	63.94±0.35	64.46±0.34	16.93±0.17	13.06±0.13	81.95±0.68
Male, 4PPI	9	33.33±1.42	69.44±1.12	68.33±1.07	18.22±0.54	13.56±0.42	82.89±2.17

N= number of goat sample ; BWt= body weight ; BL= body length ; RHt= rump height ; RL= rump length ; RW= rump width ; PG= paunch girth

Table 31 Continued (Sex by age interaction)

Effects		HG		StHt		HtW		CD		CW
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P-value		0.14		0.11		0.001		0.25		0.04
Female, 1PPI	96	60.29±0.43	96	33.81±0.26	96	55.17±0.33	96	26.04±0.19	96	14.17±0.17
Male, 1PPI	29	63.59±0.78	29	37.21±0.47	29	60.41±0.61	29	26.41±0.35	29	15.89±0.31
Female, 2PPI	143	63.22±0.35	143	35.97±0.21	143	59.88±0.27	14	27.40±0.16	14	15.15±0.14
Male,2PPI	41	66.54±0.65	41	37.71±0.39	41	62.76±0.51	41	28.54±0.29	41	16.65±0.27
Female, 3PPI	196	68.77±0.29	196	38.13±0.18	196	63.10±0.23	19	28.66±0.13	19	16.12±0.12
Male, 3PPI	25	72.28±0.84	25	40.16±0.50	25	64.84±0.66	25	29.80±0.38	25	16.52±0.34
Female, 4PPI	91	71.54±0.44	91	39.42±0.26	91	64.82±0.34	91	29.80±0.19	91	17.29±0.18
Male, 4PPI	9	72.56±1.39	9	41.78±0.34	9	69.44±1.09	9	31.56±0.63	9	18.11±0.56

N= number of goat sample ; HG= heart girth ; StHt= sternum height ; HtW= height at wither ; CD = chest depth ; CW= chest width

Table 31 Continued (Sex by age interaction)

Effects		ErL		HL		HLt		HW		CC
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P-value		0.49		0.78		0.24		0.02		0.69
Female, 1PPI	96	11.85±0.23	90	6.01±0.22	96	16.28±0.12	96	10.91±0.09[b]	96	6.85.±0.07
Male, 1PPI	29	13.28±0.39	28	8.25±0.39	29	17.36±0.19	29	12.34±0.18[a]	29	7.41±0.13
Female, 2PPI	143	11.82±0.18	132	7.24±0.18	143	17.14±0.09	14	11.61±0.08[b]	143	7.13±0.06
Male,2PPI	41	12.70±0.33	36	9.14±0.35	41	17.75±0.16	41	12.42±0.15[a]	41	7.89±0.11
Female, 3PPI	196	12.53±0.15	181	9.04±0.16	196	17.72±0.07	19	12.31±0.07[b]	196	7.48±0.05
Male, 3PPI	25	13.48±0.41	25	10.92±0.42	25	18.44±0.02	25	12.88±0.19[a]	25	8.24±0.14
Female, 4PPI	91	12.74±0.22	83	9.13±0.23	91	18.19±0.11	91	12.69±0.10[b]	91	7.88±0.07
Male, 4PPI	9	12.89±0.69	9	11.75±0.72	9	19.44±0.35	9	13.56±0.32[a]	9	8.67±0.22

N= number of goat sample; ErL= ear length; HL= horn length; HLt= head length; HW= head width; CC= cannon bone circumference.

4.23.5. Interaction of sex by location

The interaction effect of sex and location (district) were significantly ($p<0.05$) affected only body weight and horn length (Table 32). The remaining parameters of body measurements like body length, rump height, rump length, rump width, paunch girth, heart girth, sternum height, height at wither, chest depth, chest width, ear length, head length, head width, and cannon bone circumference were not affected ($P>0.05$) by the sex and location interaction effect. The values of body weight and horn length were larger for bucks than does in both Debub Ari and Bena-Tsemay districts.

Table 32. Least square mean (± SE) body weight (kg) and other body measurements (cm) of Debub Ari and Bena-Tsemay goat types sex by location interaction

Effects			**BWt**	**BL**	**RHt**	**RL**	**RW**	**PG**
		N	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
P-value			0.05	0.83	0.91	0.90	0.22	0.202
Debub Ari	Female	255	25.04±0.34	60.89±0.31	62.56±0.25	16.08±0.12	12.43±0.09	78.97±0.46
	Male	60	26.32±0.69	61.36±0.64	63.88±0.52	16.46±0.25	12.33±0.19	78.03±0.94
Bena-Tsemay	Female	271	20.82±0.32	58.26±0.30	59.38±0.25	15.59±0.12	11.72±0.09	73.59±0.44
	Male	44	24.29±0.81	58.95±0.75	60.79±0.61	15.93±0.29	12.02±0.23	74.66±1.09
			HG	**StHt**	**HtW**	**CD**	**CW**	**ErL**
		N	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
			0.49	0.57	0.67	0.59	0.26	0.13
Debub Ari	Female	255	68.13±0.34	37.85±0.19	62.11±0.28	28.16±0.14	16.39±0.11	13.21±0.12
	Male	60	68.42±0.69	39.06±0.39	64.20±0.57	28.72±0.29	17.28±0.23	13.58±0.25
Bena-Tsemay	Female	271	65.42±0.33	36.16±0.18	60.11±0.27	27.93±0.14	15.06±0.12	11.39±0.12
	Male	44	66.52±0.82	37.75±0.45	61.79±0.67	28.23±0.34	15.52±0.27	12.39±0.29

N= number of goat sample ; BWt= body weight ; BL= body length ; RHt= rump height ; RL= rump length ; RW= rump width ; PG= paunch girth; HG= heart girth; StHt= sternum height ; HtW= height at wither ; CD= chest depth ; CW= chest width ;ear length.

Table 32 Continued (sex by location interaction)

Effects			**HL**		**HLt**	**HW**	**CC**
		N	LSM±SE	N	LSM±SE	LSM±SE	LSM±SE
P-value			0.02		0.34	0.38	0.43
Debub Ari	Female	231	7.80±0.16	255	17.89±0.0	12.23±0.17	7.63±0.04
	Male	56	8.87±0.32	60	18.25±0.1	12.77±0.14	8.20±0.09
Bena-Tsemay	Female	255	8.16±0.15	271	16.97±0.0	11.65±0.07	7.07±0.04
	Male	42	10.48±0.37	44	17.57±0.1	12.39±0.16	7.51±0.11

N= number of goat sample; HL= horn length; HLt= head length; HW= head width; CC= cannon bone circumference.

4.23.6. Interaction of age by location

Body weight, Body length, rump height, rump width, paunch girth, height at wither, chest depth, and chest width increased from the youngest (1ppi) to the oldest (4ppi) (Table 33).The interaction of age group and location was significant ($p<0.05$) for body weight, paunch girth, body length, chest width, horn length, rump height, rump width, height at wither, chest depth, scrotum circumference, teat distance from ground, teat length, teat diameter, udder length, udder width, udder circumference and distance between teat. Differently, the interaction was not significant ($P>0.05$) for rump length, heart girth, sternum height, ear length, head length, head width, and cannon bone circumference, Debub Ari (1ppi, 2ppi, 3ppi and 4ppi) goats had higher ($p<0.05$) body weight, body length, rump height, paunch girth, height at wither, udder length and udder width than Bena-Tsemay goats. The reason may be shortage of goat feed and water at Bena-Tsematy district during data collection. The horn length of Bena-Tsemay age group (3ppi and 4ppi) goats had longer horn length than Debub Ari goats.

Table 33. Least square mean (± SE) body weight (kg) and other body measurements (cm) of Debub Ari and Bena-Tsemay goat types age by location interaction

Effect and level	BL		RH		RL		RW		PG	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P value		0.001		0.01		0.141		0.047		0.001
1PPI,Debub Ari	68	54.00±0.39	68	57.85±0.36	68	14.15±0.19	68	10.69±0.15	68	70.91±0.72
1PPI, Bena-Tsemay	57	52.93±0.42	57	55.49±0.39	57	14.21±0.22	57	10.28±0.16	57	68.28±0.79
2PPI,Debub Ari	84	59.34±0.35	84	61.64±0.32	84	15.82±0.18	84	12.34±0.13	84	76.69±0.65
2PPI, Bena-Tsemay	100	57.20±0.32	100	58.68±0.29	100	15.25±0.16	100	11.57±0.12	100	73.33±0.59
3PPI,Debub Ari	109	64.28±0.31	109	65.22±0.28	109	17.05±0.16	109	12.91±0.12	109	81.81±0.57
3PPI, Bena-Tsemay	112	60.24±0.30	112	60.88±0.28	112	16.30±0.15	112	12.40±0.12	112	75.34±0.56
4PPI,Debub Ari	54	65.65±0.44	54	66.02±0.40	54	17.39±0.22	54	13.67±0.17	54	85.91±0.81
4PPI, Bena-Tsemay	46	63.00±0.47	46	63.39±0.44	46	16.65±0.24	46	12.44±0.18	46	77.50±0.88

BL=body length; RH= rump height; RL=rump length; RW=rump width; PG=paunch girth.

Table 33 continued (Age by location interaction)

Effect and level	**HG**		**StHt**		**HtW**		**CD**		**CW**	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P value		0.407		0.206		0.032		0.025		0.001
1PPI,Debub Ari	68	61.87±0.49	68	34.98±0.31	68	56.76±0.40	68	25.88±0.23	68	14.95±0.19
1PPI, Bena-Tsemay	57	60.08±0.54	57	34.14±0.33	57	55.93±0.44	57	26.42±0.25	57	14.11±0.21
2PPI,Debub Ari	84	66.81±0.45	84	37.44±0.27	84	61.64±0.36	84	27.81±0.21	84	16.04±0.17
2PPI, Bena-Tsemay	100	64.42±0.41	100	35.45±0.25	100	59.58±0.33	100	27.53±0.19	100	15.02±0.16
3PPI,Debub Ari	109	70.82±0.39	109	39.31±0.24	109	64.83±0.32	109	29.05±0.18	109	17.20±0.15
3PPI, Bena-Tsemay	112	67.56±0.38	112	37.43±0.24	112	61.80±0.32	112	28.55±0.18	112	15.16±0.15
4PPI,Debub Ari	54	72.96±0.55	54	40.48±0.34	54	66.37±0.45	54	30.39±0.26	54	18.07±0.22
4PPI, Bena-Tsemay	46	70.06±0.60	46	38.63±0.37	46	63.91±0.49	46	29.46±0.28	46	16.54±0.23

N=number of goat sample ;HG=heart girth; StHt= sternum height; HtW=height at wither; CD= chest depth; CW= chest width

Table 33 continued (Age by location interaction)

Effect and level		**ErL**		**HL**		**HLt**		**HW**		**CC**
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P value		0.062		0.001		0.471		0.189		0.412
1PPI,Debub Ari	68	12.64±0.24	68	6.68±0.27	68	16.89±0.13	68	11.51±0.12	68	7.29±0.08
1PPI, Bena-Tsemay	57	11.71±0.27	57	6.38±0.29	57	16.17±0.14	57	10.91±0.13	57	6.61±0.09
2PPI,Debub Ari	84	13.17±0.21	84	7.72±0.25	84	17.85±0.11	84	12.24±0.12	84	7.57±0.07
2PPI, Bena-Tsemay	100	11.11±0.19	100	7.58±0.23	100	16.79±0.09	100	11.42±0.09	100	7.07±0.07
3PPI,Debub Ari	109	13.50±0.18	109	8.66±0.22	109	18.27±0.09	109	12.62±0.09	109	7.93±0.06
3PPI, Bena-Tsemay	112	11.82±0.18	112	9.87±0.21	112	17.35±0.93	112	12.12±0.09	112	7.22±0.06
4PPI,Debub Ari	54	13.75±0.26	54	8.96±0.32	54	18.65±0.13	54	12.92±0.13	54	8.20±0.09
4PPI, Bena-Tsemay	46	11.59±0.28	46	9.79±0.33	46	17.89±0.15	46	12.61±0.14	46	7.65±0.09

N= number of sampled goat ;ErL= ear length ;HL=lorn length ;HLt=head length ;HW= head width ;CC=cannon bone circumference

Table 33 continued (Age by location interaction)

Effect and level		**SC**		**TL**		**TD**		**UL**		**UW**
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P value		0.03		0.001		0.001		0.001		0.001
1PPI,Debub Ari	22	21.46±0.42	6	2.83±0.16	6	1.77±0.12	6	10.50±0.74	6	8.08±0.54
1PPI, Bena-Tsemay	6	19.67±0.79	4	2.13±0.19	4	1.30±0.15	4	7.25±0.91	4	5.50±0.66
2PPI,Debub Ari	23	23.35±0.41	33	2.73±0.07	33	1.88±0.05	33	11.06±0.32	33	8.21±0.23
2PPI, Bena-Tsemay	19	20.79±0.45	52	2.71±0.05	52	1.61±0.04	52	9.88±0.25	52	7.25±0.18
3PPI,Debub Ari	9	23.89±0.65	81	2.84±0.04	81	1.92±0.03	81	11.16±0.20	81	8.22±0.15
3PPI, Bena-Tsemay	16	23.03±0.49	72	2.48±0.05	72	1.47±0.04	72	8.85±0.21	72	6.66±0.16
4PPI,Debub Ari	7	23.29±0.74	37	2.97±0.06	37	1.93±0.05	37	11.20±0.29	37	8.58±0.22
4PPI, Bena-Tsemay	2	25.50±1.38	38	2.87±0.62	38	1.82±0.05	38	10.97±0.29	38	8.26±0.21

N= number of sampled goat; Scrotum circumference; TL=teat length ; TD= teat diameter; UD= udder length ; UW= udder width

Table 33 continued (Age by location interaction)

Effect and level		**UC**		**DBnT**		**TDFg**		**BWt**
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P value		0.001		0.001		0.01		0.001
1PPI,Debub Ari	6	21.20±1.52	6	5.23±0.27	6	30.20±0.96	68	19.00±0.48
1PPI, Bena-Tsemay	4	17.00±1.70	4	4.25±0.33	4	30.14±0.35	57	17.07±0.53
2PPI,Debub Ari	33	22.16±0.61	33	5.26.±0.12	33	30.27±0.37	84	22.98±0.44
2PPI, Bena-Tsemay	52	19.57±0.51	52	4.88±0.09	52	31.19±0.09	100	20.48±0.39
3PPI,Debub Ari	81	22.66±0.39	81	5.46±0.07	81	32.27±0.24	109	28.38±0.39
3PPI, Bena-Tsemay	72	19.58±0.41	72	4.89±0.07	72	32.24±0.25	112	22.61±0.38
4PPI,Debub Ari	37	22.88±0.59	37	5.48±0.11	37	33.25±1.07	54	31.13±0.55
4PPI, Bena-Tsemay	38	21.92±0.57	38	5.21±0.11	38	32.89±0.35	46	25.31±0.59

N= number of sampled goat; UC= udder circumference; DBnT= distance between teat ;TDFg= teat distance from ground; BWt=body weight

4.23.7. Interaction of age group, sex and location (district)

Body length, rump height, rump length, paunch girth, sternum height, height at wither, chest depth, chest width, horn length, cannon bone circumference and body weight were significantly ($P<0.05$) affected by age group, sex and district interaction (Table 34). The remaining parameters of body measurements like rump width, heart girth, ear length , head length and head width were not affected ($P>0.05$) by age group, sex and district interaction. The values for most body measurements of Debub Ari district were larger than Bena-Tsemay district except horn length. The average horn length for 1PPI of Debub Ari district goats were 5.93±0.31 (for does) and 8.24±044(for bucks) whereas the average horn length for Bena-Tsemay goats were 6.09± 0.29(for does) and 8.29±0.76(for bucks).

Table 34. Least square mean (± SE) body weight (kg) and other body measurements (cm) of Debub Ari and Bena-Tsemay goat types by age group, sex and district interaction

	Sex		**BL**		**RH**		**RL**		**RW**
		N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P value			0.001		0.001		0.01		0.086
1PPI,Debub Ari	Female	46	52.65±0.45	46	56.44±0.41	46	13.67±0.23	46	10.37±0.18
	Male	22	56.82±0.65	22	60.82±0.58	22	15.14±0.34	22	11.36±0.26
1PPI, Bena-Tsemay	Female	50	52.48±0.43	50	55.04±0.39	50	13.96±0.22	50	10.14±0.17
	Male	7	56.14±1.14	7	58.71±1.05	7	16.00.±0.59	7	11.29.±0.46
2PPI,Debub Ari	Female	62	58.92±0.39	62	61.05±0.35	62	15.76±0.20	62	12.32±0.15
	Male	22	60.64±0.65	22	63.32±0.59	22	16.00±0.34	22	12.41±0.26
2PPI, Bena-Tsemay	Female	81	57.31±0.34	81	58.36±0.31	81	15.26±0.18	81	11.53±0.13
	Male	19	56.74±0.69	19	60.05±0.64	19	15.21±0.36	19	11.74±0.28
3PPI,Debub Ari	Female	100	64.00±0.30	100	64.92±0.28	100	16.87±0.16	100	12.88±0.12
	Male	9	67.44±1.01	9	68.56±0.92	9	19.00±0.53	9	13.22±0.40
3PPI, Bena-Tsemay	Female	96	59.98±0.31	96	60.69±0.28	96	16.23±0.16	96	12.35±0.12
	Male	16	61.81±0.76	16	62.06±0.69	16	16.75±0.39	16	12.68±0.30
4PPI,Debub Ari	Female	47	64.98±0.44	47	65.53±0.40	47	17.17±0.23	47	13.62±0.18
	Male	7	70.14±1.14	7	69.29±1.05	7	18.86±0.59	7	14.00±0.46
4PPI, Bena-Tsemay	Female	44	62.82±0.46	44	63.32±0.42	44	16.68±0.24	44	12.46±0.18
	Male	2	67.00±2.14	2	65.00±1.96	2	16.00±1.12	2	12.00±0.85

N= number of sampled goats; BL=body length ; RH= rump height ; RL= rump length ; RW= rump width

Table 34 Continued (Age group, sex and district interaction)

	Sex		PG		HG		StHt		HtW
		N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P value			0.001		0.059		0.001		0.01
1PPI,Debub Ari	Female	46	69.76±0.87	46	60.69±0.58	46	34.00±0.35	46	54.94±0.45
	Male	22	73.32±1.26	22	64.32±0.85	22	37.05±0.50	22	60.59±0.65
1PPI, Bena-Tsemay	Female	50	68.46±0.83	50	59.92±0.56	50	33.64±0.33	50	55.38±0.43
	Male	7	67.00±2.23	7	61.28±1.49	7	37.71.±0.89	7	59.86.±1.16
2PPI,Debub Ari	Female	62	76.07±0.75	62	66.11±0.50	62	37.08±0.29	62	60.87±0.39
	Male	22	78.64±1.26	22	68.77±0.85	22	38.46±0.50	22	63.82±0.65
2PPI, Bena-Tsemay	Female	81	73.57±0.66	81	64.53±0.44	81	35.12±0.26	81	59.12±0.34
	Male	19	72.32±1.35	19	63.95±0.91	19	36.84±0.54	19	61.53±0.70
3PPI,Debub Ari	Female	100	81.68±0.59	100	70.55±0.39	100	38.96±0.24	100	64.45±0.31
	Male	9	83.22±1.96	9	73.78±0.32	9	43.22±0.78	9	69.11±1.02
3PPI, Bena-Tsemay	Female	96	74.46±0.60	96	66.92±0.40	96	37.26±0.24	96	61.69±0.31
	Male	16	80.63±0.47	16	71.44±0.99	16	38.44±0.59	16	62.44±0.77
4PPI,Debub Ari	Female	47	86.06±0.86	47	72.92±0.58	47	40.26±0.34	47	65.77±0.45
	Male	7	84.86±2.23	7	73.29±1.49	7	42.00±0.89	7	70.43±1.16
4PPI, Bena-Tsemay	Female	44	77.57±0.89	44	70.07±0.59	44	38.52±0.36	44	63.82±0.46
	Male	2	76.00±4.17	2	70.00±2.80	2	41.00±1.67	2	66.00±2.17

N= number of sampled goats; PG=paunch girth ; HG= heart girth ; StHt= Sternum height ; HtW= height at wither

Table 34 Continued (Age group, sex and district interaction)

	Sex		CD		CW		ErL		HL
		N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P value			0.01		0.001		0.081		0.02
1PPI,Debub Ari	Female	46	25.61±0.27	46	14.35±0.22	46	12.21±0.30	43	5.93±0.31
	Male	22	26.46±0.39	22	16.23±0.32	22	13.43±0.41	21	8.24±0.44
1PPI, Bena-Tsemay	Female	50	26.44±0.26	50	14.00±0.21	50	11.52±0.29	47	6.09±0.29
	Male	7	26.29±0.69	7	14.86±0.57	7	12.86.±0.71	7	8.29.±0.76
2PPI,Debub Ari	Female	62	27.27±0.24	62	15.61±0.19	62	13.07±0.25	57	7.46±0.27
	Male	22	29.36±0.39	22	17.28±0.33	22	13.43±0.41	19	8.53±0.46
2PPI, Bena-Tsemay	Female	81	27.52±0.21	81	14.80±0.17	81	10.92±0.21	75	7.07±0.24
	Male	19	27.58±0.42	19	15.95±0.35	19	11.89±0.43	17	9.88±0.50
3PPI,Debub Ari	Female	100	28.95±0.19	100	17.06±0.15	100	13.43±0.19	90	8.54±0.21
	Male	9	30.11±0.62	9	18.78±0.50	9	14.33±0.63	9	9.78±0.67
3PPI, Bena-Tsemay	Female	96	28.37±0.19	96	15.15±0.15	96	11.61±0.19	91	9.56±0.22
	Male	16	29.63±0.46	16	15.25±0.38	16	13.00±0.47	16	11.60±0.52
4PPI,Debub Ari	Female	47	30.15±0.27	47	17.98±0.22	47	13.78±0.27	42	8.67±0.32
	Male	7	32.00±0.69	7	18.71±0.57	7	13.57±0.71	7	10.83±0.82
4PPI, Bena-Tsemay	Female	44	29.43±0.28	44	16.57±0.23	44	11.64±0.28	41	9.56±0.31
	Male	2	30.00±1.31	2	16.00±1.07	2	10.50±1.33	2	14.50±1.42

N= number of sampled goats; CD=chest depth ; CW= chest width ; ErL= ear length ; HL= horn length

Table 34 Continued (Age group, sex and district interaction)

	Sex		**HLt**		**HW**		**CC**		**BWt**
		N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
P value			0.063		0.46		0.01		0.05
1PPI,Debub Ari	Female	46	16.51±0.16	46	11.07±0.14	46	7.07±0.09	46	17.96±0.54
	Male	22	17.57±0.21	22	12.46±0.19	22	7.75±0.13	22	21.18±0.78
1PPI, Bena-Tsemay	Female	50	16.09±0.14	50	10.76±0.13	50	6.65±0.08	50	17.03±0.52
	Male	7	16.71±0.36	7	12.00±0.35	7	6.36±0.23	7	17.36.±1.38
2PPI,Debub Ari	Female	62	17.69±0.12	62	12.11±0.12	62	7.35±0.08	62	21.82±0.46
	Male	22	18.32±0.20	22	12.63±0.21	22	8.21±0.13	22	26.43±0.79
2PPI, Bena-Tsemay	Female	81	16.73±0.11	81	11.24±0.10	81	6.96±0.07	81	20.04±0.42
	Male	19	17.11±0.22	19	12.21±0.21	19	7.53±0.14	19	22.42±0.86
3PPI,Debub Ari	Female	100	18.21±0.09	100	12.56±0.09	100	7.85±0.06	100	28.00±0.38
	Male	9	18.89±0.31	9	13.33±0.30	9	8.78±0.20	9	32.33±1.22
3PPI, Bena-Tsemay	Female	96	17.21±0.09	96	12.04±0.09	96	7.10±0.06	96	21.55±0.38
	Male	16	18.19±0.24	16	12.60±0.24	16	7.94±0.15	16	29.10±0.94
4PPI,Debub Ari	Female	47	18.55±0.14	47	12.84±0.14	47	8.12±0.09	47	30.61±0.54
	Male	7	19.29±0.37	7	13.43±0.35	7	8.86±0.23	7	34.43±1.38
4PPI, Bena-Tsemay	Female	44	17.79±0.14	44	12.54±0.14	44	7.64±0.09	44	25.12±0.56
	Male	2	20.00±0.66	2	14.00±0.65	2	8.00±0.42	2	29.50±2.58

N= number of sampled goats; HLt=head length ; HW= head width ; CC= cannon bone circumference ; BWt= body weight

4.23.8 Structural and Functional indices of Debub Ari and Bena-Tsemay goats

Linear measurement traits can be used to calculate structural or body indices. To construct indices, measurements that are anatomically related to each other are paired. Calculated structural indices are used to assess the type and function of the breed. Some structural indices of the bucks and does reared at the two districts are presented in (Table 35). The result revealed that the goats of Debub Ari and Bena-Tsemay districts were more suitable for meat than milk production.

Table 35. Some Morphometric indices of Debub Ari and Bena-Tsemay goats

	Fully matured (4PPI) goats			
Structural Indices	Debub Ari		Bena-Tsemay	
	Female	Male	Female	Male
Body index	89.11	95.71	89.66	95.71
Proportionality index	101.21	100.41	101.59	98.51
Compact index	4.63	4.88	3.94	4.47
Transverse pelvic index	20.76	20.21	19.66	18.46
Longitudinal pelvic index	26.20	27.21	26.34	24.61
Dactyl thorax index	11.12	12.09	10.89	11.43

4.23.9. Correlation between body weight and body measurements

The Pearson correlation coefficient (r) measure the strength and direction of the relationship between two quantitative continuous variables it can take value in the [-1,1] range. +1 indicates perfect positive correlation, -1 indicates perfect negative correlation and 0 indicates no correlation between two variables. Up to 0.3 tells weak correlation, 0.3 up to 0.7 indicates moderate correlation and over 0.7 indicates strong correlation.

Pearson correlation matrix that indicates the association between live weight and other body measurements in sampled males and females goats are shown in Table 36. In males, most of linear body measurements had a positive association with body weight. strong correlation with ($P<0.01$) significant level was found between body weight and heart girth(0.88), paunch girth

(0.85), chest depth(0.81), body length(0.79), rump height(0.79), height at wither (0.75) and cannon bone circumference (0.75) , whereas scrotum circumference (0.69), head length (0.62), sternum height (0.62), chest width(0.57), rump width (0.53), head width (0.49), rump length (0.47) and head length(0.39) showed moderate correlation with body weight. But ear length (0.22) had weak correlation with body weight with ($P<0.05$) significant level. This linear body measurement that showed weak correlation was may not significantly be affected by the change in body weight; hence, it is not more important in the prediction of the live body weight of the animal. Similarly In females, most of linear body measurements had a positive association with body weight. strong correlation with ($P<0.01$) significant level was found between body weight and body length (0.75), rump height (0.75), paunch girth (0.74) and heart girth (0.74), whereas height at wither (0.69), chest width (0.64), head length (0.64), cannon bone circumference (0.64), chest depth (0.58), sternum height (0.58), rump width (0.56) head width (0.53), rump length (0.49), ear length (0.36) and horn length(0.31) showed moderate correlation with body weight. Generally, as the result of correlation showed, heart girth (chest girth) was the most important than other linear body measurements for males and body length, rump height and paunch girth were the most important than other body measurements to estimate body weight of female goats.

Table 36. **Pearson's correlation coefficient (r) for quantitative traits of male (above diagonal line) and female (below diagonal line) for sampled populations males= 104, females =526, Total =630**

	BWt	BL	RH	RL	RW	PG	HG	StHt	HtW	CD	CW	ErL	HL	HLt	HW	CC	SC
BWt		.79**	.79**	.47**	.53**	.85**	.88**	.62**	.75**	.81**	.57**	.22*	.39**	.62**	.49**	.75**	.69**
BL	.75**		.79**	.68**	.64**	.62**	.72**	.77**	.83**	.72**	.53**	.26**	.39**	.64**	.58**	.60**	.53**
RH	.75**	.81**		.47**	.42**	.67**	.72**	.76**	.86**	.69**	.67**	.27**	.35**	.55**	.52**	.69**	.47**
RL	.49**	.74**	.65**		.52**	.34**	.44**	.52**	.48**	.45**	.39**	.11NS	.31**	.48**	.43**	.28**	.39**
RW	.56**	.68**	.65**	.69**		.42**	.49**	.48**	.54**	.54**	.44**	.29**	.24*	.46**	.48**	.42**	.40**
PG	.74**	.59**	.62**	.37**	.55**		.92**	.49**	.59**	.80**	.54**	.28**	.31**	.61**	.46**	.65**	.62**
HG	.74**	.70**	.71**	.53**	.67**	.83**		.58**	.66**	.79**	.57**	.29**	.38**	.65**	.55**	.66**	.65**
StHt	.58**	.69**	.73**	.59**	.57**	.43**	.54**		.82**	.58**	.62**	.37**	.33**	.48**	.49**	.49**	.34**
HtW	.69**	.79**	.84**	.66**	.65**	.54**	.69**	.78**		.73**	.69**	.24*	.36**	.55**	.59**	.59**	.44**
CD	.58**	.55**	.54**	.33**	.45**	.52**	.59**	.49**	.57**		.55**	.22*	.48**	.61**	.59**	.56**	.55**
CW	.64**	.51**	.59**	.33**	.58**	.60**	.63**	.45**	.52**	.50**		.30**	-.003NS	.48**	.57**	.62**	.45**
ErL	.36**	.31**	.32**	.19**	.16**	.24**	.27**	.29**	.27**	.19**	.27**		-.25*	.08NS	.02NS	.12ns	.08ns
HL	.31**	.47**	.41**	.42**	.38**	.20**	.39**	.43**	.46**	.37**	.29**	.16**		.39**	.31**	.15ns	.23*
HLt	.64**	.66**	.68**	.54**	.61**	.54**	.61**	.52**	.64**	.51**	.55**	.28**	.37**		.67**	.50**	.53**
HW	.53**	.62**	.62**	.51**	.58**	.40**	.53**	.61**	.59**	.46**	.52**	.28**	.45**	.60**		.35**	.45**
CC	.64**	.57**	.62**	.29**	.43**	.52**	.52**	.47**	.50**	.43**	.52**	.31**	.14**	.52**	.48**		.59**

** = correlation is significant at the 0.01 level;* = correlation is significant at the 0.05 level; NS=not significant; BWt =body weight ; BL= Body length; RH= Rump height; RL= Rump length; RW= Rump width; PG= Paunch girth; HG= Heart girth ;StHt= sternum height; HtW= height at wither ;CD=chest depth; CW= chest width ;ErL= ear length ; HL= horn length ;HLt= head length; HW= head width ;CC= cannon bone circumference; SC= scrotum circumference .

4.23.10. Estimation of body weight of goats from other body measurements

The knowledge of animals live weight is very important in the livestock production and marketing practices (Birteeb and Ozoje, 2011). Even though the use of conventional weighing scales is the best way of determining live weight of an animal, proper weight measurements are often difficult in villages due to lack of weighing scales. To predict the live weight of animals without weighing scales, mathematical equations can be developed based on actual weight linear body measurement data (Solomon and Kassahun, 2008). In this study around 22 and 16 body measurements of does and bucks respectively were used for estimation of live body weight respectively and only best measurements were selected by step wise regression method.

Step wise multiple regression analysis of live body weight from different body measurements for does and bucks are presented in Tables 37 and 38 respectively. The results revealed that paunch girth was the best important variable for prediction of live body weight of does and heart girth was important variable for prediction live weight of bucks. The inclusion of other linear body measurements with hearth and paunch girth improved the accuracy of the prediction model (R^2) value for does and bucks. So that weight can be estimated more accurately by combination of two or more factors than only one. For field condition simple measurement with maximum of one or two variables is enough to predict the dependent variable. This is because addition of more variable under field condition increases error, and besides this some variables are more affected by the animal posture compared to others, which makes it so difficult to measure such variables accurately. In this study body weight was predicted with better accuracy ($R^{2)}$ for bucks than does. Chest girth (heart girth) was highly significant in the model for bucks and this result in agreement with the previous

research findings (Grum ,2010; Halima *et al.*,2012a). The regression equation was developed for does by using paunch girth and rump height and for bucks heart girth and cannon bone circumference were used as independent variable and body weight as dependent (predicted) variable. Parameter estimates in multiple linear regression model showed that bucks had higher coefficient of determination (82.8%) value than does (65%). This point out that those linear measurements could predict more accurately in males compared to females. The prediction of body weight could be based on the following regression equation: Y=-39.361+0.339 (X1) +0.604 (X2) for does and Y= -37.611+0.685 (X1) +2.14 (X2) for bucks.

Table 37 .Step wise multiple regression analysis to estimate live weight from different linear body measurements for does

Female goats		Parameters								
	Model	Intercept	β1	β2	β3	β4	β5	β6	R^2	R^2 change
Debub Ari	RH	-34.790	0.966						0.47	0.000
(N=255)	RH+PG	-41.944	0.696	0.301					0.617	0.147
	RH+PG+CW	-41.944	0.621	0.255	0.548				0.651	0.034
	RH+PG+CW+BL	-42.703	0.404	0.201	0.658	0.326			0.688	0.037
	RH+PG+CW+BL+CC	-47.309	0.338	0.204	0.603	0.314	0.786		0.697	0.009
Bena-Tsemay	PG	-8.947	0.42						0.43	0.000
(N=271)	PG+HLt	-29.688	0.372	1.412					0.531	0.101
	PG+HLt+UC	-29.022	0.296	1.357	0.298				0.586	0.055
	PG+HLt+UC+HtW	-40.761	0.275	0.859	0.327	0.348			0.625	0.039
	PG+HLt+UC+HtW+UL	-37.735	0.294	0.686	0.511	0.340	-0.486		0.644	0.019
	PG+HLt+UC+HtW+UL+HG	-39.218	0.380	0.830	0.486	0.440	-0.438	-0.202	0.657	0.013
All females	PG	-13.462	0.491						0.523	0.000
(N=526)	PG+RH	-39.361	0.339	0.604					0.651	0.128
	PG+RH+BL	-41.82	0.322	0.420	0.248				0.666	0.015
	PG+RH+BL+CW	-41.858	0.278	0.335	0.271	0.453			0.683	0.017
	PG+RH+BL+CW+ DBnT	-42.763	0.261	0.339	0.268	0.361	0.707		0.691	0.008

RH= rump height ; PG= paunch girth ; CW= chest width ; BL= body length ; CC= cannon bone circumference ; HLt= head length; UC =udder circumference ;HtW= height at wither; udder length ;HG=heart girth; DBnT= distance between teat; N= number of goats; $R^{2=}$ coefficient of determination

Table 38. Step wise multiple regression analysis to estimate live weight from different linear body measurements for bucks

Male goats		Parameters							
	Model	Intercept	β1	β2	β3	β4	β5	R^2	R^2 change
Debub Ari	HtW	-38.724	1.011					0.847	0.000
(N=60)	HtW+BL	-38.347	0.662	0.358				0.876	0.029
	HtW+BL+PG	-42.041	0.528	0.315	0.192			0.896	0.02
	HtW+BL+PG+CC	-45.756	0.397	0.279	0.214	1.548		0.916	0.02
Bena-Tsemay	PG	-23.285	0.641					0.853	0.000
(N=44)	PG+SC	-27.977	0.517	0.642				0.906	0.053
	PG+SC+HL	-29.872	0.513	0.549	0.397			0.932	0.026
All males	HG	-34.773	0.893					0.773	0.000
(N=104)	HG+CC	-37.611	0.685	2.14				0.828	0.055
	HG+CC+BL	-41.392	0.522	1.692	0.302			0.859	0.031
	HG+CC+BL+PG	-40.811	0.237	1.475	0.342	0.235		0.872	0.013
	HG+CC+BL+PG+SC	-41.881	0.198	1.296	0.341	0.227	0.261	0.878	0.006

HtW= height at wither; BL= body length; PG=paunch girth ; CC= cannon bone circumference ; SC=scrotum circumference; HL=horn length ; HG=heart girth;;; N= number of goats; $R^{2=}$ coefficient of determination

5. SUMMARY, CONCLUSION AND RECOMANDATION

5.1. Summary and conclusion

Planning of any breeding program including community based breeding strategy and /or breed improvement scheme needs the identification of genotypic and phenotypic traits of the particular goat breed and also to know the genetic ability of that breed and the production environment that can influence productivity of the animal.

A total of 180 households were selected for production system characterization, and 630 goats were sampled for phenotypic characterization of goat population (qualitative and quantitative characters).The study revealed that, mixed crop-livestock production system was the dominant form of production system in Debub Ari district and pastoral livestock production system was practiced in Bena-Tsemay district.

The mean goats flock size (14.97±7.45) owned per house hold in Bena-Tsemay district was significantly ($P<0.01$) higher than Debub Ari district (9.07±6.3). Breeding does accounted for the largest proportion in Debub Ari (3.69±2.33) and Bena-Tsemay (5.34±2.63) goat flock. The primary purpose of keeping male goats in Debub Ari and Bena-Tsemay districts was for saving (to be used as an asset) similarly the primary reason for keeping female goats in Debub Ari also was for saving however, the primary purpose of keeping female goats for Bena-Tsemay pastoralists was to use them as income generation. Traits like appearance and body conformation, age, fast growth rate , coat color and mating interest were selection criteria for breeding bucks and appearance, age, mothering ability, fast growth rate, litter size and coat color were also selection criteria for breeding does in both Debub Ari and Bena-Tsemay

districts. Natural bushes and shrubs were the main feed sources during rainy and dry seasons both in Debub Ari and Bena-Tsemay distrits. The main source of water for goat during dry and rainy season in Debub Ari district was river, whereas pond was the major water source for Bena-Tsemay pastoralists (54.4%) in dry season and rain water (47.8%) was the main source of water during rainy season. Most goats (64.4%) in Debub Ari had roofed and separate goat house while 88.9% of Bena-Tsemay district pastoralists housed their goats in traditional enclosure (kraal). Housing below suspended granary and adjoining family house (veranda) were also reported as goat houses in rare case.

Average sexual maturity (age at puberty) was 10.19±1.17 and 11.71±0.81 months for males and 9.92±0.93 and 11.45±1.04 months for females in Debub Ari and Bena-Tsemay, respectively. In this study the average age at first kidding for Debub Ari and Bena-Tsemay goat was 14.92±0.93 and 16.47±1.04 months, respectively. The average kidding interval for Debub Ari and Bena-Tsemay goat was 8.57±0.62 and 8.09±0.65 months, respectively. The average reproductive life span of Debub Ari and Bena-Tsemay does were 5.67±0.81 and 5.27±0.72 years, respectively. The results of this study showed that on average a doe can produce 9.53±1.88 (Debub Ari) and 7.97±0.81 (Bena-Tsemay) kids in her life time.

Internal parasites, CCPP, external parasite and PPR were the major diseases reported for goats in both Debub Ari and Bena-Tsemay districts with various degree of economic importance. Disease, seasonal feed shortage, recurrent drought and water scarcity were the major production constraints in both districts. During focus group discussion in Debub Ari district some respondents mentioned predator as problem of goat production (monkeys killed goat kids around browsing area)

On the other hand, increased level of inbreeding and decreased genetic diversity may be the result of the utilization of breeding buck/s born with in the flock, small flock's size, uncontrolled mating and lack of awareness about inbreeding. In this study utilization of breeding buck/s born with in flock believed as main reason to increase the level of inbreeding.

Goat populations found in the study area had a wide range of coat color types. Brown (20.00%), black (18.19%) and creamy white (11.74%) in Debub Ari and brown (20.45%), black (18.18%) and light brown (13.64%) in Bena-Tsemay were the predominant coat color types. 52.38% of Debub Ari and 60.00% Bena-Tsemay goat had patchy coat color pattern. Majority of Debub Ari (female 87.45% and male 90%) and Bena-Tsemay (female 93.73% and male 95.45%) goat populations were horned.

Sex of goats had highly significant ($P<0.001$) effect on most of linear body measurements and body weight except body length, rump length, paunch girth and heart girth. Male goats had higher body weight and others body measurements. Similarly most linear body measurements and body weight were significantly ($P<0.001$) affected by age group except distance between teat and teat distance from ground. Dentation group 3PPI and 4PPI had higher values than those 1PPI and 2PPI dentation groups. Body weight and most of leaner body measurements were significantly ($P<0.05$) affected by location but chest depth was not affected ($P>0.05$) by location. Except horn length and teat distance from ground Debub Ari district goats had higher value than Bena-Tsemay district. The reason may be difference of feed and water availability between two districts (location) during data collection.

The Interaction of sex and age group significantly ($P<0.05$) affected, body length, rump height, rump length, height at wither, chest width, and head length. The value of males was

higher than females in 1PPI, 2PPI, 3PPI and 4PPI the remaining parameters of body measurements including body weight were not affected by ($P>0.05$) by the sex-age interaction. Interaction effect of sex and location(district) were significantly ($P<0.05$) affected by only body weight and horn length Debub Ari district female and male goats had higher body weight value than Bena-Tsemay district female and male goats and Bena-Tsemay district male goats had higher value for horn length. The remaining parameters of body measurements were not affected by sex and location interaction. The interaction of age group and location was significant ($P<0.05$) for most linear body measurements including body weight, Debub Ari district goats (1PPI, 2PPI, 3PPI and 4PPI) goats had higher body length, rump height, paunch girth, height at wither, chest width, teat diameter, udder length, udder with, udder circumference, distance between teat and body weight than Bena-Tsemay district goats whereas Bena-Tsemay district goats age group (3PPI and 4PPI) had higher value of horn length than Debub Ari goats. Differently the interaction of age group and location was not significant ($P>0.05$) for rump length, heart girth, sternum height, ear length, head length, head width, and cannon bonne circumference. Interaction of age group, sex and district was significantly ($P<0.05$) affected by most linear body measurements. The value of Debub Ari district goats was higher than Bena-Tsemay district except horn length. The remaining parameters of body measurements like rump width ,heart girth, ear length, head length and head width were not affected ($P>0.05$) by age group, sex and district interaction. Structural and Functional indices indicated that the goats of Debub Ari and Bena-Tsemay districts were more suitable for meat than milk production.

Pearson correlation matrix that indicates the association between live weight and other body measurements in sampled males and females goats, Pearson correlation matrix of the males sample population showed a strong positive correlation ($p<0.01$) between body weight and and heart girth(0.88), paunch girth (0.85), chest depth(0.81), body length(0.79), rump height(0.79), height at wither (0.75) and cannon bone circumference (0.75) , whereas scrotum circumference (0.69), head length (0.62), sternum height (0.62), chest width(0.57), rump width (0.53), head width (0.49), rump length (0.47) and head length(0.39) showed moderate correlation with body weight. But ear length (0.22) had weak correlation with body weight with ($P<0.05$) significant level. Similarly In females, most of linear body measurements had a positive association with body weight. strong correlation with ($P<0.01$) significant level was found between body weight and body length (0.75), rump height (0.75), paunch girth (0.74) and heart girth (0.74), whereas height at wither (0.69), chest width (0.64), head length (0.64), cannon bone circumference (0.64), chest depth (0.58), sternum height (0.58), rump width (0.56) head width (0.53), rump length (0.49), ear length (0.36) and horn length(0.31) showed moderate correlation with body weight. The result of step wise multiple regression revealed that Paunch girth (52.3%) and chest girth (77.3%) had high coefficient of determination (R^2) for does and bucks respectively to estimate live body weight from others linear body measurements. In general goat population of Debub Ari and Bena-Tsemay are related phenotypically but some quantitative and qualitative differences may be due to difference of agro ecology, feed availability and quality between two districts during data collection.

5.2. Recommendations

More emphasis needs to be placed on the management and improvement of Debub Ari and Bena-Tsemay goat breeds due to their significant contribution for income and their ability to survive and reproduce in the extreme environments in which crop production as well as maintaining large ruminants is difficult so

To know genetic potential of animals (goat population) good environment should be in place so different goats' production constraints of study area should be solved by concerned bodies.

Qualitative traits like coat color type is one of goats' selections criteria of respondents so that assignment of economic value for such traits is suggested.

Linear body measurements could be valuable to estimate live body weight where sensitive weighing scales are not readily available.

Goats' populations of study area are related with woyito-guji goats' type and more suitable for meat than milk production but further genetic breed characterization as genotypic or molecular level is necessary to investigate and classify the goat type clearly.

6. References

Abebe Mekoya, 1999. Husbandry practice and productivity of sheep in Lalo-mama Midirworeda of central Ethiopia. An M.Sc Thesis submitted to the School of Graduate Studies of Alemaya University of Agriculture, Dire Dawa, Ethiopia. 99p

Adane Hirpa and Girma Abebe. 2008. Economic significance of sheep and goats. Pp. 325-340. In: Alemu Yami and R C Merkel (eds.).Sheep and Goat Production Handbook of Ethiopia. .ESGPIP (Ethiopian sheep and goat productivity improvement program). Branna Printing Enterprise. Addis Ababa, Ethiopia.

Adedeji, T.A 2012 Effect of Some Qualitative Traits and Non-Genetic Factors on Heat Tolerance Attributes of Extensively Reared West African Dwarf (WAD) Goats. International Journal of Applied Agricultural and Apicultural Research. 8 (1): 68-81

Ahmed Seid, 2013. On-farm phenotypic and production system Characterization of indigenous goats in Horro Guduru Wollega Zone, Western Ethiopia M.sc. thesis Haramaya, university.112p

Alayu Kidane, Surafel Melaku and Ayinalem Haile 2014. Characterization of goat population and breeding practices of goat owners in Gumara-Makisegnit Watershed-North Gondar, Ethiopian. Agricultural Journal 9(1): 5-14, 2014

Alexander, G.,G.Aumont, J. C. Mainaud, J. Fleury, M. Naves, 1999. Productive performances of Guadeloupean Creole goats during the suckling period. Small Rumin. Res.,34:155-160

Alubel Alemu, 2015. On-farm phenotypic characterization and performance evaluation of Abergelle and Central Highland goat breeds as an input for designing community-based breeding program MSc thesis Haramaya university, 2015.147p

Ameha Sebsibe 2008. Sheep and goat meat characteristics and quality. In: AlemuYami and R.C. Merkel (Eds). Sheep and goat production handbook for Ethiopia. Ethiopian sheep and goats productivity improvement program (ESGPIP), Addis Ababa Ethiopia. pp 323-3

Armstrong, J.B., 2006. Inbreeding: Why we will not do it? Accessed on September 15, 2008

from http://www.parispoodles.com/Inbreeding.html.28.

Arse G, Feyisa H, Gurmessa U, Merga M and Girma D, 2012. Assessment on challenges and opportunities ofgoat farming system in Adami Tulu, Arsi Negelle and Fantale districts of Oromia Regional State,Ethiopia. Adami Tulu Agricultural Research Center, P. O. Box 35, Batu, Ethiopia.

Assen E and Aklilu H .2012. Sheep and goat production and utilization in different agro-ecological zones inTigray, Ethiopia. Livestock Research for Rural Development. Volume24,Article#16.RetrievedNovember15,2014,fromhttp://www.lrrd.org/lrrd24/1/asse24016.ht

Azage Tegegne, Tesfaye Mengistie, Tesfaye Desalew, Worku Teka and Eshete Dejen, 2009. Transhumance cattle production system in North Gondar, Amhara Region, Ethiopia: Is it sustainable? IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project. Working Paper No.14. ILRI (International Livestock Research Institute), Nairobi, Kenya. 73p.

Bedhane M.,Haile A., Dadi H.and Alemu T.2013 Estimates of genetic and phenotypic parameters for growth traits in Arsi-Bale Goat in Ethiopia. J Anim Sci Adv 2013, 3 (9):439-448

Bekalu Muluneh, 2014. Phenotypic characterization of indigenous goat types and their production system in West Gojam Zone of Amhara region, Ethiopia. MSc Thesis Haramaya university.109p

Belete Shenkute, 2009. Production and Marketing Systems of Small Ruminants in Goma District of Jimma Zone, Western Ethiopia. MSc. thesis Submitted to School of Graduate Studies. Hawassa University, Awassa, Ethiopia. 144p.

Belete Assefa, 2013. On-farm phenotypic characterization of indigenous goat types and their production system in Bale zoneof Oromia region, Ethiopia.MSc thesis. Submitted to the School of Graduate Studies of Haramaya University, Ethiopia.116p

Belay Deribe and Mengistie Taye, 2013. Evaluation of Growth Performance of Abergele Goats under Traditional Management Systems in Sekota District, Ethiopia. Pakistan Journal of Biological Sciences, 16: 692-696.

Berhane G and Eik L O. 2006. Effect of vetch (Vicia sativa) hay supplementation to Begait and Abergelle goats in northern Ethiopia II. Reproduction and growth rate. Small Ruminant Research, 64, 233¬240.

Birteeb, P.T. and M.O. Ozoje, 2011. Prediction of live body weight from linear body measurements of West African long-legged and West African dwarf sheep in Northern Ghana. Online J. Anim. Feed Res., 2(5): 42-434.

Cochran,W.G. (1997).sampling techniques. Hoboken ,NJ:John wiley & Sons,Inc.

Charoensook, R.,C. Knorr, B. Brenig, and K. Gatphayak, 2013. Thai pigs and cattle production, genetic diversity of livestock and strategies for preserving animal genetic resources. Maejo Int. J. of Sci. and Tech. 7(01):113-132.

Central Statistical Agency: The 2007 Population and Housing Census of Ethiopia: Statistical Report for Southern Nations, Nationalities and Peoples' Region; Part I: Population Size and Characteristics. July 2010.

CSA.2019/20. Federal Democratic Republic of Ethiopia, Central Statistical Agency(CSA) Agricultural sample survey, Volume II, report on livestock and livestock characteristics (private peasant holdings).Statistical bulletin,589, March 2020, Addis Ababa, Ethiopia.

Cote, Steeve D., Sandra Hamel, Antoine St-Louis & Julien Mainguy. 2013. Do mountain goats habituate to Helicopter disturbance? Journal of Wildlife Management 77(6):1244-1248; 2013.

DAGRIS, 2007. Domestic Animal Genetic Resources Information System (DAGRIS).(Eds. S. Kemp, Y. Mamo, B. Asrat, and T. Dessie).International Livestock Research Institute, Addis Ababa, Ethiopia.http://dagris.ilri.cgiar.org

Dejen Assefa, 2010. Phenotypic characterization of indigenous sheep types in Kaffa and Bench-Maji zones of Southern Nations Nationalities and Peoples Region. An M.Sc Thesis presented to the School of Graduate Studies of Alemaya University, Dire Dawa, Ethiopia.

Dereje T, Mengistu U, Getachew A and Yoseph M 2015 A review of productive and reproductive characteristics of indigenous goats in Ethiopia. Livestock Research for Rural Development 27 (2) 2015

Dereje Tsegaye, Berhanu Belay and Aynalem Haile, 2013. Morphological Characterization of Indigenous Hararghe Highland Goat Breed in Their Native Environment, West Hararghe, Ethiopia. American-Eurasian J. of Sci. Res. 8 (2):72-79

Deribe Gemiyu., 2009. On-Farm Performance Evaluation of Indigenous Sheep and Goats in Alaba, Southern Ethiopia. MSc thesis, Submitted to the School of Graduate Studies of Haramaya University, Ethiopia. 163p.

Devendra, C. and McLeroy, G.B., 1988. Goat and Sheep Production in the Tropics, (Longman Group Ltd, London)

Districts Livestock and fishery resource Offices (DLFRO, 2019), 2020. Annual report, South Omo Zone, Jinka, Ethiopia

Dhaba Urgessa, Belay Duguma, Solomon Demeke and Taye Tolamariam. 2012. Sheep and goat production systems in Ilu Abba Bora zone of Oromia Regional State, Ethiopia: Feeding and management strategies. Global Veterinaria 9(4):421–429.

EndeshawAssefa, 2007.Assessment of Production and Marketing System of Goats in Dale District, Sidama Zone. An MSC Thesis submitted to the school of graduate studies. Hawasa Ethiopia, Hawasa University

ESGPIP.2008. Genetic improvement of sheep and goat.Ethiopia Sheep and Goat Productivity Improvement Program. Sheep and goat production handbook for Ethiopia. Addis Ababa, Ethiopia pp. 99-101.

ESGPIP (Ethiopia Sheep and Goat Productivity Improvement Program) 2009 Goat breeds of Ethiopia: A guide for identification and utilization. Technical Bulletin 27. Addis Ababa, Ethiopia: ESGPIP.

Falconer, D.S. and T.F.C. Mackay, 1996. Introduction to Quantitative Genetics. 4th ed.

Harlow, England, Longman. 438P.

FAO, 2007.Global plan of action for animal genetic resources and the Interlaken declaration, Rome, Italy.

FAOSTAT 2008 http://faostat.fao.org/default.aspx

FAOSTAT2010 http://faostat.fao.org/Portals/_Faostat/Downloads/Zip files/Production Livestock Processed. East Africa-1.zip

FAO. 2012. Draft Guidelines on Phenotypic Characterization of Animal Genetic Resources. Commission on Genetic Resources for Food and Agriculture. Thirteenth, Regular session, Rome, 18-22 July 2012

FAO. 2015. The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture, edited by B.D. Scherf& D. Pilling. FAO Commission on Genetic Resources for Food andAgriculture Assessments. Rome (available at http://www.fao.org/3/a-i4787e/index.html).

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

Fikru S and Gebeyew K , 2015. Sheep and Goat Production Systems in Degehabur Zone, Eastern Ethiopia:Challenge and Opportunities. J Adv Dairy Res 3: 134. doi:10.4172/2329-888X.1000134

Galal, s,(2005). Biodiversity in goats. Small Ruminant research.6.(1-2):75-81

Gebreyesus G, Haile A and Dessie T 2012: Participatory characterization of the Short-eared Somali goat and its production environment around Dire Dawa, Ethiopia. Livestock Research for Rural Development. Volume 24, Article #184.Retrieved October 11, 2017, from http://www.lrrd.org/lrrd24/10/gebr24184.htm

Getachew T, Lema S, Tadesse D, Mekoya A and Gizaw S (2006).Proceeding of the First Annual Regional Conference on Completed Livestock Research Activities.14-17 August, 2006. Bahir Dar, Ethiopia.

Getahun,L., 2008. Productive and Economic performance of Small Ruminant production in production system of the Highlands of Ethiopia (Doctoral dissertation, Ph.D. dissertation. University of Hohenheim, Stuttgart, Hoheinheim, Germany)

Getinet M. 2016. Molecular characterization of Ethiopian indigenous goatpopulations:genetic diversity and structure,demographic dynamics and assessment of the kisspeptin gene polymorphism Degree of Doctor of Philosophy in Applied Genetics Addis Ababa University. 274p.

Girma Abebe, 2002. Growth performances of crossbred goats. Debub Univesity, Awassa Colleg of Agriculture. Annual Research Report.43p.

Gizaw,S., Komen, H., Hanote, O., van Arendonk, J.A.M., Kemp, S., Haile, A., Mwai, O. and Dessie, T., 2011. Characterization and conservation of indigenous sheep genetic resources: A practical framework for developing countries. ILRI Research Report No. 27. Nairobi, Kenya, ILRI.

Grum Gebreyesus., 2010. Community-Based Participatory Characterization of the Short Eared Somali Goat Population around Dire Dawa .MSc thesis, Submitted to the School of Graduate Studies of Haramaya University, Ethiopia: 129p.

Grum Gebreyesus, A Haile and T Dessie, 2013. Breeding scheme based on community-based participatory analysis of local breeding practices, objectives and constraints for goats around Dire Dawa, Ethiopia. Livestock Research for Rural Development. Volume 25 Article #48.Retrived March 20,2015,fromhttp://www.Irrd.org/Irrd25/3/grum25048.htm

Gurmesa U, Misgana D, Feyisa H, Merga M (2011). Participatory analysis of problems limiting goat production at selected districts of East Showa zone, Ethiopia. DOI: 10.5897/AJAR11.314. Afr. J. Agric. Res. 6(26): 5701-5714

Hagan, J. K., Apori S. O., Bosompem M., Ankobea G. and Mawuli A., 2012. Morphological Characteristics of Indigenous Goats in the Coastal Savannah and Forest Eco-Zones of Ghana. J. Anim. Sci. Adv., 2(10):813-821.

Halima Hassen, Samer Lababidi, Barbara Rischkowsky, Michael Baum and Markos Tibbo, 2012a. Phenotypic characterization of Ethiopian indigenous goat populations. Afr. J. of Biotech. 11(73), 13838-13846.

Hailu Tilahun, Ayinalem Haile, and Ahmed Seid "Phenotypic Characterization of Indigenous Goats in North Shewa Zone, Amhara Region, Ethiopia" International Journal of Research Studies in Agricultural Sciences (IJRSAS), 2019; 5(7), pp. 44-55, http://dx.doi.org/10.20431/2454-6224.0507005

Halima, H., Lababidi, S., Rischkowsky, B., Baum, M. and Tibbo, M. 2012b.Molecular characterization of Ethiopian indigenous goat populations. Tropical Animal Health Production 44(6):1239–1246.

Hassamo, H.E., J. B. Owe and M. F. A. Farid, 1986. Body condition score in fat tailed Awassi sheep under range conditions. Res.Dev.Agri.3:99-104.

Hirst, K. Kris.2008."The History of the Domestication of Goats".About.com. Accessed August 18, 2008

Hole, F., 1996. The context of caprine domestication in the Zagros region. The Origins and Spread of Agriculture and Pastoralism in Eurasia, Smithsonian Institution Press, Washington, DC, pp.263-281

Homann S, Van Rooyen A, Moyo T, Nengomasha Z (2007). Goat production and marketing: Baseline information for semi-arid Zimbabwe. Bulawayo, Zimbabwe: International Crops Research Institute for the Semi-Arid Tropics. 84p

Hulunim Gatew, 2014. On-Farm Phenotypic Characterization and Performance Evaluation of Bati, Borena and Short Eared Somali Goat Populations of Ethiopia. MSc thesis, Submitted to the School of Graduate Studies of Haramaya University, Ethiopia. 140p. IBM Corp. Released 2012.

IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.

IFAD (International Fund for Agricultural Development), 2009. Livestock and pastoralist. Available at http://www.ifad.org/lrkm/index.htm (Accessed 25/ 10/ 2013).

Jaitner J., J. Soweb, E.Secka-Njieb, and L. Demp, 2001. Ownership pattern and management

practices of small ruminants in The Gambia-implications for a breeding programme. Small Ruminant. Research.. 40:101-108.

Jimmy, S., David, M., Donald, K.R. and Dennis, M., 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), pp.98-105

Judith Moses, 2006.Small ruminant final report draft of Amara region of Ethiopia.Funded by USAID Coordinated by Virginia State University. AMAREW 06/2006 Part 1 July 24th to August 11

Judith Sandford and Steven Ashley, 2008. Livestock Livelihoods and Institutions in the IGAD Region, the IDL group

Karua S K 1989 Some performance indicators of Malawi indigenous goats under village and ranch conditions. In: R.T. Wilson and M. Azeb (eds), African small ruminant research and development, 120¬141.

Kassahun Awgichew and Solomon Abegaz, 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

Kidus Negussie. 2010. Goat breeds utilization and productivity of crossbred goats in eastern and southern Ethiopia and biophysical model. MSc thesis. Addis Ababa, Ethiopia: Addis Ababa University

Kiwuwa GH (1992). Breeding strategies for small ruminant productivity in Africa. Rey B, Lebbie S H B, Reynolds L (Editors). Small ruminant research, and development in Africa, Proceedings of the First Biennial Conference of the African Small Ruminant Research Network, 10-14 December 1990, ILRAD, Nairobi, Kenya.

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

Lanari MR, Taddeo H, Domingo E, Centeno MP, Gallo L (2003).Phenotypic differentiation of exterior traits in local Criollo goat population in Patagonia (Argentina). Archiv Tierzucht Dummerstorf.46:347–356.

Lishan Tsehay, 2007. Woody and herbaceous species composition and the condition of the rangelands in Shinille zone of Somali regional state, Ethiopia. An MSc Thesis submitted to the school of Graduate Studies of Haramaya University, Dire Dawa, Ethiopia.171p.

Marshall, F. 2000. The origin and spread of domestic animals in East Africa. In: Blench, R.M. and MacDonald, K.C. (eds), The origins and development of African livestock: Archaeology, genetics, linguistics and ethnography. London, UK: UCL press.

Markos Tibbo 2000 Livestock production constraints in a M2¬2 sub¬agro ecological zone with special reference to goat production. In: Proceeding of a conference held at Debub University, 10¬12 November 2000, 113¬117.

Mahmoud, A.A., 2010. Present status of the world goat populations and their productivity. King Faisal University, al-ansa, Saudi Arabia. 45(2) pp 42

Martins CEN, Quadros SAF, Trindade JPP, Quadros FLF, Costa JHC, Raduenz G (2009). Shape and function in Braford cows: The body shape as an indicative of performance and temperament. Archivos deZootecnia 58:425–433.

Mestawet T, Girma A, and Tove,Judith, Gerd Tormod. 2012. "Milk production. composition and variation at different lactation stages of four goat breeds in Ethiopia." (acadamic journal) 105, no. 1-3 (2012).

MOA (Ministry of Agriculture) 1999 National livestock research and development workshop (Amharic translation). March 29-April 1, 1999. Addis Ababa, Ethiopia.

Misbah, F., 2013. Community-based characterization of Afar goat breeds around Aysaita district of Afar region (Doctoral dissertation, MSc thesis. Jimma, Ethiopia: Jimma University).

Mohammed B, Aynalem H, Hailu D and Tesfaye AT 2012: Estimates of genetic and phenotypic parameters for milk traits in the Arsi-Bale goat in Ethiopia.Livestock Research for Rural Development.Volume24,Article#98. RetrievedOctober6, 2017, fromhttp://www.lrrd.org/lrrd24/6/bedh24098.htm

Mukasa-Mugerwa, E., Anindo, D., Sovani, S., Lahlou-Kassi, A., Tebely, S., Rege, J.E.O. and Baker, R.L., 2002.Reproductive performance and productivity of Menz and Horro sheep lambing in the wet and dry seasons in the highlands of Ethiopia. Small Ruminant Research, 45: 261-271.

Nega F, Erik M, Josef D, Eric T (2009). Rural livestock asset portfolio in northern Ethiopia: A microeconomic analysis of choice and accumulation. Contributed Paper prepared for presentation at the International Association of Agricultural Economists Conference, August 16-22, 2009. Beijing, China.

Ntume, Barnabas, Nalule, Agnes S. and Baluka, Sylvia A. 2015. The role of social capital in technology adoption and livestock development. Livestock Research for Rural Development 27 (9) 2015.

Odubote, I.K. (1994b). Influence of qualitative traits on the performance of West African Dwarf goats. Nigerian Journal of Animal Production. 21:25-28.

Okpeku, M., A. Yakubu, S. Peters, M. Ozoje C. Ikeobi, O. Adebambo, I. Imumorin, 2011.Application of Multivariate Principal Component Analysis to Morphological Characterization of Indigenous Goats in Southern Nigeria.ActaAgricultureaSlovenica, 98 (2): 101 -109

Oluwatayo, I. B. and T. B. Oluwatayo, 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(1),pp.179-186

Peacock C. 1996. Improving goat production in the tropics. A Manual for Development workers. Published jointly by FARM-Africa and Oxfam (UK and Ireland), Oxfam, UK.87pp.

Quisumbing, A. R., E. Payongayong, J. B. Aidoo, and K. Otsuka, 2001. Women's land rights in the transition to individualized ownership: implications for the management of tree resources in western Ghana. Econ.Devel.and Cult. Change, 50: 157-182.

Rege, J.E.O. and Lebbie, S.H.B., 2000.The goat resource of Africa, origin, distribution, and contribution to the national economies. In: Seventh international conference on goats, 15-21 May 2000, Tours, France, pp927-931

Saddul , D 1999. Evaluation of the performance of the smallholder goat production system in Mauritius. Food and Agricultural Research Council, Réduit, Mauritius

Salako AE, Ngere LO (2002). Application of multi factorial structuraldiscriminant analysis in the morphometric structural differentiation of West African Dwarf and Yankassa sheep in South West Nigeria.Niger. J. Anim. Prod. 29(2):163-167.

Samuel Menbere, 2005. Characterization of livestock production system; A case study of Yerer water shed, Adaa Liben district of east Showa, Ethiopia. An M.Sc Thesis presented to the School of Graduate Studies of Alemaya University, Dire Dawa, Ethiopia. 184p.

SAS (2008) Statistical Analysis Systems Institute. Version 9.1, SAS Institute Inc., Cary, North Carolina, USA.

Solomon Abegaz, Kassahun Awgichew, and GirmaAbebeYami. 2008. Sheep and goat production systems in Ethiopia. In: AlemuYami and Merkel, R.C. (eds), Sheep and goat production handbook for Ethiopia. Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP). Addis Ababa, Ethiopia. pp. 27–32, and 347p

Solomon Gizaw, AzageTegegne, BerhanuGebremedhin and Dirk Hoekstra. 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 Abegaz, 2014. Design of community based breeding programs for two indigenous goat breeds of Ethiopia. PhD thesis.Vienna, Austria: University of Natural Resources and Life Sciences, Vienna.

Solomon A K, Mwai O, Grum G, Haile A, Rischkowsky B A, Solomon G and Dessie T 2014 Review of goat research and development projects in Ethiopia. ILRI Project Report. Nairobi, Kenya: International Livestock Research Institute.

Solomon Gizaw, 2009. Goat Breeds of Ethiopia: A guide for Identification and Utilization. (eds) AlemuYami, KassahunAwgichew, T.A. Gipson and R.C. Merkel. Technical bulleting no.27 Ethiopian sheep and goat production improvement program (ESGPIP)

Solomon Abegaz, J. Sölkner, S. Gizaw, T. Dessie, A. Haile & M. Wurzinger 2013. Description of production systems and morphological characteristics of Abergelle and Western lowland goat breeds in Ethiopia:implication for community-based breeding programmes. Animal Genetic Resources,. Food and Agriculture Organization of the United Nations, 2013, 53, 69–78.

Solomon Abegaz, 2007. In situ characterization of Gumuz sheep under farmers manqgemant in north western lowland of Amhara region. An M.Sc Thesis presented to the School of Graduate Studies of Alemaya University, Dire Dawa, Ethiopia. 32p.

Tatek Woldu, Hailu Dadi, Mieso Guru and Dadi Gelashe, 2004. Productivity of Arsi Bale goat types under farmers' management condition: a case of Arsi Negelle. Pp.67-71. In: Tamrat Degefa and Fekede Feyissa (Eds). Proceedings of the 13th Annual Conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 25- 27, 2004.234p.

Tegegn Fantahun, Kefyalew Alemayehu & Solomon Abegaz 2013. Identification and phenotypic characterization of goat ecotypes in the Bench Maji zone, Southwestern Ethiopia. Animal Genetic Resources, 2013, Food and Agriculture Organization of the United Nations. 53, 19–26.

Tekleyohannes Berhanu, Jamroen Thiengtham, Sayan Tudsri, Girma Abebe, Asrat Tera & Somkiert Prasanpanich 2012. Purposes of keeping goats, breed preferences and selection criteria in pastoral and agro-pastoral woredas of South Omo Zone. Livestock Research for Rural Development. Volume 24, Article #213. Retrived March 05, 2014, from http://www.Irrd.org/Irrd24/12/berh24213.htm

Tesfaye Kebede, Aynalem Haile & Hailu Dadi, 2012. Smallholder goat breeding and flock management practices in the central rift valley of Ethiopia. Trop Anim Health Prod (2012) 44:999–1006.

Tesfaye Getachew, Sisay Lema, Dereje Tadesse, Abebe Mekoya, and Solomon Gizaw, 2006. Proceeding of the First Annual Regional Conference on Completed Livestock Research Activities. August 14-17, 2006, Bahir Dar, Ethiopia.

Tesfaye Tsegaye, 2009. Characterization of Goat Production Systems and On- Farm Evaluation of the Growth Performance of Grazing Goats Supplemented With Different Protein Sources in Metema , Amhara Region, Ethiopia. MSc Thesis, Submitted to the School of Graduate Studies of Haramaya University, Ethiopia. 108P.

Tesfaye Alemu. 2004. Genetic characterization of indigenous goat populations of Ethiopia using microsatellite DNA markers, PHD thesis, National Dairy Institute, Haryana, India. 188p.

Tesfaye Getachew, 2008. Characterization of Menze and Afar Indigenous Sheep Breeds of Smallholders and Pastoralist for Desighing Community Based Breeding Strategies in Ethiopia. An M Sc Thesis presented to the School of Graduate Studies of Haramaya University, Dire Dawa, Ethiopia.

Tesfaye Kebede, 2010. Assessment of On-Farm Breeding Practices and Estimation of Genetic and Phenotypic Parameters for Reproductive and Survival Traits in Indigenous Arsi Bale Goats. MSc Thesis Submitted to the School of Graduate Studies of Haramaya University, Ethiopia: 142p.

Tibbo, M. 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. Faculty of Medicine and Animal Science Department of Animal Breeding and Genetics.Ph.D. Dissertation. Swedish University of Agricultural Sciences, Uppsala, Sweden.pp 11-63

Tsedeke Kocho 2007 Production and marketing systems of sheep and goats in Alaba,Southern Ethiopia. An MSc Thesis, Hawasa 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. (Unpublished MSc thesis, Submitted to the School of Graduate Studies of Haramaya University, Ethiopia. 108p.

Tsegaye, D., B. Belay and A. Haile, 2013. Morphological characterization of Indigenous Hararghe Highland Goat Breed in Their Native Environment, West Hararghe, Ethiopia. American Eurasian J. Sci. Res., 8(2): 72-79.

Uerpmann, H.P., 1996.Animal domestication-accident or intention. The origins and spread of agriculture and pastoralism in Eurasia, pp.227-237

Urge M (2007). Performance of the Ethiopian Somali Goat duringdifferent Watering Regimes: (PhD thesis, Swedish University of Agricultural Sciences. Uppsala, Sweden.

Wilson R.T. 1991.Small ruminant production and the small ruminant genetic resource in Tropical Africa.Animal prod Health. FAO, Rome. 88:20-28.

Workneh Ayalew, 1992. Preliminary survey of indigenous goat types and goat husbandry practices in Southern Ethiopia. M Sc Thesis. School of Graduate Studies, Alemaya University of Agriculture. 153p.

Wurzinger M., Sölkner J. and Iniguez L., 2011.Important aspects and limitations in considering community-based breeding programs for low-input smallholder livestock systems. Small Ruminant Research, 98:170–175

Yakubu A (2010a). Path coefficient and path analysis of body weightand biometric traits in Yankasa lambs. Slovak J. Anim. Sci. 43:17–25.

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

Zeder M. A. and B. Hasse, 2000.The initial domestication of goats (Capra hircus) in the Zagros Mountains 10,000 years ago.Sci., 287:2254-2257

Zeleke Mekuriaw, 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). Available at http://www.cipav.org. (Accessed 12 /02/ 2014).

Zewdu Edea, 2008. Characterization of Bonga and Horro indigenous sheep breeds of small holders for designing community based breeding strategies in Ethiopia . A Msc thesis submitted to the department of animal science, school of graduate studies, Haramaya University .33p.

7. APPENDICES

7.1. Appendix A, Questionnaire for the survey part

PARTICIPANT INTRODUCTION AND INFORMATION STATEMENT

Greet the farmer/pastoralist in local language and explain the information sheet to him/her. The researchers aimed to Characterize Indigenous Goat Populations Reared under Farmers/pastoralists Management in South omo Zone of Southern Regional State. We are collecting data related to goats' production, reproduction, management, linear body measurement and qualitative physical characteristics from farmers /pastoralists/ in selected districts for this study.

Ethiopia is endowed with huge livestock AnGRs and Goats production is an ancient and widely practiced in our country. The previous research implementation on characterization of indigenous goat populations was impressive but there are goat populations still not characterized and productivity or output per goat is low due to number of limitations. There for this questionnaire is designed to characterize indigenous goat populations in study area to generate baseline information on goat populations (type) and this information shows the clue how to conserve for sustainable utilization and how to alleviate the existing challenges on indigenous goats' production and productivity.

Based on these objectives we would like to ask you some questions related to the practice of goat production and management, in addition to this we are going to take linear body measurement and qualitative physical characteristics from your goats. Your information will be kept confidential and only be used for this study. We very

much appreciate your cooperation. Continue to interview, if the farmer/pastoralist/ is willing to participate!

Part one

General information on households

Questionnaire number _____ name of enumerator_____

_____

Date _____ kebele /village _____

Zone:_____ Woreda/District/ _____

NATURAL ENVIRONMENT

GPS readings: Latitude _____Longitude _____ Altitude _____

Average Temperature_____C^0 Rain fall_____mm

1.1, Name of the respondent _____

1.2, Age of the respondent _____ sex _____

1.3, Education level:

1. illiterate (unable to read and write) 2. First cycle (1-4) school

3. second cycle (5-8) school 4. Secondary (9-10+2) 5. Other specify

1.4, Marital status A=Married B=Single C=Divorced D=Widowed

1.5, Family size (number): Male _____ Female _____Total _____

1.6, What is your major farming activity? 1. Livestock production 2. Crop production

1.7, Non-farm activities ? 1. Hand craft 2. Trading 3. Daily labor 4. Others (specify)

1.8, Major HH Food Source: 1. Maize 2. Sorghum 3. Cassava 4. Teff 5. Others specify

1.9, Major HH **Cash income** 1. crop 2. livestock 3. Both crop and livestock 4. IF others specify

1.10 trend in land holding. 1, increases 2, decreases 3, no change.

Reason _____

_____

Part 2. Production and management systems

2.1, Types of livestock reared

C/N	List of Live stock	Number currently owned
1	cattle	
2	goats	
3	sheep	
4	chickens	
5	camel	
6	Equines	
7	bee families	

2.2, trend in livestock holding

C/N	Trend in livestock population	increasing	decreasing	Noch ange
1	cattle			
2	goats			
3	sheep			
4	chickens			
5	camel			

6	Equines			
7	bee families			

Reasons _____

_____

2.3, When did you start keeping goats? Year_____

2.4, With how many goats did you start your goat farming with? _____

_____

2.5. Where did you get your first goats from?

1, Inherited (from mother or father)? **2**, Purchased from neighboring farm/market

3 , Obtained from a development project as gift **4**, Obtained from a development project as loan

5, As a gift from relatives/friends **6,** Other (specify) _____

2.6, Type of goats production system

1, Grassland-based systems 2, Pastoralist 3, Crop–livestock 4, Mixed systems 5, Agro pastoralist 6, Agroforestry–livestock 7, Landless 8, Industrial 9, other specify

2.7, Level of confinement of goats (refers to whether or not and for what periods goats are confined in a shed/cage/ pen, etc.)

1, Most goats are continuously unconfined 2, Most goats are confined only at night

3, Most goats are confined on a seasonal basis 4, Most goats are continuously confined

2.8, Flock size and composition

Goats category	Number sold over last 12 months	Number died over last 12 month due to diseases	Number lost due to predation	Number of lost due to drought	Number currently owned
Breeding does					
Replacement does					
Breeding bucks					
Males not used for breeding					
Castrated males (bucks)					
female kids					
male kids					

2.9, Do you have cross breed / non-local goats,?

1. Yes 2. No

2.10, If you have cross breed / non-local goats, when did you acquire your first cross breed? _____

2.11, If you have cross breed goat, how did you acquire the first cross breed ?

1, inherited (from mother or father) 2, Purchased from neighboring farm/market 3, Obtained from a development project as gift 4, Obtained from a development project as loan 5, others (specify)

2.12, what are the main objectives that you keep female goats for?

1. Milk 2. Sale(cash income) 3. Meat 4. Hide 5. Manure 6. Blood 7. Saving 8. Ceremonies gift 9. Sacrifices 10. Others specify

Rank	Rank your purpose of female goat keeping
1st	
2nd	
3rd	
4th	
5th	

2.13, what are the main objectives that you keep male goats for?

1. Sale(cash income) 2. Meat 3. Hide 4. Manure 5. Blood 6. Saving 7. Ceremonies gift 8. Sacrifices 9. Others specify

Rank	Rank your purpose of male goat keeping
1st	
2nd	
3rd	
4th	
5th	

2.14, If you use goats for milk production

Criteria	**Rainy (cropping) season**	**Dry (non-cropping) season**
Milk yield/day in liter		
Lactation length in month		
Frequency of milking (once, twice, or thrice a day)		
Milk feeding to weaning in month		
Milk feeding to weaning 1.suckling 2.Bucket feeding 3. Other specify		
Uses of milk 1, Market 2 , Household 3, Others specify _____		

2.15, If the family use milk, the way of preparation and utilization is

1, Raw milk, 2, Boiling, 3, Pasteurization, 4, Skimming/making butter out of it,

5, others

2.16, what type of mechanism do you use to wean kids? 1. Natural, 2. Assisted

2.17, Average weaning age of kids in months _____

2.18, Do you keep any kind of records for your goat enterprise? 1,Yes 2,No

2.19, If yes, what types of records do you keep?

1 , Breeding records 2, Sales and purchases records **3,** Production records 4, Births records

5, Feeding records 6, Veterinary (treatment) 7, Deaths records 8, Other (specify)_____

2.20, How do you usually identify your goat?

1, Ear tag **2,** Parentage 3, Name **4,** Color **5,** Others (specify)

2,21, Mobility pattern of goats 1, Sedentary, 2. Seasonal, 3. Pastoral

2.22, What is the Reason for mobility?

1, In search of feed, 2, in search of water 3, Security issues, 4, Disease outbreak, 5, Others _

2.23, what is composition Flock movement? 1, Whole flock, 2, Adults only, 3, Others ___

2.24, Members of household and hired labour **responsibilities for goat production activities**

[_√__] (tick the appropriate answer)

Activities	Family				Hired labour			
	Female		Male		Female		male	
	≤15years	>15	≤15years	>15	≤15years	>15	≤15years	>15
Purchasing								
Selling								
Herding								
Breeding								
Caring sick								
Feeding								
Milking								
Making								
Barn								
Slaughtering								

2.2. Feeding and grazing management

2.2.1, Feed source (√□tick the appropriate answer) *and rank them*

Type of feed source	**Wet season**	**Rank**	**Dry season**	**Rank**
Natural pasture				
Established pasture				
Hay				
Crop residues				
Fallow land				
Concentrates				
Others/specify ____				

2.2.2, The three major crop residues used for goats' feed (Rank according to priority)

Major crop residues	Wet season	Rank	Dry season	Rank
Maize				
Sorghum				
Bananas				
Fruit/tree				
Teff				
Wheat				
Aftermath				

Others				

2.2.3, What are Major three established pasture plant species do you use for goats feeding? (rank them according to priority) 1,_____2,_____ _____3,_____

2.2.4. Grazing land ownership 1. Private ; 2. Communal ; 3. Both

2.2.5. Grazing/browsing method during dry season. 1. Roaming ,2. Tethered, 3. Herding,

4. Paddock, 5. Zero, 6. Others/specify ____

2.2.6. Grazing/browsing method during wet season 1.roaming ,2. tethered, 3.Herding,

4. Paddock, 5. Zero, 6. Others/specify ____

2.2.7. Length of grazing and/ or browsing time during dry season

1. Morning, 2. Afternoon, 3. Whole day

2.2.8. Length of grazing and/ or browsing time during wet season:

1. Morning, 2.Afternoon, 3. Whole day

2.2.9. Trend in communal grazing areas? 1. Decreasing 2. Increasing 3. Stable

What do you think the reason? _____

2.2.10, how is goat flock herded during the day time? 1. Male and female are separated,

2. kids are separated; 3. Male and female goats are herded together; 4. All classes goats herded together

2.2.11. Goat flock is herded. 1. Together with cattle, 2. Goats herded separately, 3. Together with sheep, 4. Together with camel, 5. Together with calves, 6. Together with equines, 7. All herded together

2.2.12.Is there seasonal fluctuation in feed supply? 1= Yes, 2= No

2.2.13. if yes ,At which month(s) of the year do you experience most feed shortage? _____

2.2.14, what is your solution for feed shortage?_____

2.2.15. Do you supplement your goats? 1= Yes 2= No

2.2.16. If your answer is yes for question 2.2.13 what is your supplementation (Rank according to importance)

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

2.2.17. Do you practice goat fattening 1= Yes 2=No

2.2.18. If your answer is yes for question no. 2.2.15, which categories of animals do you fatten? (you can tick more than 2)

1. Older males 2. Older female 3. Castrates 4. Young males 5. Young female 6. Culled young male 7. Culled Young female

2.2.19. At which periods of the year do you commonly fatten goat? _____

Season Fattening duration (in months) Reason_____

_____

2.2.20. What type of feed resources do you use to fatten goats?

1. Naturel Pasture 2. Crop residues 3, Concentrate 4, Others(specify) _____

Watering

2.2.21, Source of water (√□tick the appropriate answer)

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

Others (specify)

2.2.22, Distance to nearest watering point

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

Frequency of watering(√□tick the appropriate answer)

Frequency	**Wet season**	**Dry season**
Freely available		

Once a day		
Once in 2 days		
Once in 3 days		
Others		

Housing

2.2.23, **Housing/enclosure type for goat (Tick one or more boxes)**

With roof (In family house)	
Separate house With roof	
Yard (enclosed land)	
Others (specify)	

2.2.24 Housing materials(√□tick the appropriate answer)

Type	**Roof**	**Wall**	**Floor**
Iron sheets			
Grass/Bushes			
Wood			
Stone/bricks			
concrete			
Earth/mud			
others			

2.2.25, Are goats housed together with other animals? 1,yes 2,No

2.2.26, If yes, what are the advantages and disadvantages you noticed?

_____

2.2.27, Are kids housed with adult goat? 1. Yes 2. No

If no, reason_____

GoatHealth

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

1, Clinical signs_____

2, Clinical signs_____

3, Clinical signs_____

2.2,29, Do you have access to veterinary services 1. Yes 2. No

2.2.30, If yes, which type of veterinary service you accessed?

1. Government veterinarian 2. Private veterinarian 3, NGOs 4. Other (specify)

2.2.31, How long the Distance to nearest veterinary services?_____

_____

2.2.32, Do Most animals are provide with veterinary treatment when they are sick?

1. regularly 2. Occasionally 3. Never, why? _____

2.2.33, Do Most animals are subject to traditional treatments?

1. Regularly 2. Occasionally 3. Never, why? _____

Adaptability traits of goats

Adaptability	**good**	**moderate**	**less**
Disease			
Internal parasite			
External parasite			
Heat			
Frost			

Drought			
Feed shortage			
Water shortage			

Breeding practices

3.1, Do you have breeding buck? 1, Yes 2, No

If yes, Number of local breeding buck? _____

Number of crossbred breeding buck? _____

Number of exotic breeding buck? _____

3.2, If you have exotic and/or crossbred buck, how do you have it? _____

_____

3.3. If you have more than one breeding buck, why do you need to keep more than one? _____

3.4	Purpose of keeping buck	Rank
1	Mating	
2	Socio-cultural	
3	Fattening	
4	other(specify)	

3.5. For how many years on the average is the one buck serves in your flock? ___

_____

3.6, Is there any special management for breeding buck? 1. Yes 2. No

3.7, If yes, specify type of management_____

3.8, If No, question 3.1, Source of breeding buck _____

.3.9, Do you practice selection for breeding male and doe 1. Yes, 2. No

3.10, If yes, which attributes or traits do you consider in selecting breeding **buck**?

Rank the traits in order of importance for selection.

Traits	Rank 5 max
Growth rate	
Physical appearance /body size/	
Coat color	
Temperament/behavior	
Libido	
Litter size	
Hardship tolerance	
Body size	
Feed intake	
Market value	
Resistance to disease	
age	
Longevity	
Other specify	

3.11, If yes, which attributes or traits do you consider in selecting breeding **doe?**

Rank the traits in order of importance for selection

Traits	Rank 5 max
Growth rate	
Physical appearance /body size/	
Coat color	
Fertility (kidding interval)	
Fertility (Litter size)	
Temperament/behavior	
Milk production potential	
Hardship tolerance	
Body size	
Mothering ability	
Kid weights	
Age during first kidding	
Feed intake	
Market value	
Meat quality	

Resistance to disease	
Age	
Longevity	
Other specify	

3.12, do you prefer any colour of goat? 1,yes 2, No

3.13, if yes 3.12 , list the top 3 prefered color 1,_____2,_____3,

_____ specify why _____

_____

3.14, if yes 3.12 , list the top 3 unwanted color 1,_____2,_____3

_____ why_____

_____

3.15, Age of selection (months); Breeding male _____, Breeding female _____

3.16, Type of mating used 1. Controlled; 2. Uncontrolled/Random

3.17, If controlled Methods employed for controlled mating:

1. Hand or pen mating 2, Artificial insemination 3. Embryo transfer

3.18. If uncontrolled, what is the reason? 1. Goats grazed &/or browse together, 2. Lack of awareness, 3. In sufficient number of bucks, 4. Others/specify ____

3.19, Could you be able to identify the sire of a kid? 1. Yes 2. No

If yes**,** specify the criteria used to identify _____

3.20, Do you allow a buck to mate his relatives like mother, daughter and sister ?

1. Yes 2. No Reason _____

3.21. Do you allow your buck to serve does other than yours?

Reason

1. Yes _____

2. No _____

3.22, Do you allow your doe to be served by anyone else buck? 1, yes 2, No

Reason

if Yes _____

if No _____

3.23, The average age at puberity of female goat in month _____

3.24, Do you fix age at first mating for the female goats? 1, yes 2, No

3.25, average age at first kidding in month._____

3.26, Occurrences of birth type in your goat flock?

1. Mostly single 2, always Single 3. Mostly twin 4, always twin 5, Rarely twin 4. Rarely triplet 5. Rarely quadruple 6. Other specify.

3.27, The average age at puberity of male goat in month _____

3.28, Do you fix age at first mating for males? 1, yes 2, No

3.29, List the months during which mating occurs_____

_____

3.30, On average, what is the kidding interval of your doe (in month)?_____

_____

3.31, What is pre weaning kid survival rate in percent?

1. During dry season in permanent place _____
2. During good season in permanent place _____
3. Out of permanent place (during mobility) _____

3.32, Average number of kidding per doe life time _____

3.33, Average reproductive life span of female goats in year_____

3.34, Average life span kid crop of goat in number_____

3.35. Do you castrate your buck? 1,Yes 2,No

3.36, If you castrate your buck, what are your **reasons** for castration? 1. Control breeding

2. Improve fattening 3. Better price 4. Others(Specify)

3.37, At what age do you castrate bucks? _____

3.38, If you castrate your buck Specify Castration method you use

1. By your own (traditional) ; 2) Veterinarians(modern)

3.39, If you castrate traditionally, what type of **materials** do you use for castration?

_____

3.40, What would you usually do with the **best buck born** in your flock?

1. Sell them soon before they mature(less than one year)

2. Keep them for breeding for about three years

3. Keep them for breeding for more than three years

4. Keep them for fattening for some time

5. Others, specify _____

3.41, Basic temperament of your goats.

1. Docile 2. Moderately tractable 3. Wild 4. others

Marketing

4.1, Which class of goat do you **sell first** in case of cash need?

Class	**Rank**
male kids less than 6 months	
Female kids less than 6 months	
Buck kids between 6 months and one year	
Doe kids between 6 months and one year	
Breeding does	
Breeding bucks	
Castrated	
Old does	
Old bucks	

4.2 Average market age in months male_____female_____

4.3, Average culling age in years due to old age male_____ female_____

4.4, Have you ever slaughtered goats from the flock for household consumption over the last

years? 1. Yes 2. No

4.5, If yes, how many goats in a year time? _____goats.

4.6, What are the main constraints for goat production? (**Rank** with significance)

Constraints	Rank
Feed shortage	
Disease occurrences	
.Recurrent drought	
water scarcity	
Labor shortage	
Market problem	
Genotype	
Predator	
Theft	
Others, specify	

Thank you very much for your cooperation !!!

7.2. Appendix B, Points governing the focal group discussion

Discussion with clan or village leaders, goat owners, elderly female and male member of the society who is known to have better knowledge and development agents

- Origin and history of the goat's population.
- What is local Name of the goat population of the area?
- What is Background for such name?
- What do you know about geographical distribution of Benatsemay and Debub Ari indigenous goats?

- Production system and social bylaws on communal interest like communal grazing land, watering point and utilization of buck for breeding
- What are the Main uses and roles of the breed in this production environment? Prioritize and put in order
- What are special peculiarities/qualities of goat of the district?
- How often did farmers/pastoralists use the best breeding bucks selected by the cooperative?
- Do farmers/ pastoralists know about inbreeding problem of goats? If yes what are the symptoms?
- Are there any unnecessary goat's population/Genetic resources/ dilution practices?
- What type of solution do you recommend to conserve indigenous goats?
- Is there any cultural taboo that prohibit goat keeping?
- How do you evaluate gender aspects of work and income sharing from goat business?
- What are the challenges of goat's production around this area?
- What opinion do you have to improve production and productivity of goats?
- How can farmers/pastoralists estimate goats' age?

7.3. Appendix C, Description of qualitative trait and respective code

1. District: 1 =Debub Ari , 2= Benatsemay
2. Peasant association: 1= Baytsimal ,2 =Arkisha, 3= Kayisa, 4= Mukocha , 5= Alduba, 6= Luka
3. Agro ecology= 2= Mid land , 3 = Lowland.
4. Sex of the animal: 1= Female, 2= Male.
5. Coat color pattern: 1= plain 2= Patchy 3= Spotted.
6. Coat color type: 1= Black, 2 = Brown, 3= Light brown, 4= Dark brown, 5= Red, 6= light red, 7= Dark red, 8= Fawn 9= Gray, 10= white, 11= Gray and White, 12= Black, Gray and White, 13= Brown with white patch, 14 =Brown with dark patch, 15= White with small light patch.
7. Hair type: 1= Glossy, 2=Smooth, 3= Straight long hair, 4= Curly rough hair, 5=Dull.
8. Horn shape: 1= Scars, 2= Straight, 3=Curved, 4= Spiral, 5 = Corkscrew,
9. Horn orientation: 1= Lateral, 2=Obliquely, 3= Upward, 4=Back ward, 5= Polled.
10. Ear orientation: 1= Erect, 2= carried horizontally, 3= pendulous, 4= semi pendulous.
11. Head profile; 1= Straight, 2= Concave, 3= Convex, 4= Ultra convex.
12. Back profile: 1= Straight, 2= Slop up toward the rump, 3= Slop down from wither, 4= Curved.
13. Rump profile: 1= Flat, 2= Slopping, 3= Roofy
14. Wattle: 1= Present, 2= Absent.
15. Beard: 1= Present, 2= Absent.
16. Ruff: 1= Present, 2= Absent

7.4. Appendix D, Checklist for collection of secondary data

1. Human population in each district_____
2. Livestock population _____
3. Average land holding per household (in ha)_____
4. Seasons of the year
   1. Rainy season from to ___to ____ 2. Dry season from to__ __to_____
5. Topography of the zone (%):
Plain_____Mountain_____Plateau_____Other_____
6. Climatic data (distribution and amount)
Annual average temperature_____Maximum_____Minimium_____
Annual average rain fall_____Maximum_____Minimium_____
Humidity (%) Annual average humidity_____Maximum_____Minimium_____
7. Agro ecological zone of each district (%)
Lowland (500-1500) _____
Intermediate (1500-2300) _____
Highland (>2300) _____
8. Land use pattern (in hectare or in percent)_____
9. Production system /Farming system in percent_____
10. Vegetation cover_____
11. Major soil types 1._____ 2._____

12. Opinion on relative importance of goats in the pastoralists/farmers' livelihood (Income contribution of the a activity in percent)
13. Major goats' production constraints in each district?
14. Organization/institutions actively involved in the area and their role in goat production
15. Name of goat breed, origin, distribution and the status of the breed at present?
(Increasing, decreasing or stable and reasons for the trend)
16. Major goat disease, occurrence, mortality, and treatment
17. Any efforts on-gonging in areas of goats market (cooperatives, linking producers with traders, infrastructure development and market routes)

7.5. Appendix E, List of tables

Appendex Table1 . Description of morphometric traits

Parameters	Technique for measurement	Measuring equipment used
Body weight (BWt)	Body weight each male and female goats	Suspended weighing scale (50 Kg spring balance),
Body length(BL)	The distance from the point of shoulder to the pin bone.	Tailors measuring tape
Chest girth (CG)	Measured by taking the measurements of the circumference of the chest; behind the forelegs	Tailors measuring tape
Chest depth (CD)	From withers to the bottom brisket surface, just behind the elbow	Wooden stick
Chest width (CW)	The widest point of shoulders	Wooden stick
Ear length (EL)	Taken from the base to the tip of the ear.	Tailors measuring tape
Fore canon circumference (CC)	The circumference of the lower part fore cannon bone or the smallest circumference of the foreleg.	Tailors measuring tape
Height at withers (HtW)	Measured as a distance from the surface of the platform to the withers of the animal.	Wooden stick
Height at rump (RHt)	Measured as a distance from the surface of the platform to the rump of the animal.	Wooden stick
Rump length (RL)	Measured as the distance from the hip (tuber coxae) to the pin (tuber ischi)	Tailors measuring tape
Rump width (RW)	The horizontal distance between the extreme lateral points of the hook bone (tuber coxae) of the pelvis)	Tailors measuring tape
Head length (HLt)	The length of the front head from the middle of the top head to the top head to the end of the nose.	Tailors measuring tape
Head width (HW)	The width of the front head from the base of left and right ear.	Tailors measuring tape

Horn length (HL)	Measured from root of horn to the tip along the outer curvature.	Tailors measuring tape
Scrotum circumference (SC)	Surrounding distance taken from half way of scrotum.	Tailors measuring tape
Sternum height(StHt)	Measured from flat ground surface to the sternum	Wooden stick
Paunch girth (PG)	Circumference of the belly at the center	Tailors measuring tape
Distance between teats(DBnT)	Length between two teats	Tailors measuring tape
Teat distance from ground (TDFg)	Measured from flat ground surface to the tip of teat	Wooden stick
Teat length (TL)	Length of the teat measured from the base of the teat to the end of the teat	Tailors measuring tape
Teat diameter (TD)	Circumference taken from half way of teat	Tailors measuring tape
Udder circumference (UC)	Surrounding distance of udder above teats	Tailors measuring tape
Udder length (UL)	Distance from end point of teat to mammary attachment	Tailors measuring tape
Udder width (UW)	Horizontal distance of udder	Tailors measuring tape

Appendex Table 2. Description of body condition score

Score	Condition	Features
1	Very thin	Back bone prominent and sharp, ends of short ribs are sharp, easy to press between, over and around
2	Thin	Backbone prominent but smooth, short ribs are well rounded ends can feel between, over and around smoothly
3	Average	Backbone can be felt but smooth and rounded, short ribs ends are smooth and well covered and felt with firm pressure
4	Fat	Backbone detected with pressure on the thumb, individual short ribs can be felt with firm pressure
5	Obese	Backbone can be felt with firm pressure and hard to felt short ribs even with firm pressure

Appendex Table3. Estimation of goats age from dentition

Stage (Age)	Characteristic change on teeth
Kids under one year	8 sharp milk incisors
Yearling (1-2 years)	Central pair of permanent incisors
Young adult (2-3 years)	2 pairs of permanent incisors
Adult (3-4 years)	3 pairs of permanent incisors

Mature (4-5 years)	4 pairs of permanent incisors
Old (over 5 years)	without teeth and some missing

Table 4. ANOVA of body weight of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	2174.830090	2174.830090	151.22	<.0001
Sex	1	1175.369449	1175.369449	81.73	<.0001
Age	3	8252.088375	2750.696125	191.26	<.0001
Error	624	8974.28836	14.38187		
Corrected Total	629	20075.57143			

Appendex Table 5. ANOVA of body length of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	1033.346534	1033.346534	151.22	<.0001
Sex	1	386.505206	386.505206	81.73	<.0001
Age	3	9263.484937	3087.828312	191.26	<.0001
Error	624	6170.72751	9.88899		
Corrected Total	629	16552.98571			

Appendex Table 6. ANOVA of rump height of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	1536.973409	1536.973409	191.90	<.0001
Sex	1	545.175920	545.175920	68.07	<.0001
Age	3	5148.218219	1716.072740	214.26	<.0001
Error	624	4997.73910	8.00920		
Corrected Total	629	11958.37460			

Appendex Table 7. ANOVA of rump length of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	37.3970767	37.3970767	14.46	0.0002
Sex	1	53.9349062	53.9349062	20.86	<.0001
Age	3	708.1581773	236.0527258	91.30	<.0001
Error	624	1613.406819	2.585588		
Corrected Total	629	2374.293651			

Appendex Table 8. ANOVA of rump width of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro eco	1	67.5534302	67.5534302	45.84	<.0001
Sex	1	15.1222371	15.1222371	10.26	0.0014
Age	3	511.6592382	170.5530794	115.73	<.0001
Error	624	919.601497	1.473720		
Corrected Total	629	1498.541270			

Appendex Table 9. ANOVA of punch girth of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro eco	1	3947.03341	3947.03341	108.60	<.0001
Sex	1	206.28772	206.28772	5.68	0.0175
Age	3	10479.46847	3493.15616	96.11	<.0001
Error	624	22679.85045	36.34591		
Corrected Total	629	37187.66508			

Appendex Table 10. ANOVA of heart girth of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	1006.606191	1006.606191	62.82	<.0001
Sex	1	383.324522	383.324522	23.92	<.0001
Age	3	8379.258153	2793.086051	174.30	<.0001
Error	624	9999.22762	16.02440		
Corrected Total	629	19484.07143			

Appendex Table 11. ANOVA of sternum height of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	394.027643	394.027643	68.97	<.0001
Sex	1	390.247175	390.247175	68.31	<.0001
Age	3	2087.101761	695.700587	121.77	<.0001
Error	624	3565.033560	5.713195		
Corrected Total	629	6271.626984			

Appendex Table 12. ANOVA of height at wither of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	658.857535	658.857535	66.62	<.0001
Sex	1	844.001456	844.001456	85.34	<.0001
Age	3	6123.375146	2041.125049	206.40	<.0001
Error	624	6170.92291	9.88930		
Corrected Total	629	13347.84286			

Appendex Table 13. ANOVA of chest depth of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	9.579734	9.579734	2.73	0.0992
Sex	1	78.829085	78.829085	22.43	<.0001
Age	3	1035.987700	345.329233	98.27	<.0001
Error	624	2192.781322	3.514073		
Corrected Total	629	3259.307937			

Appendex Table 14. ANOVA of chest width of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	391.5351931	391.5351931	111.63	<.0001
Sex	1	60.0518549	60.0518549	17.12	<.0001
Age	3	74.9338056	24.9779352	7.12	0.0001
Error	624	1541.223471	2.469909		
Corrected Total	629	2424.165079			

Appendex Table 15. ANOVA of ear length right of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	205.4716086	205.4716086	64.30	<.0001
Sex	1	6.7479417	6.7479417	2.11	0.1467
Age	3	68.4197982	22.8065994	7.14	0.0001
Error	624	1993.850253	3.195273		
Corrected Total	629	2277.460317			

Appendex Table 16. ANOVA of ear length left of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	391.5351931	391.5351931	111.63	<.0001
Sex	1	60.0518549	60.0518549	17.12	<.0001
Age	3	74.9338056	24.9779352	7.12	0.0001
Error	624	2188.720626	3.507565		
Corrected Total	629	2727.326984			

Appendex Table 17. ANOVA of horn length of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	65.1793707	65.1793707	14.73	0.0001
Sex	1	346.7641022	346.7641022	78.34	<.0001
Age	3	915.6815035	305.2271678	68.96	<.0001
Error	578	2558.477800	4.426432		
Corrected Total	583	3731.979024			

Appendex Table 18. ANOVA of head length of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	102.7716579	102.7716579	100.33	<.0001
Sex	1	55.2837915	55.2837915	53.97	<.0001
Age	3	320.6827026	106.8942342	104.36	<.0001
Error	624	639.181661	1.024330		
Corrected Total	629	1094.706746			

Appendex Table 19. ANOVA of head width of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	50.0228913	50.0228913	57.01	<.0001
Sex	1	75.5948568	75.5948568	86.15	<.0001
Age	3	206.1547203	68.7182401	78.32	<.0001
Error	624	547.5298343	0.8774517		
Corrected Total	629	856.3317460			

Appendex Table 20. ANOVA of cannon bone circumference of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	52.41112123	52.41112123	142.12	<.0001
Sex	1	35.87164258	35.87164258	97.27	<.0001
Age	3	72.60967383	24.20322461	65.63	<.0001
Error	624	230.1269649	0.3687932		
Corrected Total	629	385.0162698			

Appendex Table 21. ANOVA of scrotal circumference of Bena-Tsemay and Debub Ari

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	68.1996498	68.1996498	16.69	<.0001
Age	3	135.2207044	45.0735681	11.03	<.0001
Error	100	408.5541652	4.0855417		
Corrected Total	104				

Appendex Table 22. ANOVA of teat length left of Bena-Tsemay and Debub Ari

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	3.97935926	3.97935926	25.84	<.0001
Age	3	3.71039826	1.23679942	8.03	<.0001

Error	318	48.97317015	0.15400368		
Corrected Total	322	56.44625387			

Appendex Table 23. ANOVA of teat length right of Bena-Tsemay and Debub Ari

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	4.05866719	4.05866719	26.30	<.0001
Age	3	3.64214598	1.21404866	7.87	<.0001
Error	318	49.06744653	0.15430015		
Corrected Total	322	56.55671827			

Appendex Table 24. ANOVA of teat diameter left of Bena-Tsemay and Debub Ari

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	8.42041686	8.42041686	92.05	<.0001
Age	3	1.93895052	0.64631684	7.07	0.0001
Error	318	29.08930863	0.09147581		
Corrected Total	322	39.28006192			

Appendex Table 25. ANOVA of teat diameter right of Bena-Tsemay and Debub Ari

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	8.42041686	8.42041686	92.05	<.0001
Age	3	1.93895052	0.64631684	7.07	0.0001
Error	318	29.08930863	0.09147581		
Corrected Total	322	39.28006192			

Appendex Table 26. ANOVA of udder length of Bena-Tsemay and Debub Ari

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	208.8324273	208.8324273	58.82	<.0001
Age	3	59.4510257	19.8170086	5.58	0.0001
Error	318	1129.069272	3.550532		
Corrected Total	322	1389.987616			

Appendex Table 27. ANOVA of udder width of Bena-Tsemay and Debub Ari

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	110.1307875	110.1307875	59.73	<.0001
Age	3	48.4133547	16.1377849	8.75	<.0001
Error	318	586.3410099	1.8438397		
Corrected Total	322	742.1780186			

Appendex Table 28. ANOVA of udder circumference of Bena-Tsemay and Debub Ari

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	563.1582722	563.1582722	46.69	<.0001
Age	3	246.4987688	82.1662563	6.81	0.0002
Error	318	3835.933623	12.062684		
Corrected Total	322	4639.040248			

Appendex Table 29. ANOVA of distance between teats of Bena-Tsemay and Debub Ari

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	25.59496928	25.59496928	55.14	<.0001
Age	3	3.23418220	1.07806073	2.32	0.0751
Error	318	147.6212399	0.4642177		
Corrected Total	322	176.9746749			

Appendex Table 30. ANOVA of teats distance from ground of Bena-Tsemay and Debub Ari goats

Source	DF	Type III SS	MS	F Value	Pr > F
Agro ecology	1	206.4361041	206.4361041	43.69	<.0001
Age	3	20.4829007	6.8276336	1.44	0.2297
Error	318	1502.663635			

Corrected Total	322	1721.213622

7.6. Appendix F, list of figures

Figure 1 Suspended weighing scale (50 Kg spring balance)

Figure 2, Focus group discussion at Alduba, Arkisha, mukecha and luka peasant association.

7.7. Appendix G, BIOGRAPHICAL SKETCH

The author of this thesis, Zerihun Fiseha, was born on January 29, 1983 in Aleta Wondo district, Geribicho Kila Peasant Association from his father Mr. Fiseha Bogale and his mother Mrs. Liyou Shawul. He attended his elementary education in Finch wuha elementary School, at Hagereselam district, and his secondary school in Aleta Wondo high school. He joined Dilla ATVET College of Agriculture in 2003 and graduated with diploma in animal science in 2005. After completion of his diploma study, he worked as agriculture development agent in Wonsho woreda agricultural office. In 2008 he joined Haramaya University and graduated with BSc degree in animal science in 2013.

Later on he moved to Daalle district agricultural office and served as bee keeping expert and in 2015 he moved to Sidama zone agricultural department and served as Bee keeping expert for one year then he moved to southern region livestock and fishery resource bureau and he has been working as meat resource development expert since 2016.

In 2019 he joined the School of Graduate Studies (SGS) of Hawassa University to pursue his MSc study in animal breeding and genetics in the Department of Animal and Range science.