MORPHOLOGICAL CHARACTERIZATION AND TRADITIONAL BREEDING PRACTICES OF FARMERS REARING INDIGENOUS GOATS IN HIDABU ABOTE, OROMIA REGIONAL STATE, ETHIOPIA

M.Sc. THESIS

GENANEW ABERA

HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

MARCH, 2020

HAWASSA, ETHIOPIA

MORPHOLOGICAL CHARACTERIZATION AND TRADITIONAL BREEDING PRACTICES OF FARMERS REARING INDIGENOUS GOATS IN HIDABU ABOTE, OROMIA REGIONAL STATE, ETHIOPIA

GENANEW ABERA TESHOME

MAJOR ADVISOR: Prof. ABERRA MELESSE (PhD)

CO-ADVISOR: SANDIP BANERJEE (PhD)

A THESIS SUBMITTED TO THE
SCHOOL OF ANIMAL AND RANGE SCIENCE, COLLEGE OF AGRICULTURE, SCHOOL OF GRADUATE STUDIES,
HAWASSA UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTERS OF SCIENCE IN ANIMAL AND RANGE SCIENCES (SPECIALIZATION: ANIMAL BREEDING AND GENETICS)

MARCH, 2020

HAWASSA, ETHIOPIA

GRADUATE STUDIES

HAWASSA UNIVERSITY

ADVISORS' APPROVAL SHEET

This is to certify that the thesis entitled"**Morphological Characterization and Traditional Breeding Practices of Farmers Rearing Indigenous Goats in Hidabu Abote, Oromia Regional State, Ethiopia**" submitted in partial fulfillment of the requirements for the degree of master's with specialization in **Animal Breeding and Genetics,** the Graduate Program, the School of **Animal and Range sciences**, and has been carried out by **Genanew Abera Id. No SGSK/249/09**, 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.

_____	_____	_____
Name of major advisor	Signature	Date
_____	_____	_____
Name of co-advisor	Signature	Date

ACKNOWLEDGEMENTS

I am thankful to God almighty, the most gracious and the most beneficent, who enables me to accomplish this work.

It is my pleasure to express my frank appreciation and special gratitude to my major advisor, Prof. Aberra Melesse for his extraordinary support, generosity, guidance, encouragement and constructive comments at all stages of the research work. I am also glad to my co-advisor Dr. Sandip Banerjee for his important comments, and insightful suggestions

I am thankful to Hidabu Abote district agricultural offices for providing me information and facilitating the field work during data collection. I am also indebted to focal persons and enumerators for their courage and enthusiasm during data collection, all the goat owning farmers in the study area for providing me their time, opinion and their animals work upon.

Finally my deepest gratitude and appreciation is extended to Instructor Elias Tekle, for his kindness and ever by allocating his personal computer for me.

DEDICATION

This piece of work is dedicated to my father, Abera Teshome who was always enveloped in imaginary about my success, though death come ahead of his life a bit before my success in joining of the College and to all members of my family.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my legal 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 Hawassa University and is deposited in the University Library to be made available to borrowers under the rules of the Library. I truly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Brief quotations from this thesis are allowed without special permission, provided that accurate acknowledgement of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the Head of Department of Animal Sciences or the Dean of the School of Graduate Studies when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author.

Name: Genanew Abera **Signature**: _____

Place: College of Agriculture, Hawassa University, Hawassa

School: Animal and Range Sciences

Date of Submission: _____

ABBREVIATIONS AND ACRONMYS

AFK	Age at First Kidding
AIC	Alkaike's criteria
AnGR	Animal Genetic Resource
ANOVA	Analysis of variance
BL	Body length
BW	Body weight
CD	Chest depth
CW	Chest width
C (P)	Mallows C Parameters
CSA	Central Statistical Authority
EARO	Ethiopian Agricultural Research Organization
EIAR	Ethiopian Institute of Agricultural Research
EL	Ear length
ESGPIP	Ethiopian Sheep and Goat Productivity Improvement Project
FAOSTAT	Food and Agriculture Organization of the United Nations Statistical divission
GDP	Gross Domestic Product
GLM	General Linear Model
HADLFRO	Hidabu Abote District Livestock and Fishery resourse office
Head L	Head length
Head W	Head width

HG	Heart girth
Horn L	Horn length
IBC	Institute of Biodiversity Conservation
ICARDA	International Center for Agricultural Research in Dry Areas
ILCA	International Livestock Center for Africa
IPCA	International principal component Axis
LBM	Linear Body Measurement
NABC	Netherlands Africa Business Council
RH	Rump height
RL	Rump length
R^2	Coefficient of determination
SBC	Schwarz Bayesian criteria
SGS	School Graduate Studies
SL	Scrotum length
SSA	Sub Saharan Africa
TLU	Tropical Livestock Unit

TABLE OF CONTENTS

Contents **Pages**

LIST OF TABLES

Tables **Pages**

LIST OF FIGURE

Figure **Page**

LIST OF TABLES IN THE APPENDICES

Appendices Tables **Pages**

LIST OF FIGURES IN APPENDICES

Figures in appendix Pages

Morphological Characterization and Traditional Breeding Practices of Farmers Rearing Indigenous Goat in Hidabu Abote, Oromia Regional State, Ethiopia

By Genanew Abera

Major Advisor Prof. Aberra Melesse (PhD)

Co-Advisor Sandip Banerjee (PhD)

ABSTRACT

The study was conducted to describe morphological features, traditional breeding practices of farmers rearing indigenous goat types at Hidabu Abote district. The district was stratified in to highland, midland and lowland. Multi-stage sampling techniques were applied to select the kebeles and households within each agroecology. The research was composed of data collection using semi-structured questionnaire and morphological characterization. One hundred twenty households were randomly selected representing three agro-ecologies. For morphological studies, 342 goats of both sexes were used. Based on morphometrical traits, 16 structural and functional indices were calculated. The results indicated that the average goat flock size in highland, midland and lowland were 3.8, 7.2 and 12.0, respectively; and were significantly different between agro-ecologies. The overall average age at first kidding in highland, midland, and lowland was 11.4, 11.1 and 11.1 months, respectively. The kidding interval of goats in highland, midland, and lowland was 8.9, 8.4 and 8.2 months, respectively. Average number of litter size in highland, midland, and lowland was 1.5, 1.6, and 1.9, respectively. Disease, feed, and water shortage were reported as major constraints. From qualitative traits, the dominant coat color patterns of both sexes were plain (78.7%), pied (21.1%) and spotted (0.3%). The frequently observed coat color types were white (53.2%), brown (26.6%) and light red (15.5%). The proportion of goats with horns and wattles was 95.9% and 71.9, respectively. About 69% of the goats were characterized with concave head profile. There were significant differences ($P<0.05$) among sex, agro-ecology, and age, except ear length ($P>0.05$) for body weight and some morphometric traits. The respective average body weight (kg) of both sexes in highland, midland and lowland was 31.1, 30.1 and 32.3 being significantly different from each other. Goats reared in the lowland had higher ($p<0.05$) body length, chest depth and rump length values compared with those raised in other agro-ecologies. Similarly, scrotal circumference was higher ($p<0.05$) in lowland goats than in the highland. Heart girth was found to be the best independent variable to predict body weight for both sexes (R^2=95%). The structural indices result showed that the body index was 0.87, which classify the studied goats as medigline goat. The compact index value 4.6, which classified them as meat type. However, the proportionality index (107) which is above 100 classifying them as dairy type breeds. In conclusion, the highest values for body weight, body length, chest depth, rump length and scrotal circumference were observed in those goats raised in the lowland. It is thus recommended to focus on the genetic and management improvement strategies of goats reared in the lowland.

Keywords: agroecology, breeding practices, morphologically characterization, structural indices,

1. INTRODUCTION

Livestock production is a major component of the agricultural economy of developing countries and they play an important role especially among the agrarian societies (CSA, 2013). Livestock in general and small ruminants in particular serve as living banks for the small and marginal members of the society (NABC, 2010).

The livestock population of Ethiopia comprises of 60.39 million heads of cattle, 31.3 million heads of sheep 32.74 million heads of goats, 2.01 million heads of horse, 8.85 million heads of donkeys, 0.46 million heads of mule, and 4.5 million heads of camels (CSA, 2018). Livestock sector has been contributing a considerable portion to the economy of the country however their contribution does not commensurate to their population (NABC, 2010). The contribution of the livestock towards the gross domestic product of the country has been reported to be16-19% GDP and their contribution to the agricultural has been reported to be 35-40% GDP (Behnke, 2010).

Ethiopia is home for diverse goat /*Capra hircus/* genetic resources spreading across diverse ecology, reared by several communities and under vivid production systems (Solomon Gizaw, 2009). The milk and chevon of goat have higher digestibility and goat milk is said to have therapeutic values (Anaeto *et al*., 2010). Goats can inhabit a wide range of climates (Bagley, 2006). Genetic diversity among livestock and goats being no exception is quite high in Africa and Ethiopia is a hotbed of genetic diversity (FAO STAT, 2012). Most of the goats like those of other parts of the developing world are raised under low input and low output system of management. The nutrition received by the goats vary across seasons and also within a season in a given agroecology. These animals are also exposed to vagaries of nature and hence are exposed to different diseases and parasites besides predatory attacks (Workneh *et al*., 2004a).

The genetic relationship between breeds can be quantified by estimating the allelic frequencies from genetic analysis (Yang, 2010). The classical description of breeds are based on their morphological traits which can be further classified into qualitative (coat color, horns, tail type, etc.) and quantitative traits (height, length, weight etc.) (FAO, 2012). Morphometrical characterization can be complementary to the most biotechnological tools for assessment of their genetic diversity at the level of the genome. Livestock characterization tools range from simple descriptions of traditional livestock populations to a highly sophisticated molecular genetics tools (Solomon *et al*, 2011).

Understanding about livestock diversity, their distribution, their comparative performance and their status of each country's animal genetic resources are crucial for their efficient and sustainable use, development and conservation (Tewodros, 2017). Complete national inventories, supported by periodic monitoring of trends and associated risks, are the basic requirements for the effective management of livestock genetic resources of a region in particular and a country in general (FAO, 2007). Performance studies under traditional management practices are usually provide information on location specific production conditions (Zergaw, 2016). Without proper documentation, scientific interventions (in case the population is showing a downward trend) and sustainable usages of the prevailing livestock may lead to decline in the population dynamics (Kgosikoma, 2014). Hence documentation of the population dynamics is the prerequisite for any species and also genotypes within a species (Yoshida, 2007).

Out of the total goats (32.74 million) reported in Ethiopia, about 70.49% are females and 29.51% are males and almost all of them 99.97% are indigenous (CSA, 2018). According to (DAGRIS, 2007) there are four families and 13 breed types and their distribution described according to

distinct agro–ecologies and climatic conditions (Tesfaye, 2004), while a genetic characterization showed only 8 distinctively different types (Tesfaye, 2004). Getinet (2016) also regrouped the Ethiopian goat breeds into seven on molecular basis. To identify the type and functional of goat breed, structural indices from linear body measurements could be calculated. Structural indices are a combination of several linear body measurements that are used to assess the type, weight and function of the breeds of animals and further enhance the ability of breeders to select potential breeding stock (Chacón et al., 2011).

The indigenous goat types are widely distributed and are found in all administrative regions of the country. The majority of the goat population is found in large flocks in the arid and semi-arid lowlands. Goats in the highland are widely distributed in mixed crop-livestock production systems with very small flock size with an increase in all agro-ecologies (Tsegahun *et al*., 2000). Among the total goat populations in the country, the largest population (26.24%) were found in the Oromia regional state of Ethiopia which had 8.59 million heads of goat population with its great variation in climate and topography represents a good reservoir of goat genotypes (CSA, 2018). As the study area, Hidabu Abote was characterized by diverse agro-ecological locations where goats play increasingly significant role for communities that keep them. There is a long tradition of goat production and huge goat resources in the zone particularly in the study area. Despite having huge benefits for the society, studies on goat's physical traits and documented information on phenotypic characterization and structural indices of goat in the studied area is lacking. So it needs some work to identify the performance, breeding problem, breeding goal, reduce inbreeding. Therefore, applying such approaches in the characterization of indigenous livestock breeds in the country was crucial. Therefore, the present study was carried out to address these issues with the following objective

General Objective

To morphologically characterize the indigenous goat populations reared in Hidabu Abote, of Oromia Regional state.

. **Specific objectives**

- To characterize the qualitative and morphometrical traits of indigenous goat types;
- To identify the traditional breeding practices and trait preferences of their owners and
- To determine the function and type of the indigenous goats using structural indices.

2. LITERATURE REVIEW

2.1. Goat Breeds in Ethiopia

The ancestors of Ethiopian goats are closely associated with goat types which migrated from the Middle East and North Africa (FARM Africa, 1996). Information compiled on physical description and management system shown that there are 14 goat types in Ethiopia and Eritrea (Farm-Africa, 1996). Almost all indigenous goat types in Ethiopia (Table 1) fall under the general group of Short eared Small-horned goats found throughout eastern, central and southern Africa. They inhabit all agro-climatic zones and production systems in the areas. There is only one breed (barka) from a different breed group, and it comes mainly from Eritrea (Asfaw and Tamrat, 2003). However, a recent genetic characterization of Ethiopian goats by Tesfaye (2004) was inconsistent with this classification of Farm Africa. Following the analysis of 15 microsatellite loci, the results indicate eight separate genetic entities: the Arsi-Bale, Gumez, Keffa, WoytoGuji, Abergelle, Afar, Highland Goats (previously separated as Central and North West Highland) and the goats from the previously known Hararghe, Southeastern Bale and Southern Sidama provinces (Hararghe Highland, Short eared Somali and Long-eared Somali goats).

Table 1. Distribution of indigenous goat breeds/types in Ethiopia

Breed	Breed name	Synonym	Distribution
Long eared goats	Barka	Bellenay, Beni Ame	Northern and northwestern Ethiopia near the border with Eritrea and the Sudan
	Long eared Somali	Digodi, Melebo, Boran Somali, Benadir, Gigwain	Rangeland of the southern Ogaden, Bale, Borana and Southern Sidama with the Somali and Borana Pastoralists
	Short eared Somali	Ogaden, Mudugh, Dighier,Abgal, Issa-Somali, Bimal	Northern and Eastern Ogaden and around Dire Daw
Short eared Small horned	Western Highland	Agew	Highlands of Western Ethiopia (Gondar, Gojjam, Wollega and Shoa
	Western Low land	Gumuz	Low lands of Western Ethiopia (Metekel, Assosa, and Gambella
	Abergelle	NA	Southern Tigray, North Wollo, and North Gondar
	Afar	Adal, Assaorta, Denakil	Afar region and parts of Eritrea and Djibouti with the Afar Pastoralists
	Arsi-Bale	Sidama, Manta, Awarch	Arsi, Bale, Sidamo and western Hararghe Zones
Short eared Small horned	Central Highland	Brown Goat, Kaye	Highland of Central Ethiopia from Tigray through Wollo, Gondar to Shoa
	Hararghe Highland	Kotu-Oromo	Highlands of eastern and western Hararghe

Source: Asfaw and Tamrat, (2003), NA=not available

2.2. Goat flock structure

Flock structure is the proportion in the flock of the different age and sex classes of goats. The number of males and females in flocks and their ages are often used as an indicator of a particular traditional management system in Africa (FARM, 1996). Flock structure is also a basis for calculating or forecasting flock productivity. For instance, a relatively low proportion of young stock in a flock would suggest that adult mortality is low or pre weaning mortality is high, or the kidding percentage is low. Alternatively, it may mean that more kids were sold during the year. When the primary objective is to produce milk, the proportion of females retained is usually higher than when the objective is to produce meat (FARM Africa, 1996). A high proportion of castrates suggest that the system is likely to be related to meat production objectives. For example, in lowland goats of Ethiopia, the primary objective is to produce milk and castrates with four pairs of incisors account for 0.5% of the total flock, whereas for the Central Highland goats whose primary purpose is meat production and sale in times of need the proportion of castrated males with four pairs of incisors is 2.2% (Nigatu, 1994).

2.3. Trait Preference and Selection Criteria of Goats

In breeding programs for most species, animals in the dam and sire selection pathways are selected very intensely with a higher accuracy than in the other selection pathways. Selection is based on breeding values estimated using either a selection index or, if possible, best linear unbiased prediction. Depending on the traits under considerations, these procedures require information on the performance of the individual and its relatives (Mbuku *et al*., 2006). Such procedures are too complex for the pastoralist to apply, but this should not be misconstrued to mean that they do not consider the performances of the individual and its relatives when

selecting animals to be the parents of the next generation. The pastoral communities involved individual and family selection, with much attention paid to the latter. Body size, offspring quality, milk yield and drought tolerance were important qualities of the potential new buck's dam (Mbuku *et al*., 2006). The general appearance of goats will offer some insight into their present health. Condition (fatness) of the goat will be determined by reproductive stage, level of production and age of the individual. For example, does which have recently weaned kids would be expected to be thinner than does which fail to breed or failed to produce much milk in lactation. Health and confirmation should be prime considerations. When production records are available, special consideration should be given to kidding rate, weaning weights and age at market weight. Production (quantitative) traits were more important than qualitative traits were in the selection of breeding stock. Selection of breeding stock by farmers is through using their indigenous knowledge. They depended on information about the performance of potential buck/does and growth performance, information from relatives/ancestor and assessment of the young buck and 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 (Zewdu *et al*., 2009).

2.4. Reproductive traits

Reproductive traits of economic importance in goats are age at puberty, litter size, kidding interval, the kid survived, doe fertility, and fertility of bucks. Goats are the most prolific of all domesticated ruminants under tropical and subtropical conditions and certain goats are able to breed throughout the year. The reproductive performances of small ruminants are important

factors influencing flock productivity. All forms of output, including milk, meat and skins, depend on these factors. The factors vary mostly between breeds and even within flocks in a given population Zewdu *et al*., (2009). Considering reproductive parameters in the selection and crossbreeding programs will directly influence the efficiency of milk and meat production and the rate of genetic progress (FAO,2012), and the size of the crop for replacement. These factors are influenced by many factors, including genotype, nutrition, diseases and other management practices. In addition, these performance parameters are not a single trait each but the combination of other several traits that determine their expression.

Table 2. Definitions of reproductive traits

Traits	**Definitions**	**Traits value**
Puberty	An age when the goat first exhibits behavioral estrus and in males, it is the stage of growth when they are able to produce spermatozoa capable of fertilizing an egg	5 to 8 months for most tropical breeds
Age at first kidding	The age of Doe at the time of first parturition	12 to 15 months
Litter size	The number of kids born per Doe per kidding	1 to 2
Kidding interval	The interval between successive kidding	About 8 months for T
Kid survival	The number of young surviving to a given age usually 3m	

Source: ESGPIP (2010), M = months, T = Tropical

2.4.1. Age of puberty

Puberty in small ruminants is interrelated to age and body weight. Most rams/bucks reach puberty at the age of 4–6 months and 60% of mature body weight (Jainudeen *et al*., 2000). Once the animals have reached puberty, they may be used for breeding. It is difficult to have an accurate measure of puberty unless hormonal assays are done at certain intervals. On

experimental stations, puberty may be recorded as the first behavioral estrus observed. This estrus is called pubertal estrus. The manifestation is not strong and its duration is short, hence, requiring close attention for heat detection (Girma *et al*., 2008). Several factors influence reproductive traits. In the tropics, nutritional status and breed rather than photoperiod are important influencing factors. Age, weight and growth rate interact in determining the onset of puberty.

2.4.2. Age at first kidding

It is an economically vital trait because it decides the rate of genetic progress and population turnover rate. However, many factors affecting pubertal development would also affect age at first kidding. Genetic and environmental factors, especially nutrition determine pre-pubertal growth rate, reproductive development, onset of puberty and subsequent fertility (Mukasa-Mugerwa and Azage, 2002) and type of birth; number of progeny (kids) born with multiple litters attained age at first kidding later than their single born counterparts Tsedeke(2007). Under traditional systems, where small ruminants breeding males are available in the flocks, age at first kidding is a good indicator of early sexual maturity in does. Reported that mean ages at first kidding (AFk) of 16.4 months in traditional systems. The study conducted in central highland of Ethiopia indicated the average age at first kidding to be about 13.2 months for goats (Samuel, 2005) and Tsedeke (2007) indicated that age at first kidding was 12.1 months for Arsi-Bale goats that were maintained under traditional goat management systems in Ethiopia.

2.4.3. Kidding interval

Kidding interval is the interval between two parturitions that determines reproductive efficiency in goat production. The doe with long kidding interval has a lower reproductive efficiency.

Extended kidding intervals commonly arise from long post-partum anoestrus intervals, repeated cycles of service intervals without conception, embryo death or abortion. On-farm monitoring of goats indicated kidding interval of 8.1 months for Arsi Bale goats. Samuel (2005) reported parturition interval of 11.5 for goats in Yerer water shade and kidding interval of 6.9 months was reported for Arsi-Bale goats (Tsedeke, 2007).

2.4.4. Litter size

Litter size is a combination of ovulation rate and embryo survival. It is the number of kids born per parturition and influenced by several factors including; ovulation rate, breed, level of nutrition, parity and age (Wilson and Murayi, 1988). From an evolutionary point of view, the size of the litter could be considered as an indicator of fitness or adaptive capacity of the animals to their environmental conditions. These attributes are very useful under tropical conditions where the environment is quite harsh and variable, and where the hardest animal and adapted females are able to rear and nourish their offspring, according to their capacity to walk and eat a low or medium quality pasture (Menendez- Buxadera *et al.*, 2004) and Tsedeke (2007) reported the proficiency rate of about 1.7 for Alaba goats, which was higher than the reported litter size of 1.03 for goats in the southern region (Girma *et al*., 2000). The report of Endeshaw (2007) indicates that the litter size of Arsi Bale goats under traditional management were varied from 1.08 to 1.75 with an average of 1.38 kids born.

2.5. Major constraints of goats production

The integration and full utilization of tropical goats is constrained by various factors, including high prevalence of diseases, low genetic potential and plane of nutrition, poor management and

extensive production systems. Of these factors, diseases are widespread and have a significant impact on the performance of animals (Gurmesa *et al*., 2011b). It appears that the potential productivity of goats is constrained by a poor understanding of the value of goats and of strategies for improved natural resource management in target environments. It also constrained by various factors, including high prevalence of diseases, low genetic potential, plane of nutrition, poor management and extensive production systems. Proper diagnosis is a pre-requisite for health interventions (Markos *et al*, 2004). In traditional livestock management, does and bucks run together all year round. Feed scarcity (quantity and quality) and access to credit were prioritized, as a problem in all villages (FAO, 2018).

2.6. Characterization of farm Animal Genetic Resources

Breed characterization is the first step in the serious task of genetic resource conservation. In order to make a first attempt to identifying the goat types of Ethiopia, FARM-Africa began a national goat breed survey of Ethiopia and Eritrea in 1996. This document identifies and characterizes the indigenous goat types in Ethiopia and Eritrea (FARM-Africa, 1996). There are two types of breed characterization: phenotypic and genotypic characterization. The genetic relationship between breeds can be quantified by estimating allelic frequencies from genetically analysis (Lenstra, *et al*, 2012). The classical description of breeds (coat color, horns, tail type, etc.) is based upon phenotype. Phenotypic characterization can be complementary to the powerful biotechnological tools for measuring genetic diversity at the level of the genome. Characterization tools range from simple descriptions of traditional livestock populations to a highly sophisticated molecular genetics tools (Solomon *et al*., 2011). Characterization of indigenous breeds is a base for any breed or productivity improvement programs.

Characterization should include physical description, reproduction and adaptations, uses, prevalent breeding system, population trends, predominant production system, description of environments in which it is predominantly found and an indication of performance levels (Workneh *et al*., 2004).

2.6.1. Phenotypic characterization

Phenotypic characterization of animal genetic resources for food and agriculture (AnGR) is the practice of systematically documenting the observed characteristics, geographical distribution, production environments and uses of these resources. The information provided by characterization studies is essential for planning the management of AnGR at local, national, regional and global levels (FAO, 2012). In the developed world, livestock recording schemes provide a continuous source of data for monitoring trends in the industry, including improved understanding of breeds and the production system. Unfortunately, such structures are not available in most developing countries. Here, designed, rapid, on-farm surveys can be useful for collecting basic information on production systems, population statistics of breeds, physical (descriptive characteristics and performance levels-milk production, fertility, mortality, longevity, growth, meat production etc. (FAO, 2011). FAO published a comprehensive list of variables for describing the phenotypic and genetic characteristics of animal genetic resources as the basis for systematic phenotypic characterization and to facilitate global valid comparison and classification of breeds within a species. However, the organization had come to recognize that these descriptors were far too complex for universal application (FAO, 2007).

2.6.2. Genetic characterization

Genetic characterization involves the description of breeds in terms of the relative allelic frequencies, degree of polymorphism using a set of neutral reference markers and classifying livestock breeds using genetic distances between breeds. Genetic characterization tools included biochemical (protein) polymorphisms and molecular polymorphisms. Molecular characterization involves describing and classifying of livestock breeds and species at molecular level by measuring frequencies of genotypes and alleles, degree of polymorphophism, allelic diversity and genetic distances (Solomon *et al*., 2011). Tools for molecular analysis are polymorphisms and molecular DNA. Molecular polymorphisms have become the markers of choice for molecular-based survey of genetic variation. However, in Ethiopia limited goat genetic characterization activities conducted on some goat breeds using microsatellite markers (Tesfaye, 2004; Halima *et a*l., 2012 and Getinet, 2016).

2. 7. Qualitative and quantitative traits

Knowledge of linear body measurements is important from various aspects. These have been used to find differences in body proportion as well as short-term changes in body proportion, especially due to loss in weight and belly filling (FAO, 2012).

Qualitative traits covers the external physical form, shape, color and appearance of animals which are recorded as discrete or categorical (FAO, 2012). Qualitative are those that can be categorized like coat color, presence/absence of horns, beard, ruff, muzzle, toggle, facial profile, ear form *etc*.

Quantitative traits covers the size and dimensions of animals' bodies or body parts, which are more directly correlated to production traits than qualitative traits and have continuous expression because of numerous genes that determine their expression (FAO, 2012). These traits include different body measurements. Heights (rump, withers), lengths (diagonal, head, ear, horn, neck, muzzle, tail, legs) and

heart girth (belly chest) depths as reported by some other previous researchers. The physical descriptions of different Ethiopian goat breeds were reported by (Solomon *et al*., 2009).

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

Breed	WH	BW	CG	Reference
Nubian	70.1 ± 3.4	34.1+5.4	74.3+3.8	Nigatu (1994)
Barka (Begayit)	67.9+4.3	33.8+5.3	73.9+4.8	Gebrekiros et al. (2016)
Afar	60.9+3.3	23.7+3.4	67.4+3.8	Nigatu(1994)
Abergelle	*65.0+2.8*	*28.4+3.5*	*71.2+3.8*	Alemayehu *et al*. (2012)
Arsi-Bale	66.66 ±0.04	29.52 ± 0.16	71.95 ±0.17	Belete (2013)
WoytoGuji	66.65 ± 4.0	26.7 ± 3.1	73.11 ± 4.3	Yaekob et al. (2015)
Hararghe High.	65.2 ± 5.1	23.9 ±5.4	59.0 ± 4.7	Dereje *et al* (2013)
Short-eared Som.	61.8 ± 4.1	27.8 ± 6.0	70.4 ± 4.7	Aynalem *et al* (2012)
Central Highland	67.5 ± 0.2	29.5 ±0.2	72.9 ±0.2	Netsanet (2014)
Western Highland	70.8 ± 4.7	33.0 ± 6.0	75.8 ± 4.5	Ahmed *et al* (2016)
Western Lowland	63.5 ± 3.8	33.9 ± 6.9	75.9 ± 5.2	Workneh (1992)
Keffa	66.7 ± 4.0	28.2 ± 5.2	72.2 ± 4.5	FARM-Africa (1996)

BW = Body weight; WH = Wither height; CG = Chest girth

2.8. Linear Body measurements

There are a number of linear dimensions, which can be used to quantify the size of an animal and to estimate weight. The most widely used body linear measurements include height at withers, heart girth, chest depth, body length, fore cannon bone, rump height, distance between eyes, ear length, ear width, paunch girth and rump length. Heart girth and cannon bone length

are least affected by the posture of the animal. The report of Abegaz and Awgichew (2009) described that hearth girth measurement is one of linear body measurement used to estimate live body weight. The better association of body weight with a chest girth was possibly due to the relatively larger contribution of heart girth to body weight, which consists of bones, muscles and viscera (Thiruvenkadan, 2005). This indicates that reliable heart girth-live body weight relationships are obtained from mature animals. In excessively hairy small ruminants like Arsi Bale goats make sure to compress the hair while measuring heart girth and Hararghe highland, local goat of Shebelle zone and local goat of Nuer zone had higher heart girth for male and female.

2.8.1. Correlation between body weight and linear body measurements

The correlation is one of the most common and useful statistics that describes the degree of relationship between two variables. Amongst body measurements, high correlation coefficient values have been found between chest girth and body weight (Bello, and Adama, 2012). In addition, the highest relationship between body measurements may be used as the selection criterion (Khan *et al*., 2006). The reports of Halima *et al*. (2012) and Yaekob *et al*. (2015) showed that heart girth was the best parameter for estimating body weight due to high correlation estimates.

Table 4. Correlation coefficient between body weight and heart girth of some goat in Ethiopia

Goat breed /local population	Female	Male	References
Begayit	0.89*	0.96*	Gebrekiros *et al*. (2016)
Hararghe Highland	0.94*	0.97*	Dereje *et al*. (2013)
Short –eared Somali	0.88*	0.84*	Grum (2010)
Short –eared Somali	0.73*	0.79*	Hulunim *et al*. (2015)
Woyito- Guji	0.86*	0.88*	Yaekob *et al*. (2015)
Abergelle	0.88*	0.91*	Alemayehu *et al*. (2012)
Bati	0.82*	0.85*	Hulunim *et al*. (2015)
Borana	0.82*	0.86*	Hulunim *et al*. (2015)
Local goat of Bale zone	0.65*	0.75*	Belete (2013)
Local goat of Shebelle zone	0.93*	0.97*	Alefe (2014)
Local goat of Nuer Zone	0.91*	0.96*	Tsigabu (2015)
Central Highland	-	-	-

* = significantly different among breeds and sexes of Ethiopian goats ($p<0.05$)

2.8.2. Prediction of body weight from linear body measurements

Live body weight is an important for decisions of breeding, weaning, supplementary feeding and health management should be made with an understanding of the live weight of the animals involved. Although live body weight is an important growth and economic trait, it is not always possible to measure it primarily due to lack of weighing scales, particularly in rural areas. However, body weight can be reasonably estimated from some linear body measurements (Singh and Mishra, 2004).

2.8.3. Generating body weight from heart girth

Body weight is usually, regressed on body measurements to determine a weight-prediction equation (Kashoma, *et al*., 2011). Regression models allow us fast evaluation of the body weight of an animal and are used for the optimization of feeding, determination of optimum slaughtering age and as selection criteria (Yakubu, *et al*., 2011). Regression model can be constructed based from linear body measurements based on sex and age of animals because linear body measurement can be varied based on sex and age of animals (Farhad, *et al*., 2013). It is reasonable to suggest that there is a need to develop different predictive models for different species or breeds of livestock by considering age, sex, management and local areas (Assan, 2013). In addition, more than one linear measurement may be used in an equation to improve the predictive ability as seen in the work of (Pesmen and Yardimci, 2008).

A stepwise multiple regression analysis was also carried out when other body measurements were added, one at a time, to heart girth. The essence was to determine how other body measurements would influence the precision of live weight predictions compared to using Heart girth alone (Afolayan, *et al*., 2006). However, as we increase the number of variables in the model, it can cause complexity under farmer's level (Yaekob *et al*., 2015). According to the report of Zewdu *et al*., (2009) on Bonga and Horro sheep and Getachew, *et al*., (2009) on Menz and Afar sheep indicated that incorporating of more linear body measurement in the prediction equation has improved prediction accuracy. However, heart girth parameter is the easiest way, most appropriate and the confident parameter to use for live weight prediction in field conditions, especially under the smallholder farmers (ESGPIP, 2009; Getachew, *et al*., 2009; Alemayehu and Tikabo, 2010).

Table 5. Prediction of the body weight from heart girth of some goats breeds in Ethiopia.

Goat breeds	Female	Male	References
Begayit	BW=-48.33+1.2HG	BW=-60.61+1.29HG	Gebrekiros *et al*.(2016)
Hararghe Highland	BW=-31.42+0.83HG	BW=-36.21+0.92HG	Dereje *et al*.(2013)
Short –eared Somali	BW=-22.3+0.67HG	BW=-25.7+0.72HG	Grum (2010)
Abergelle	BW=-21.42+0.65HG	BW=-21.72+0.67HG	Alemayehu *et al*. (2012)
Woyito –Guji	BW=-28.20+0.74HG	BW=-39.12+0.88HG	Yaekob *et al.* (2015)
Local goat of Bale	BW=-16.24+0.63HG	BW=-19.27+0.67HG	Belete (2013)
Goat of Shebelle	BW=-50.35+1.11HG	BW=-63.45+1.3HG	Alefe (2014)
Local goat of Nuer	BW=-24.94+0.72HG	BW=-11.08+0.53HG	Tsigabu (2015)

BW= body weight, HG= heart girth

2.9. Structural and functional indices of goat

Structural indices are the combination of several linear measurements or morphometric measurement, the results of which are expressed as a percentage and indicate the type and function of the particular breed. It enhances the ability of breeders to select potential breeding stock. Structural indices provided tested empirical values which are limited in the use of single measurements and calculated from morphometric traits (Salako, 2006; Chacón *et al*., 2011). Salako (2006) suggested that indices produced from measurements that are more closely associated with bone growth are appropriate for assessment of the type. Especially in function of meat production can be assessed from body measurements, which are more closely associated with bone or muscle growth (Salako, 2006 and Chacón *et a*l., 2011).

3. MATERIALS AND METHODS

3.1. Description of the study area

The study was conducted in Hidabu Abote district of North Shoa, Oromia Regional State. Hidabu Abote is one of the 13 districts of the North Shoa zone and located about 147 km North of Addis Ababa and 37Km North from zone administration town of Fiche. It comprises 20 kebeles, and of them19 kebeles located in rural and one kebele located in Ejere town of the district. The district lies between 9°58’ 30"to10° 2' 30"N latitude and 38° 29' 0" to 38° 36'0"E longitude and 1116m to 3000 m.a.s.l. It was bordered by Warra Jarso in the West, by Kuyu in the Southwest, by the Dera and Jema River in the North, and by the Degam in the East. Hidabu Abote district classified into three agro-climatic zones, lowland 44%, the midland 50%, and highland 6%. According to the district’s livestock agency, the mean annual temperature and rainfall ranges from 23^0c to 31^0c and 750 mm to 1100 mm, respectively. Hidabu Abote accounts an area of 486 sq. Km. The total livestock population of Hidabu Abote district is 79,636 head of indigenous cattle, 1520 head of exotic with hybrid cattle, 47,596 head of goats 23,899 head of sheep, 439 head of horse, 173 head of mule, 12528 head of donkey, and 43814 head of chicken (HADLFRO, 2018).

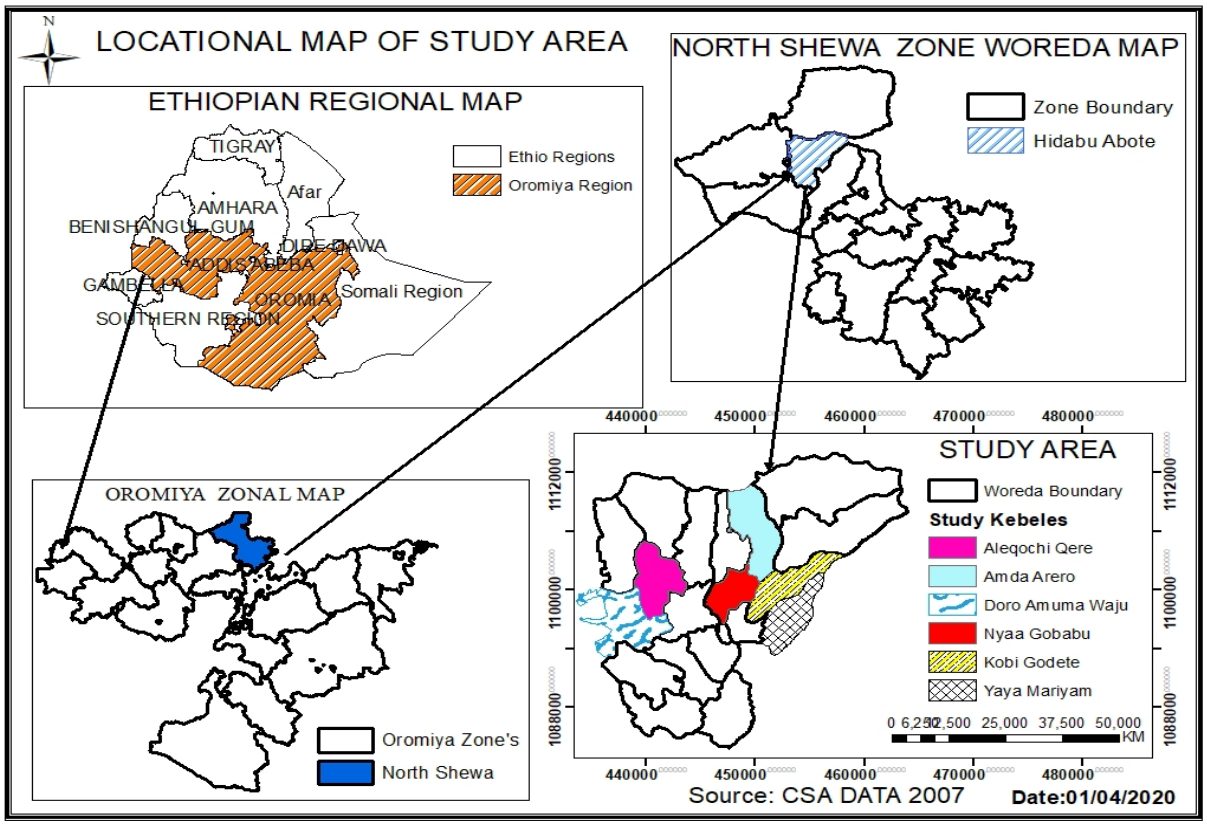

Figure in appendix 1 : Geographical location of the study area. (Source: Developed from CSA; 2013)

3.2. Sampling design

Multi-stage sampling techniques were applied to select a district kebeles and households for the study. In the first stage, out of thirteen districts four potential districts in goat production were identified. Among these four districts, one district (Hidabu Abote) was purposively selected on the basis of connecting with the other three district. The selected district was further divided in to three agro-ecologies, namely highland, midland and lowland. In second stage of sampling, one, three, and two Kebeles were randomly selected from highland, midland and lowland agro-ecologies, respectively. In the third stage, the number of households from each selected Kebeles

were determined accordingly and 120 households were randomly selected (20 from each Kebeles). The sample size for body weight and linear body measurements were 10% of the total population of each kebele and a total 342 goats selected for both sexes (FAO, 2012).

Table 6. Sample designing of goat population in each kebeles for the study

Kebeles	Total goat population	Sampled goat from the total
Yaya Mariam	490	49
Kobi Godeti	570	57
Nya'a Gebabu	590	59
Daro amoma Wajju	540	54
Alqoch Qarre	600	60
Hamdo Ariro	630	63
Total		**342**

3.3. Data collection using survey

In study area data were collected from secondary data sources, stakeholders pretested semi-structured questionnaire (breeding practices, selection criteria, etc.), employing field measurements (on quantitative traits), and observation from January to April 2019. General information list of FAO (2012) and that of Oromia Livestock breed survey questionnaire (Workneh and Rowlands, 2004) were used as a checklist in designing the questionnaire. At each sampling site, households were briefed about the objectives of the study before the beginning of the data collection and random open-ended discussion was held. A formal interview was carried out with selected respondents from each Kebeles, to get information on household characteristics. General information about the area, vegetation cover, topography, climatic data and livestock population size were obtained from secondary data of the district. The questionnaire was designed to address the description of the production environment and goat

husbandry practices. Goat breeding practices, selection practices and criteria, purposes of keeping goats, and the production and reproduction characteristics of goats were collected.

3.3.1. Qualitative and quantitative traits

For qualitative data, visual observation was made and morphological features were recorded based on breed phenotypic characteristics descriptor list of FAO (2012) for phenotypic characterization of the goat. Data were recorded in the pre-prepared format and each animal was identified by sex, dentation, and agroecology in which pregnant does and castrated bucks were excluded from sampling. Data were collected starting from 1PPI to 4PPI age groups. Thirteen qualitative traits, including coat color (pattern and type), hair type, horn (shape and orientation), ear orientation, presence or absence of (horn, wattle, and beard), facial, profile or head profile were collected. Moreover, sixteen morphometrical traits were taken including body weight, body length, heart girth, withers height, rump height, chest width, chest depth, neck length, horn length, scrotum circumstances, head width, head length, ear length, pelvic width, and teat length. Linear body measurements were taken using measuring tape while the live body weight of animals was weighted by weighing balance having 50 kg capacity with ± 50g error margin (FAO, 2012). All measurements were taken in the morning to avoid the effect of feeding and watering on the animal's live weight.

3.3.2 Calculation of rankings and body indices

Rankings

Ranking indices were calculated by computer excel to provide a rank of purpose of keeping, selection criteria of both buck and doe and constraints of goat production according to the formula, Index = {of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) given for particular qualitative

variables divided by the {of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) for all qualitative variable considered (Musa *et al*., (2006).

Structural and functional indices

To assess the type and function of indigenous goat in the study area, fifteen structural indices were calculated from the morphometrical traits according to methods suggested by Salako (2006), Chacón *et al*. (2011) and Chiemela *et al*. (2016). The following formulas were used to calculate the indices:

1. Cephalic index = (head width / head length) x 100
2. Body index = body length /chest girth
3. The relative depth of thorax = (chest depth/height at withers) x 100
4. Proportionality = (height at withers /body length) x100
5. Longitudinal pelvic index = (rump length /rump height) x 100;
6. Relative body index or length index = body length / height at withers
7. Pectoral index =($\frac{\text{withers height+rump height}}{2}$)/(Height at withers – chest depth)
8. Thoracic development = chest girth / height at withers;
9. Body ratio = height at withers / height at the rump
10. Compact index = (weight / height at withers) x 10
11. Foreleg index = withers height – chest depth;
12. Conformation index = $(\text{chest girth})^2$ / height at withers)
13. Area index = height at withers x body length
14. Pelvic index = (pelvic width /rump length)x100
15. Height slope index = (Height at withers- Rump height)

Pearson correlation coefficients were conducted between body weight and linear body measurements for the populations within in all age groups and both sexes. The body weight of the animals within all age groups and sex was assessed using stepwise regression analysis to estimate the body weight in place the weighing scale is not available and for practical purpose.

3.4. Statistical analysis

Qualitative data were analyzed using the frequency procedure of SPSS while quantitative data were analyzed using the Generalized Linear Model procedure of SAS (SAS, 2014 and 9.2). The agroecology, sex and age group were fitted as fixed effects while linear body measurements were fitted as dependent variables. The mean comparison was conducted using Duncan multiple range test. The means were considered significant at $P<0.05$. The model to analyze qualitative and quantitative were:

Model 1: for qualitative traits

$Y_{ij} = \boldsymbol{\mu} + B_i + S_j + e_{ij}$

Y_{ij}= repose variables

$\boldsymbol{\mu}$= overall mean

B_i = effect due to i^{th} agroecology (i = highland, midland and lowland)

S_j = effect due to j^{th} sex (j= male, female)

e_{ij} = random error

Model 2. For quantitative traits

$Y_{ijk} = \boldsymbol{\mu} + A_i + S_j + B_k + e_{ijk}$

Where: Y_{ijk}: observed variables

$\boldsymbol{\mu}$: Overall mean

A_i = effect of i^{th} age group (i = 3PPI & 4PPI)

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

B_k = effect of k^{th} agroecology (k = Highland, Midland & Lowland

e_{ijk} = residual error.

Model 3. For the prediction of body weight

For female: $Y = a + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \ldots + \beta_{16}X_{16} + ej$

Where: Y = the response variable; body weight

a = the intercept

X_1, X_2, X_3… and X_{16} are the explanatory variables of LBMs

β_1, β_2... β_{16} is a regression coefficient of the variables X_1, X_2 …X_{16}

e_j = residual error

For male: $Y = a + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \ldots + \beta_{16}X_{16} + ej$

Where: Y = the response variable; body weight

a = the intercept

X_1, X_2, X_3 … X_{16} are the explanatory variables of LBMs

β_1, β_2, β_3... β_{16} is a regression coefficient of the variables X_1, X_2, X_3…X_{16}

e_j = the residual random error

4. RESULTS AND DISCUSSION

4.1. General household characteristics

The general household characteristic of the study area is presented in Table 7. The majority of the households in the study area were male headed ($p<0.05$). Female headed were lower than the male headed, which is similar to the report of (Belete, 2013) in the Bale Zone area where 73.9 % were male headed while only 26.1 % were female headed. These could be females work load inside the house and the chance of getting females outside of house is low. And additionally the men play a leading role in decision making over livestock production management. The current result was agreement that of Workneh and Rownalds (2004) also reported that the majority of the households (94%) in Oromia region were male headed while the rest 6% were female headed. According to respondents in this study, the overall proportions of households were married. There is no significance difference ($p>0.05$) between agroecology of the district in average age of households. The mean age (44.6) of the respondents which indicate that the community is in high productive age group and contributes more for goat production. The majority of the respondents were illiterate followed by primary school and secondary. These might indicate that there were poor in management for goat production.

Table 7. Household characteristics in three agroecology of the study area (N, %)

Household character	Highland	Midland	Lowland	Overall	X^2-value
AV. Age HH	43.0±1.57	45.1 ±1.27	44.6 ±1.28	44.6±.80	
Educational status					
Illiterate	10(50)	30(50)	23(57.5)	63(52.5)	
Primary	5(25)	20(33.3)	12(30.0)	37(30.8)	
Secondary	5(25)	10(16.7)	5(12.5)	20(16.7)	
Sex of Household					
Male	19(95)	56(90)	39(97.5)	114(95)	
Female	1(5)	4(10)	1(2.5)	6(5.0)	0.877*
Marital status					
Single	0	1(1.6)	1(2.5)	2(1.7)	
Married	19(95)	58(96.7)	38(95)	115(95.8)	
Divorced	1(5)	1(1.6)	0	2(1.7)	
Widowed	0	0	1(2.5)	1(.8)	4.5*

X^2 = chi-square; N = number of respondents, % = percentage of the respondents, * = (P<0.05)

4.2. Composition of livestock

The most livestock species in the study area were cattle, goats, sheep, donkeys, chicken, horses, and mule (Table 8). The number of cattle was higher followed by goat donkey chicken, sheep and horse in order. There was significant difference between agroecology in goat population ($p<0.05$). The results indicated that the average flock size in highland was significantly lower number of goat than midland and lowland. The overall average goat size per household was 8.2, which is comparable with the report of Tesfaye *et al.* (2008) who reported 7.8 goats per household. The current result indicates that the goat flock size in the study area was small which might be resulted from farmers raise goat and other livestock species with crop production that enforce them not to keep large flock due to decreasing grazing / browsing land / as the land

replaced by crop production. The result agreed with that of Tegegne *et al*. (2016) who reported small goat flock size in the mixed crop-livestock production system.

Table 8. Livestock composition and their number per household in the study area

Livestock species	Highland	Midland	Lowland	Mean	TLU
Cattle	5.1±.48	5.8±.35	5.2±.28	5.5±.22	3.85±.22
Goats	3.8^{c}±.79	7.2^{b}±.22	12.0^{a}±.34	8.20±.3	0.82±.31
Sheep	3.1^{a}±.68	0.5^{b}±.12	0.1^{b}±.09	0.8±.16	0.08±.16
Donkey	1.60±.19	1.6±.11	1.7±.12	1.7±.08	0.75±.08
Chicken	2.5±1.04	9.7±.95	9.2±1.09	8.9±.63	0.089±.63
Horse	0.6±.152	0.03±.023	0	0.1±.03	0.08±.034
Mule	0	0.02±.017	0.1±.042	0.03±.0	0.015±.016

^{a,b,c} Means with different superscript letters across agroecologies differ significantly at $p<0.05$
SE = standard error

4.2.1. Rank of Livestock based on income generate

Farmers in the study area have ranked their livestock species according to the income generates (Table 9). The results indicated that in highland, goat, chicken and sheep have been ranked by farmers as first, second and third in order of importance. This might be due to the fact that the farmers could support small ruminants sold to generate the income for different purposes than large ruminants and therefore small ruminant present one option to generate cash for families. Results from the focal group discussion indicated that goats have been serving as an immediate source of income. Moreover, households preferred goats over other livestock due to their short generation interval and prolificacy as well as low initial capital investment and their broad feeding habits (Solomon *et al*, 2010).

Table 9. Rank of Livestock based on income generation across agroecology in the study area

Rank for income generate	Highland	Midland	Lowland	Overall
Goats	9(45)	29(48.3)	26(65)	64(53.3)
Sheep	3(15)	0	0	3(2.5)
Chicken	8(40)	24(40)	14(35)	46(38.3)
Crop	0	7(11.7)	0	7(5.8)
X^2-value				**23.736***

X^2 = chi- square; N=number of respondent; %= percentage of respondent with total;*=P<0.05)

4.2.2. Livestock population trend in the study area

The perception of households on the population status of livestock species for the last ten years in the study area is summarized in table10. The majority of the farmers in crop based farming system reported a decrease trend in sheep, goats, horse and cattle population. The possible reasons reported by respondents for this trend were mainly related to the increasing human population and the replacement of grazing land with crop production. Moreover, shortage of labor for herding since all family were going to school even though attractive price for livestock.

Table 10. Trend of livestock in the study area (N, %)

Livestock	Highland		Midland		Lowland		Over all %		X^2
	I	D	I	D	I	D	I	D	
Cattle	11(55)	9(45)	22(36.7)	8(20)	8(20)	32(80)	34.2	65.8	37.7*
Goat	0	100	12(20)	48(80)	32(80)	8(20)	28.3	71.7	55.2*
Sheep	13(65)	7(35)	1(1.7)	59(98.3)	0(0)	40(100)	11.7	88.3	69.6*
Donkey	18(90)	2(10)	54(90)	6(10)	36(90)	4(10)	90	10	2.2^{ns}
Chicken	10(50)	10(50)	45(75)	15(25)	33(82.5)	7(17.5)	73.3	26.7	11.4*
Horse	9(45)	11(55)	29(48.3)	31(51.7)	0(0)	40(100)	33.3	66.7	27.8*
Mule	9(45)	11(55)	45(75)	15(25)	40(100)	0(0)	78.3	21.7	40.7*

X^2 = chi-square; N=number of respondent; %= percentage of respondent with total;*= P<0.05)

4.2.3. Flock structure

The proportion of the different classes of animals reflected the management decision of the producers which in turn is determined by their production objectives (Solomon *et al*., 2010). In this study, as compared to other age groups, kids less than 6 months made a major share followed by breeding does(females >1 years) in lowland and highland agro-ecologies. However, in the midland, female goats greater than 1 years were more abundantly (Table 11). These might be indicate that they sold their goat at early age and the left in the flock was female. The mean male less than 6 months was significantly different across agro-ecology and from 1 year with in agro-ecology. These might be indicate that the male goat is the sources for cash generation as age of male increase the number become decline. The result agreed with that of Tesfaye *et al.* (2011b) who reported lower male in flock in Shalla and Adami Tulu Jido Kombolcha districts.

Table 11. Average number of goat with respective age group in the study area (Means +SE)

Group of Goat by age	Highland	Midland	Lowland	Overall mean
Kids<6months	3.6^{c}±.184	4.6^{b}±.193	5.7^{a}±.209	4.8±.139
Male 6 months	1.4^{c}±.131	2.1^{b}±.113	3.2^{a}±.170	2.4±.102
Male >6months	0.7^{c}±.105	1.1^{b}±.109	1.6^{a}±.118	1.2±.075
Female6 months	1.6^{c}±.134	3.5^{b}±.180	5.6^{a}±.231	3.9±.175
Female>1yrs	3.2^{c}±.150	5.0^{b}±.162	5.2^{a}±.171	4.7±.121
Male>1yrs	0.4^{c}±.112	0.6^{b}±.069	1.2^{a}±.076	0.8±.056
Castrate	0.4^{c}±.109	1.5^{b}±.113	3.9^{a}±.183	2.1±.148

^{a,b,c} Means with different superscript letters between agroecologies differ significantly at $p<0.05$; SE = standard error

4.3. Responsibility of household member in goat husbandry activities

Although all the family members are involved in the routine goat husbandry activities, the size and percentage of coverage were different because of age and gender categories in the household. Detail profiles of each of the housed members in the routine goat husbandry activities in highland, midland and lowland of the district is presented in Table 12. In the study district, purchasing and selling activities were left for husband. This is because he is believed to be knowledgeable to select the best breeding does and bucks when he purchase and he can sell animals at best price by negotiation. Overall, the husbands involved in purchasing, selling and caring sick animals' activities respectively. Whereas the wives are involved in pen cleaning, caring sick animals, purchasing and selling activities in the district. These obviously showed that husbands were exclusively decision maker in economic issues in the family. Relatively higher percentage of involvements of boys and hired laborers were observed in herding, feeding and watering activities. The daughters and wives did cleaning of goat's pen activities.

Table 12. Member of household responsible for goat husbandry activities in the study area

Activities	Husbands (N, %)	Wives (N, %)	Boys (N, %)	Daughters (N, %)	Labour (N, %)	X^2
Purchasing	105(87.5)	11(9.2)	4(3.3)	0(0)	0(0)	4.6^{ns}
Selling	106(88.3)	11(9.2)	3(2.5)	0(0)	0(0)	4.2^{ns}
Herding	10(8.3)	0(0)	59(49.2)	10(8.3)	41(34.2)	25.4*
Caring sick	75(62.5)	28(23.3)	17(14.2)	0(0)	0(0)	8.68*
Feeding	9(7.5)	26(21.6)	66(55.0)	8(6.6)	11(9.2)	59.7*
Watering	6(5.0)	4(3.3)	76(63.3)	8(6.6)	26(21.7)	44*
Cleaning the house	0(0)	49(40.8)	0(0)	71(59.2)	0(0)	11.2*

N=number of respondents, %=percentage of the respondents from the total, * = significant

4.4. Purposes of keeping goats

The purpose of keeping goats in the study area is presented in Table 13. A ranking of the goat production objectives were for varying products, including milk, meat and fiber (Galal, 2005). In the study area, goats are kept as a source of income, meat for home consumption, ceremony, wealthy, manure, and skin. Rank for purposes of keeping goats in highland, midland and lowland of the district was the same with similar index value for each income generate followed by meat house consumption and wealth status. Different studies in Ethiopia concerning goat production objectives indicated that cash income is the primary goat production objective by the respective goat keepers. The farmers in highland, midland and lowland agroecology were rearing their goats mainly for cash income, home consumption meat and wealth status. The finding was in agreement with the reports of Mahilet (2012) for Hararghe Highland goat, Kassahun *et al* (2015) for Horro Guduru goats and Solomon (2013) for Abergelle and Western lowland goat breeds who reported that cash income was the first rank among different goat production objectives.

Table 13. Purpose of goat keeping in the study area ranking by agroecology

Rank of goat	Highland				Midland				Lowland			
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I
Meat	3	13	4	0.33	19	34	5	0.36	0	27	10	0.27
Income	17	3	0	0.48	39	11	7	0.41	38	2	0	0.49
Ceremony	0	1	3	0.04	0	1	4	0.02	0	0	4	0.02
Wealth status	0	3	12	0.15	2	14	35	0.19	0	9	22	0.17
Manure	0	0	0	0.00	0	0	8	0.02	2	2	4	0.06
Skin	0	0	1	0.01	0	0	1	0.00	0	0	0	0.00

R1= rank 1, R2= rank2, R3= rank 3 & I=index

4.5. Reproductive traits

4.5.1. Average age of sexual maturity

The average age of sexual maturity of the study area is presented in Table 14. The average age of sexual maturity of male goats in lowland area was 6.1 month and significantly different from highland and midland. These might be due to the management of the kids in the lowland is better than the other. The mean age of sexual maturity of female goats in lowland area was 5.7 month. These might indicate the management in the lowland was better than the other agroecologies.

4.5.2. Age at first kidding

The average age at first kidding of the study area is presented in Table 14. The age at first kidding for lowland agroecology of the study area goat was 11.1 month. Consistent to the current finding, Tsedeke (2007) and Belete (2009) reported similar ages for Arsi-Bale and Keffa goats, respectively. These might be indicating the feeding and management of the lowland goat was better than highland and midland agroecologies.

4.5.3. Kidding Interval

The average age of kidding interval of the study area is presented in Table 14. Kidding interval is one of the major components of reproductive performance that influences production systems. The overall mean kidding interval of the study area goats were 8.9, 8.4 and 8.2 months, respectively. The results were lower than reported for Abergelle and Central highland goats in Sekota district (Belay and Mengistie, 2013). Short kidding intervals can improve the rate of turnover of generations of animals and so speed up response to selection. The reason is the presence of buck and feed to some extent.

Table 14. Reproductive traits of goats in three agroecologies of the study area (Means + SE)

Traits	Highland	Midland	Lowland	Overall
Average age of bucks sexual maturity (M)	6.9±.24	6.4±.09	6.1±.19	6.4±.09
Average age of sexual maturity of Doe (M)	6.1±.16	5.8±.10	5.7±.14	5.8±.07
Average age of first mating for Bucks(M)	7.3±.28	6.9±.14	6.7±.17	6.9±.10
Average age of first mating for Doe (M)	6.5±.17	6.1±.11	6.3±.15	6.2±.08
Average age at first kidding for Doe(M)	11.4±.18	11.1±.11	11.1±.14	11.1±.08
Average of kidding interval of Doe (M)	8.9±.15	8.4±.06	8.2±.06	8.4±.05
Average number of kidding per lifetime (P)	5.8±.33	8.0±.35	7.0±.39	7.3±.24
Occurrence of multiple birth /litter size/ (N)	1.5±.12	1.6±.06	1.9±.06	1.7±.04
Average age of Doe serve in flock (Y)	8.3±.25	9.5±.13	9.5±.14	9.3±.09

SE=standard error, M=month, P=parity, Y=year, N= number

4.6. Breeding practices and selection

4.6.1. Selection criteria for breeding bucks

The selection of good breeding buck is an important factor in goat production to improve genetic makeup of flock (Ahmed, 2017). Selection criteria for breeding bucks are given in Table 15. Size and growth were selected in highland and midland of the study area as the first and second rank, respectively followed by color except black and being one of twins. In the lowland, growth and color were considered as a selection criteria as first and second rank. The current findings were in agreement with the report of Tsigabu (2015) in which the appearance was the primary criteria to select breeding buck in Nuer goat. This may be due to the fact that goat producers in the study area prefer large body size and good appearance because body size is an important economic trait that influences market prices, large body sized buck will get a higher price and large sized kids.

Table 15. Selection Criteria ranks for Breeding Bucks in three agroecologies of the study area

Selection Criteria	Highland				Midland				Lowland			
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I
Size	12	7	1	0.43	33	24	3	0.42	11	12	6	0.26
Color	2	4	9	0.19	0	7	40	0.16	17	4	4	0.30
Character	0	0	0	0.00	0	1	1	0.01	0	4	4	0.05
Growth	5	7	7	0.30	26	24	5	0.36	10	19	10	0.33
Being one of twin	1	2	1	0.07	1	3	7	0.04	2	1	5	0.05
Testicular	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
Libido	0	0	0	.000	0	0	0	.000	0	0	0	.000
Pedigree	0	0	2	.016	0	1	4	.016	0	0	1	.004

R1, R2 and R3 = rank 1, 2and 3, respectively. I= index

4.6.2. Selection Criteria for breeding does

The selection criteria for breeding does in the study area are presented in Table 16. The selection criteria for breeding does in the study area include appearance, mothering ability and twining ability as the first three criteria. Households in the study area, select best performing animals to maintain good performing animals in the next generation. However, the selected does are not certainly mated with selected bucks as they freely graze together with other flocks, which make mating uncontrolled. The current study indicated the farmers were concerned more on subjective selection criteria in which size was the primary criteria to select both bucks and does. Goats with black colour were not selected rather they were culled. Because goats with black colour do not fetch a good price in the market.

Table 16. Selection criteria ranks of does across the three agroecology of the study area

Selection criteria	Highland				Midland				Lowland			
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I
Size	8	4	3	0.28	27	17	4	0.33	12	9	3	0.24
Color	0	0	0	0.00	1	0	8	0.03	11	5	5	0.20
Mothering ability	7	7	2	0.31	26	26	6	0.38	11	9	3	0.23
Kid survival	1	1	4	0.08	1	3	8	0.05	1	1	6	0.05
Kid growth	0	2	6	0.08	2	2	10	0.06	1	5	9	0.09
Short kidding interval	0	0	1	0.01	1	2	5	0.03	0	2	0	0.02
Twining ability	4	6	3	0.23	1	9	13	0.09	3	6	9	0.13
Better milk yield	0	0	2	0.02	1	1	6	0.03	1	2	5	0.05
Family history	0	0	0	0.00	0	0	0	0.00	0	1	0	0.01

R1, R2 and R3 = rank 1, 2and 3, respectively. I= index

4.6.3. Breeding practices

In the study area, about 75% of the respondents have their own buck (Table 17). Among household having their own buck, the main source of their breeding buck was from their born kids. This finding was in agreement with that of Tesfaye *et al*. (2011b) who reported the source of buck for farmers of Shala district was born within a flock (82%). These might be indicate replace the bucks from the born kids might develop the inbreeding in the flock. In the study area, about 83.3% of the respondents did not have the awareness of on the negative effect of inbreeding. These might be indicating that the community are not aware of the negative effects of inbreeding on the general performances of flocks. About 73% of the respondents were able to identify sires from the born kids by coat color and growth.

Table 17. Buck management and its mating practices in the study area (N, %)

Parameters	Highland	Midland	Lowland	Overall	X^2
Do you have any breeding Bucks					**0.76^{ns}**
Yes	14(70)	47(78.3)	29(72.5)	90(75)	
No	6(30)	13(21.7)	11(27.5)	30(25)	
What are the source of these Bucks					**2.5^{ns}**
From own flock	14(100)	45(95.7)	27(93.1)	86(95.5)	
From neighbors	0(0)	1(2.1)	0(0)	1(1.1)	
From market	0(0)	1(2.1)	2(6.9)	3(3.3)	
What is the age till use for breeding					**24.4***
<1 years	0(0)	0(0)	1(3.4)	1(1.1)	
1-2 years	10(71.4)	25(52.3)	19(65.5)	54(60)	
Till it is able to breed	2(14.3)	2(4.3)	8(27.5)	12(13.3)	
No pre-defined age	2(14.3)	20(42.3)	1(3.4)	23(25.5)	
Are you aware of ''inbreeding''					**29.1***
Yes	0(0)	3(5)	17(42.5)	20(16.7)	
No	20(100)	57(95)	23(57.5)	100(83.3)	
Aware of effect of inbreeding					**29.1***
Yes	0(0)	3(5)	17(42.5)	20(16.7)	
No	20(100)	57(95)	23(57.5)	100(83.3)	**8.35***
Able to identify sire form born Kids					
Yes	10(50)	44(73.3)	34(85)	88(73.3)	
No	10(50)	16(26.7)	6(15)	32(26.7)	
By what Method you identify the sire					**12.4^{ns}**
By observing mating	0(0)	3(6.8)	0(0)	3(2.5)	
Mating was reported by family	0(0)	1(2.3)	0(0)	1(0.8)	
Coat color	6(60)	19(43.2)	22(64.7)	47(39.2)	
Others /Growth/	4(40)	21(47.7)	12(35.3)	37(30.8)	
Types of mating					**1.23^{ns}**
Natural mating with selective Bucks	3(15)	6(10)	7(17.5)	16(13.3)	

Natural mating with unselective Bucks	17(85)	54(90)	33(82.5)	104(86.7)	
Reason for uncontrolled mating					**15.3***
Goats browse together	13(65)	35(58.3)	9(22.5)	57(47.5)	
Lack of awareness effect of inbreeding	7(35)	25(41.7)	31(77.5)	63(52.5)	
Do you allow Bucks mate his mother					**0.5^{ns}**
Yes	19(95)	54(90)	36(90)	109(90.8)	
No	1(5)	6(10)	4(10)	11(9.2)	

N = Number of respondents, **%** = percentage from the total population, ***** = significant across agroecology, **ns**= not significant between agroecology

4.8. Management practices of goats

4.8.1. Major goat feed sources and browsing/grazing management

Major goats feed sources in the highland, midland and lowland of the district during wet and dry season were presented in Tables 18 and 19. Communal grazing was the major source of goat feed in highland and midland agroecology of the district and natural plant in lowland followed by communal grazing in wet seasons. Parts of (leaves, pods, etc.) acacia species were reported as the major feed resources during the dry season in midland and lowland. The index values of communal grazing in wet season in highland, midland and lowland of the district were present in table 18. The corresponding values of fallow land in wet season were present in table 19. In dry season, crop residues, acacia plants in the highland; acacia plant and crop-residue in midland and acacia plants and crop residue were ranked first and second. This might be because of goat feed in the area is not critical; especially in the dry season after food crop is harvested and relatively good vegetation cover. Here, it is not to mean that the above mentioned goat feed sources were the only goat feed sources in the study area. There were other feed sources like locally made beverage byproducts from '*tela*' and '*areki*', which is locally called atela and food leftovers from household, backyard forages, and mineral soil.

Table 18. Feed resource ranking in wet season in three agroecology of the study area

Feed resource	Highland				Midland				Lowland			
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I
Natural pasture	5	6	4	0.26	3	31	19	0.25	18	10	11	0.35
Communal land	9	5	4	0.34	36	13	9	0.40	8	17	7	0.27
Acacia plant	0	4	4	0.10	3	5	12	0.09	1	9	7	0.12
Crop residue	0	0	0	0	0	0	0	0	0	3	8	0.06
Fallow land	5	3	1	0.18	18	9	12	0.23	12	1	2	0.17
Concentration	0	2	5	0.08	0	1	1	0.01	1	0	4	0.03
Others	1	0	2	0.04	0	1	7	0.03	0	0	1	0.00

R1, R2 and R3 = rank 1, 2and 3, respectively. I= index

Table19. Feed resource ranking in dry season in three agroecology of the study area

Feed resource in dry season	Highland				Midland				Lowland			
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I
Natural pasture	4	3	4	0.18	12	13	8	0.19	13	7	9	0.26
Communal land	2	4	1	0.13	0	0	2	0.01	0	2	2	0.03
Acacia plant	6	1	5	0.21	36	6	6	0.35	13	13	4	0.29
Crop residue	5	6	3	0.25	10	15	17	0.21	10	11	13	0.27
Fallow land	0	0	0	0	0	0	0	0	1	1	1	0.03
concentration	2	5	7	0.19	0	13	18	0.12	3	4	8	0.10
Others	1	1	1	0.04	2	13	9	0.11	0	2	3	0.23

R1, R2 and R3 = rank 1, 2and 3, respectively. I= index

4.8.2. Herding of flocks

In the study area, goats were herded alone during the dry season and all together in the wet season (Table 20). During the dry season, about 66% of the respondents herded their goats separately from other livestock and about 33.3% herded the kids are separated from the adult

goats. The reason is that predators are the main problem for the society, which kills the kids in dry season when the hired labour was not there. In the wet season, about 56% of the respondents herded their goats with the other livestock and 44.2% of respondents herded the kids alone. These might be indicate that the problem of labour for keeping. Goats in the study area spend by browsing full day in both seasons. These figures were different from the report of Tesfaye (2009) who reported that about 52% of goats in Adami Tulu Jido Kombolcha and Shalla districts were mixing kids with adult. About 45.8% of the respondents run their flock individually, while 54.2% of the respondents mix their goats together with their neighbor. The results are consistent with the findings of Anderson *et al.* (2010) who reported that mixed species grazing system may be one of the most biologically and economically viable systems available to producers.

Table 20. Herding mechanism and herding time of goats in three agroecology of the study area

Herding in dry seasons	Highland	Midland	Lowland	Overall	X^2-value
Alone	10(50)	50(83.3)	19(47.5)	79(65.8)	
All together with cattle	1(5)	0(0)	0(0)	1(0.8)	
Separate from Kids	9(45)	10(16.7)	21(52.5)	40(33.3)	**20.82***
Grazing time					
Full day	20(100)	50(83.3)	24(60)	94(78.3)	
Morning & afternoon	0(0)	10(16.7)	16(40)	26(21.7)	**14.337***
Herding in Wet seasons	Highland	Midland	Lowland	Overall	X^2-value
Herding system					
All together with cattle	13(65)	45(75)	9(22.5)	67(55.8)	
Separate from Kids	7(35)	15(25)	31(77.5)	53(44.2)	**27.643***

N = number of respondents, % = percentage from total respondents, * = significant

4.8.3. Watering sources

The major water sources in the study area were dam/pond, river, spring, pipe water and rainfall water (Tables 21 and 22). About 73.3% of the respondents reported that the major source of water in the dry season was a river, while 26.7% of them reported pipe water. During the wet season, rainwater (46.7) was reported to be the major sources of watering, followed by the dam / pond (33.3%) and river (18.3%). In highland, river water was the major water source followed by rainwater, while in the lowland, river water was the major water source, followed by damp/pond. In dry season, the majority of the respondents (56%) reported that animals are trekked a long distance (1-5 km) to get to water points.

The watering frequency in the study area was different from season to season (Tables 21 and 22). During wet season, goats were watered freely and about 37% were watered once a day. In contrast, majority of goats in dry season were watered once in a day, followed by once in two days. The present finding was in agreement with the report of Tesfaye (2008) in which two to three days of watering is common in low lands of Afar area.

Table 21. Source of water in dry season of three agroecologies of the study area (N, %)

Source of water	Highland	Midland	Lowland	Overall	X^2-value
River	20(100)	42(70)	26(65)	88(73.3)	
Pipe water	0(0)	18(30)	14(35)	32(26.7)	**9.03***
Distance of watering					
Watered at home	0(0)	8(13.3)	3(7.5)	11(9.2)	
<1Km	0(0)	10(16.7)	11(27.5)	21(17.5)	
1-5Km	20(100)	42(70)	5(12.5)	67(55.8)	
6-10Km	0(0)	0(0)	21(52.5)	21(17.5)	**73.49***
Once a day	20(100)	40(66.7)	15(37.5)	75(62.5)	
Once in two days	0(0)	20(33.3)	25(62.5)	45(37.5)	**23.11***

N = number of respondents, %= percentage from total respondents, *= significance

Table 22. Source of water in wet season of three agroecologies of the study area (N, %)

Source of water	Highland	Midland	Lowland	Overall	X^2-value
Dam /pond	3(15)	17(28.3)	20(50)	40(33.3)	
River	3(15)	15(25)	4(10)	22(18.3)	
Spring	0(0)	1(1.7)	0(0)	1(0.8)	
Pipe water	0(0)	1(1.7)	0(0)	1(0.8)	
Rain water	14(70)	26(43.3)	16(40)	56(46.7)	**13.748***
Distance					
Watered at home	12(60)	43(71.6)	36(90)	91(75.8)	
<1Km	3(15)	1(1.7)	0(0)	4(3.3)	
1-5Km	5(25)	16(26.7)	4(10)	25(20.8)	**15.257***
Frequency					
Freely available	15(75)	40(66.7)	0(0)	55(45.8)	
Once a day	5(25)	20(33.3)	19(47.5)	44(36.7)	
Once in two days	0(0)	0(0)	21(52.5)	21(17.5)	**71.932***

N = number of respondents, %= percentage from total respondents, *= significant b/n agroecology, ns= not significant across agroecology

4.8.4. Castration

In the study area, all of the respondents have been practicing castrations of their bucks (Table 23). Among the respondents who practiced castration, about 87% of them castrate their goats for fattening purpose fort a better marketing. The mean age of castration was from one year to two years followed by 6 months to one year. About 91% of respondents provided feed in the form of supplementation for their castrated goats. However, length of supplement and types of feed to be supplied varied. Most of the households supplied feed for two-seven days followed by two weeks. The main feed they supplied were concentrate. About 71% of the respondents

have been practicing the modern castration method, which was made by animal health experts at the station or veterinary clinic. On the other 29.2% of the respondents, apply traditional castration methods by using locally available materials like wood and stones.

Table 23. Castration practices of kids & adult bucks across agroecology of the study area (N, %)

Activities	Highland	Midland	Lowland	Overall	X^2
Castration kids					
Yes	4(20)	4(6.7)	6(15)	14(11.7)	
No	16(80)	56(93.3)	34(85)	106(88.3)	**3.235***
Age of castration					
6month to 1 year	4(20)	4(6.7)	6(15)	14(11.7)	
Between 1 and 2 year	16(80)	56(93.3)	34(85)	106(88.3)	**3.235***
Materials for castration					
Traditional materials	9(45)	9(15)	17(42.5)	35(29.2)	
Burdizzo	11(55)	51(85)	23(57.5)	85(70.8)	**11.697***
Do offer feed for castrated					
Yes	13(65)	60(100)	36(90)	109(90.8)	
No	7(35)	0(0)	4(10)	11(9.2)	**22.118***
Type of feed offered					
Not offer	7(35)	0(0)	4(10)	11(9.2)	
Concentrate feed	13(65)	60(100)	36(90)	109(90.8)	**22.118***

N = number of respondents, %= percentage from total respondents, *= significance

4.8.6. Fattening

About 97% of the respondents practiced fattening. About 50% of the household in midland practiced fattening, which is greater as compared to lowland and highland. Respondents in the study area practiced fattening both during the wet and dry seasons. The majority of the

respondents in the study area fattened their goats during Christian fasting events followed by for New Year and any time of the year. In the study area categories of goat fattening varied between the seasons of fattening. In the dry season, castrated was ranked first, followed by culled young male and culled young female, respectively. Where as in wet season castrated ranked first, followed by older male and older female, respectively. These might be indicate that the market price was not good in wet season and the one the used for fatten was those are old age and castrated one (Tables 24 and 25).

Table 24. Categories and periods of goat fatten across the seasons the study area

Categories of goat	Dry				Wet/Rainy /			
	R	R	R	I	R	R	R	I
Culled young female	1	33	60	0.18	5	0	0	0.02
Culled young male	6	57	34	0.23	0	0	0	0
Young female	7	5	2	0.05	2	1	0	0.01
Young male	6	6	21	0.07	2	1	0	0.02
Castrate	99	18	3	0.47	59	25	32	0.36
Older male	1	1	0	0.01	28	42	48	0.30
Older female	0	0	0	0	22	52	39	0.29

R1, R2, R3 =Rank one, two, and three, I= index

About 97% of the respondents in the study area used concentrate feed for fattening their goats and about 91% of the respondents fattening their goats during Christian fasting period. These indicate that there was a good market price at the end of fasting. In which they buy the goats after the period of fasting (Table 25).

Table 25. Type of feed used for fattening and period of fattening across agroecology of the study area

Type of feed for fatten	Highland	Midland	Lowland	Overall
No fattening at all	1(5)	0(0)	3(7.5)	4(3.3)
Concentrate	19(95)	60(100)	37(92.5)	116(96.7)
X^2- Value				**4.38***
Periods of fattening in the year				
No practice of fattening	1(5)	0(0)	3(7.5)	4(3.3)
Any time	0(0)	0(0)	1(2.5)	1(0.8)
New year	0(0)	0(0)	5(12.5)	5(4.2)
National holidays	1(5)	0(0)	0(0)	1(0.8)
During Christian fasting	18(90)	60(100)	31(77.5)	109(90.8)
X^2-Value				**22.589***

N = number of respondents, %= percentage from total respondents, *= significant b/n agroecology, ns= not significant across agroecology

4.8.7. Housing

Good house is required to protect animals from extreme temperature (rain, cold, excessive heat and wind), disease, predator, and theft. Housing of animals also make management easier and to provide suitable environment for intensive feeding and controlled breeding. As presented in Table 26, in the study area, goats were housed in different ways. The most dominant housing type in the study area was constructing a separate house followed by keeping goats within the family house and veranda. This finding is in good agreement with the report of Belete *et al*. (2013), who reported that about 58% of the households keep their goats in separate house. In the study area, kids are housed together with adults and separately from adults. All of the respondents reported that they housed their goats separately from cattle. The current observation is consistent with that of Belete et al. (2013), who reported that 99% of households reported that

they housed kids separately from adult. These might be indicate the community take a care for their goat to prevent from different weather condition and provide house separate from the family.

Table 26. Housing and housing system across agroecology of the study area (N, %)

Housing	Highland	Midland	Lowland	Overall
House with roof				
In family house	5(25)	6(10)	10(25)	21(17.5)
Separate house	15(75)	52(86.7)	28(70)	95(79.2)
Veranda	0(0)	2(3.3)	2(5)	4(3.3)
X2-Value				**5.752***
Kids housed with adults				
Yes	7(35)	3(5)	23(57.5)	33(27.5)
No	13(65)	57(95)	17(42.5)	87(72.5)
X^2-Value				**33.856***
Housed with other livestock				
Yes	0(0)	0(0)	0(0)	0(0)
No	20(100)	60(100)	40(100)	120(100.0)
X^2-Value				**1.008***

N = number of respondents, %= percentage from total respondents, *= significant b/n agroecology, ns= not significant across agroecology

4.9. Major constraints of goat production

The major goat production constraints in the study area are presented in Table 27. Disease, feed shortage, labor and water shortage were the most applicable constraints of goat production. Disease is the serious problem across all agroecologies of the district. In the highland, feed shortage and predator were identified as second and third important constraints. In the lowland, water and feed shortages were ranked 2nd and 3rd, respectively. This observation is in agreement

with that of Gurmesa *et al*. (2011) who reported that disease, predators and labor were the serious problems in Arsi Negelle Woreda. The reports of Arse *et al*. (2013) also showed that severe feed shortage, high disease prevalence and predatory were the main serious problems in Adami Tulu Jido Kombolcha, Arsi Negelle and Fentale districts.

Table 27. Index of goat production constraints in the study area

Constraints	Highland				Midland				Lowland			
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I
Genotype	0	0	1	0.01	0	1	2	0.01	0	1		0.01
Feed short.	2	12	5	0.29	1	3	8	0.05	1	21	5	0.21
Water short.	0	0	0	0	1	17	0	0.10	14	9	2	0.26
Disease	16	2	0	0.43	53	6	0	0.48	24	1	12	0.36
Drought	0	0	0	0	0	1	0	0.01	0	0	0	0
Lack super gene	0	0	6	0.05	2	6	14	0.09	0	2	10	0.06
Predator	0	6	6	0.15	1	4	25	0.1	1	5	7	0.08
Labour	2	0	2	0.07	2	22	11	0.17	0	1	4	0.03

R1, R2 and R3 = rank 1, 2 and 3, respectively. I= index

4.10. Characterization of qualitative traits

Qualitative traits of the study area are summarized in the Table 28. Out of the total sampled goat population in the study area, were plain, pied and spotted coat color pattern, respectively. In the study area, the main dominant coat color types were white, brown and white with light red color. The goat population has a concave head profile and straight. About 72% and 42% of the population had wattle and beard, respectively. About 95% of goats of the study area had horns, of which 56.4%, and 43.6% were straight and curved. The most dominant ear form was semi-

pendulous and pendulous. Hair type of goat in the study area were glossy, curly and smooth respectively across agroecology.

Table 28. Description of qualitative traits across agroecology of the study area (N, %)

Parameters	Highland	Midland	Lowland	Overall	X^2-value
Coat color pattern					
Plain	33(57.9)	133(77.8)	103(90.4)	269(78.6)	
Pied	23(40.4)	38(22.2)	11(9.6)	72(21.1)	
Spotted	1(1.7)	0(0)	0(0)	1(0.3)	**27.359***
Coat color type					
White	29(50.9)	97(56.7)	56(49.1)	182(53.2)	
Black + White + Red + Brown	8(14)	4(2.3)	4(3.5)	16(4.7)	
Light red	8(14)	20(11.7)	25(21.9)	53(15.5)	
Brown	12(21.1)	50(29.3)	29(25.4)	91(26.6)	**19.695***
Hair type					
Glossy	25(43.8)	71(41.5)	78(68.4)	174(50.9)	
Smooth	16(28.1)	39(22.8)	36(36.6)	91(26.6)	
Curly	16(28.1)	61(35.7)	0(0)	77(22.5)	**52.021***
Horn Shape					
Straight	32(56.1)	92(53.8)	69(60.5)	193(56.4)	
Curved	25(43.9)	79(46.2)	45(39.5)	149(43.6)	**1.261^{ns}**
Horn Orientation					
Oblique upward	53(93)	162(94.7)	52(45.6)	267(78.1)	
Back ward	4(7)	9(5.3)	62(54.4)	75(21.9)	**105.29***
Horn presence					
Absent	0(0)	7(4.1)	7(6.1)	14(4.1)	
Present	57(100)	164(95.9)	107(93.9)	328(95.9)	**3.649ns**
Ear orientation					

Erect	2(3.5)	4(2.3)	7(6.1)	13(3.8)	
Semi-pendulous	53(93)	162(94.7)	99(86.9)	314(91.8)	
Pendulous	2(3.5)	5(3)	8(7)	15(4.4)	**5.823^{ns}**
Head profile					
Straight	11(19.3)	36(21.1)	59(51.8)	106(31.0)	
Concave	46(87.7)	135(78.9)	55(48.2)	236(69.0)	**34.520***
Beard					
Absent	50(87.7)	150(87.7)	100(87.7)	300(87.7)	
Present	7(12.3)	21(12.3)	14(12.3)	42(12.3)	**0.00^{ns}**
Wattles					
Absent	19(33.3)	52(30.4)	25(22)	96(28.1)	
Present	38(66.7)	119(69.6)	89(78)	246(71.9)	**3.374^{ns}**

N = number of respondents, %= percentage from total respondents, *= significant b/n agroecology, ns= not significant across agroecology

4.11. Quantitative traits

The average values of body weight and linear body measurement traits of indigenous goat in the study area by agroecology, sex and age group were presented in Table 29.

Agroecology effect: Live body weight and all the linear body measurements were significantly affected by agroecology. The difference in quantitative traits between agroecology might have resulted from different management practices of the farmers. Goats in the midland agroecology possess significantly lower values in body length, heart girth, withers height, rump height, rump length, body weight, chest width, chest depth, and neck length.

Sex effect: The sex had a significant effect on all measured quantitative traits except EL (ear length). This indicates that sex is an important source of variation in live body weight and linear body measurements at all age groups. All the morphometric traits in male goats were consistently higher than females. Zewdu *et al. (*2010) indicated that the sex related differences

might be a function of the sex differential hormonal effect on the growth of animals. Moreover, Frandson and Elmer (1981) stated that differences due to sex in body weight and linear body measurements might be due to release of androgen hormone which has growth and weight stimulating effects on male animals. The current result concurs with those of Yaekob *et al*. (2015), Ahmed *et al*. (2016), Bekalu *et al*. (2016) and Hulunim *et al*. (2017) who reported that males were higher in females in most quantitative traits for goat populations kept in different parts of Ethiopia. The present finding was in contrast with the findings of Semakula *et al*. (2010) and Okpeku, *et al*. (2011) who reported that females had higher body weight and linear measurement traits than males.

Age effect: Age had a significant effect on body weight and all linear body measurement traits except ear length and neck length. In the study area, body weight and all linear body measurements had significant differences in ages (dentition) group in which, when the goat age is increased, body weight and linear body measurements also increased. This implies that goats attained higher body weight at the latter age, which is in good agreement with those of Ahmed *et al*., (2016) for Western Highland goats in the Horro Guduru Wollega zone who reported that all body measurements were increased as age group increased. The body weight and linear body measurement among the age group was differently significantly.

Table 29. Means ± SE for body weight (kg) and Linear Body Measurements (cm) for indigenous goats in the study area

Effect &level	N	BW	BL	HG	WH	RH	RL	CW	CD
Overall	342	31.0±.19	62.4±.20	71.2±.19	66.4±.19	68.5±.19	19.1±.14	13.4±.08	27.5±.12
CV		11.38	5.97	5.03	5.40	5.16	13.74	12.05	8.28
R^2		0.29	0.30	0.29	0.17	0.19	0.27	0.31	0.30
Agroecology		**	*	*	*	*	**	*	**
Highland	57	31.1^{b}±.44	62.3^{b}±.54	71.5^{a}±.46	66.6^{a}±.48	68.7^{a}±.46	19.1^{b}±.28	13.7^{a}±.22	27.4^{b}±.23
Midland	171	30.1^{c}±.25	61.7^{b}±.27	70.4^{b}±.26	65.6^{b}±.26	67.6^{b}±.26	18.3^{c}±.19	13.0^{b}±.10	26.8^{c}±.14
Lowland	114	32.3^{a}±.34	63.5^{a}±.34	72.4^{a}±.34	67.4^{a}±.33	69.6^{a}±.32	20.4^{a}±.24	13.9^{a}±.16	28.4^{a}±.25
Sex		*	*	*	*	*	*	*	*
Male	42	34.5^{a}±.58	65.6^{a}±.59	74.7^{a}±.58	68.6^{a}±.52	70.7^{a}±.53	21.1^{a}±.40	15.3^{a}±.27	29.7^{a}±.43
Female	300	30.5^{b}±.18	61.9^{b}±.20	70.8^{b}±.19	66.0^{b}±.20	68.1^{b}±.19	18.8^{b}±.14	13.2^{b}±.08	27.1^{b}±.11
Age group		*	*	*	**	**	**	*	**
1PPI	92	23.5^{c}±.30	54.7^{c}±.32	63.7^{c}±.31	58.9^{c}±.34	61.1^{c}±.33	15.9^{d}±.24	10.1^{c}±.13	25.0^{c}±.16
2PPI	108	30.7^{b}±.34	61.7^{b}±.33	70.9^{b}±.34	66.3^{b}±.35	68.4^{b}±.34	18.9^{c}±.24	13.4^{b}±.15	27.3^{b}±.22
3PPI	91	31.2^{a}±.41	62.9^{a}±.45	71.4^{a}±.42	66.4^{ab}±.41	68.5^{ab}±.40	19.1^{b}±.30	13.5^{a}±.19	27.6^{ab}±.28
4PPI	51	32.2^{a}±.46	64.0^{a}±.48	72.6^{a}±.47	67.1^{a}±.46	69.2^{a}±.45	20.1^{a}±.34	13.9^{a}±.23	28.2^{a}±.31

^{a} ,^{b}, ^{ab} ,^{c} Means with different superscripts within the same column and class are statistically different. *= Significant at 0.05; **= Significant at 0.01; CV=coefficient of variation, 1PPI = 1 pair of permanent incisor, 2PPI = 2 pair of permanent incisor, 3PPI = 3 pairs of permanent incisors and 4PPI=4 pairs of permanent incisors; BW= body weight; BL= body length; HG= heart girth; WH = withers height; CW =chest width; CD=chest depth; RH=rump height and RL = rump length.

Table 29 (continued)

Effect &level	N	NL	HoL	SC	Head W	Head L	EL	PW	TL
Overall	342	23.5±.12	13.1±.17	23.3±.36	18.0±.16	19.9±.17	14.3±.09	13.9±.07	3.3±.04
CV		9.47	24.72	8.27	16.56	15.53	12.00	8.97	15.82
R^2		0.174	0.183	0.42	0.410	0.423	0.028	0.2433	0.45
Agroecology		*	*	*	*	*	*	*	*
Highland	57	23.7^{b}±.24	11.8^{b}±.41	22.1^{a}±.94	16.7^{b}±.31	18.4^{b}±.34	13.8^{b}±.21	13.4^{b}±.20	3.1^{b}±.09
Midland	171	22.9^{c}±.14	13.6^{a}±.26	23.0^{ab}±.44	18.1^{a}±.24	20.0^{a}±.25	14.4^{a}±.12	13.6^{b}±.09	3.4^{a}±.06
Lowland	114	24.4^{a}±.24	13.0^{a}±.26	24.4^{a}±.66	18.7^{a}±.26	20.6^{a}±.26	14.3^{ab}±.17	14.4^{a}±.10	3.4^{a}±.08
Sex		*	*		*	*	Ns	*	
Male	42	24.7^{a}±.37	15.6^{a}±.74	23.3±.36	20.7^{a}±.48	22.7^{a}±.44	14.6±.20	14.9^{a}±.23	NA
Female	300	23.4^{b}±.12	12.8^{b}±.16	NA	17.7^{b}±.16	19.5^{b}±.17	14.2±.10	13.7^{b}±.06	3.3±.04
Age group		*	*	*	*	*	Ns	*	*
1PPI	92	20.2^{b}±.19	9.7^{b}±.29	17.5^{c}±.50	12.5^{c}±.24	14.4^{c}±.24	11.2±.18	10.5^{c}±.10	2.6^{c}±.05
2PPI	108	23.5^{a}±.22	13.4^{a}±.34	22.6^{b}±.66	18.3^{b}±.26	20.0^{b}±.28	14.1±.16	13.8^{bc}±.11	3.5^{b}±.06
3PPI	91	23.5^{a}±.26	13.9^{a}±.29	23.7^{ab}±.49	19.5^{a}±.25	21.3^{a}±.27	14.5±.16	14.1^{ab}±.14	3.7^{a}±.05
4PPI	51	23.9^{a}±.28	13.6^{a}±.46	25.0^{a}±.59	19.5^{a}±.34	21.7^{a}±.34	14.3±.27	14.3^{a}±.18	3.7^{a}±.10

[a, b, ab, c] Means with different superscripts within the same column and class are statistically different. Ns = Non significant; *significant at 0.05; CV=coefficient of variation, NA= not applicable; 1PPI = 1 pair of permanent incisor, 2PPI = 2 pair of permanent incisor, 3PPI = 3 pairs of permanent incisors and 4PPI=4 pairs of permanent incisors; NL= neck length; HoL=horn length; SC = scrotum circumference; Head W=head width; HL=head length; EL = ear length; PW= pelvic width; and TL = teat length

4.12. Correlation between body weight and linear body measurements

The Pearson correlation coefficient among various body measurements of goats in the study area are presented in the Table 30. The correlation of body weight with LBM ranges from weak to moderate correlation for both male and female goats. The finding was in line with that of Halima *et al*. (2012) who reported a high correlation between body weight and heart girth (r=0.89) for Ethiopian indigenous goat population. The correlation between LBM and body weight was higher in bucks than in does. This variation may be explained due to the difference in fat deposition between male and female goats. Heart girths had a high correlation with body weight for both sexes, which is in a good agreement with that of Alemayehu *et al*. (2012) for Abergelle goats. The correlation coefficient between body measurement and body weight were positive and significant except ear length for both sexes, horn length and head length goats in the study area. The correlation between body weight and ear length were negative and non-significant. This finding was in agreement with the report of Halima *et al*. (2012) and Mahilet (2012) who found a non-significant correlation of ear length with body weight. The report of Bello and Adam (2012) also indicated that there is negative correlation between body weight and ear length (r= -0.48). In this finding heart girth, chest depth and rump length had the highest correlation with body weight. This observation was consistent with that of Mahilet (2012) for Hararghe highland goats and Grum (2010) for short-eared Somali goat. The positive correlation between body weight and linear body measurements indicates that an increase in any one of the body measurement would result in a corresponding increase in body weight.

Table 30. Correlation coefficients among body measurements and weight of doe and buck goats of the study area (value above the diagonals is doe whereas the below diagonals was buck

	BW	BL	HG	WH	RH	RL	CW	CD	NL	HoL	HW	HL	EL	PW	TL
BW		.818**	.972**	.771**	.784**	.907**	.881**	.872**	.728**	.003	.079	.041	-.104	.179	.128
BL	.968**		.824**	.681**	.684**	.754**	.716**	.671**	.600**	-.039	.072	.046	-.084	.095	.094
HG	.973**	.960**		.793**	.806**	.925**	.848**	.838**	.706**	-.008	.069	.036	-.093	.159	.127
WH	.664**	.667**	.714**		.987**	.743**	.648**	.657**	.601**	-.048	.039	.007	-.103	.145	.101
RH	.662**	.666**	.732**	.986**		.772**	.662**	.673**	.618**	-.040	.051	.018	-.106	.170	.099
RL	.927**	.936**	.929**	.665**	.702**		.799**	.802**	.686**	-.046	.079	.051	-.104	.189	.099
CW	.881**	.844**	.825**	.580**	.593**	.815**		.835**	.729**	-.036	.113	.076	-.120	.188*	.135
CD	.933**	.885**	.899**	.585**	.589**	.863**	.857**		.794**	.007	.122	.082	-.153	.282**	.119
NL	.499*	.404	.455*	.329	.337	.481*	.484*	.580**		-.013	.071	.050	-.136	.198*	.121
HoL	-.251	-.193	-.254	-.236	-.260	-.261	-.278	-.187	.028		.278**	.266**	.159	.237**	.259**
HW	-.251	-.259	-.260	-.405	-.396	-.268	-.267	-.190	-.178	.494*		.958**	.128**	.231**	.523**
HL	-.217	-.237	-.233	-.353	-.348	-.271	-.166	-.161	-.117	.376	.826**		.152	.242**	.505**
EL	-.205	-.249	-.252	-.280	-.272	-.232	-.228	-.099	-.064	.256	.123	.004		.002	.092
PW	.168	.172	.122	.015	.025	.234	.182	.209	.082	-.040	.357	.346	-.260		.165*
SC.	.183	.168	.220	.013	-.051	.127	.151	.247	.093	.085	.217	.209	-.068	.079	

** = significant at (0.01),*= significant at (0.05) BW= body weight, RH= rump height, RL= rump length, BL= body length

4.13. Regression analysis

Multiple linear regression models for predicting the body weight of goats from linear body measurements are presented in Tables 31. Stepwise multiple regressions procedure were used to predict body weight from linear measurements. The independent variables were body length, heart girth, and withers height, rump height, rump length, chest width, chest depth, neck length, horn length, head length, head width, pelvic width and ear length. Scrotum circumference and teat length were included in the model for male and female goats, respectively. All body measurements were fitted into the model and through elimination procedures, the optimum model was identified. Accordingly, heart girth, chest width, body length and chest depth were found to be the most appropriate explanatory variables to predict body weight for both sexes. Among the identified predictors, heart girth was found to be more reliable in predicting body weight. The better association of body weight with heart girth was possibly due to the relatively larger contribution to the body weight of heart girth, which consists of bones, muscles and viscera (Thiruvenkadan, 2005). The result of stepwise regression analysis indicates that other measurement to the heart girth would result in significant improvement in accuracy of prediction in overall assessment even though the extra gain was small, which was in agreement with the report of (Afolayan, *et al*., 2006).

Table 31. Multiple linear regression analysis of live body weight on different LBMs for male and female goats

Sex	Model				I	b_1	b_2	b_3	b_4	R^2	C (P)
Male	HG				-38.29	0.97				0.94	43.73
	HG	CW			-30.99	0.77	0.51			0.96	16.73
	HG	CW	BL		-30.04	0.30	0.52	0.41		0.97	8.61
	BL	HG	CW	CD	-26.75	0.29	0.40	0.263	0.263	0.97	1.69
Female	HG				-36.72	0.95				0.94	119.11
	HG	CW			-30.93	0.78	0.46			0.95	36.21
	HG	CW	CD		-30.73	0.72	0.33	0.21		0.95	6.83
	BL	HG	CW	CD	-30.83	0.05	0.67	0.31	0.22	0.96	1.46

BL= body length; HG= heart girth; WH = withers height; PW =pelvic width; RH = rump height; RL=rump length; CD= chest depth; CW= chest width; NL=neck length, I= intercept, R^2=R-square, C (P) = the mallows C parameters

Table 32. Multiple linear regression analysis of live body weight on different LBMs for different age class of goats (data pooled)

Dentation	Model					I	b_1	b_2	b_3	b_4	b_5	R^2	CP
1PPI	HG					-36.0	0.94					0.96	43.07
"	HG	CD				-34.28	0.77	0.37				0.97	1.64
"	HG	CW	CD			-32.36	0.73	0.18	0.30			0.98	1.79
2PPI	HG					-36.94	0.95					0.92	112.0
"	HG	CD				-30.82	0.67	0.50				0.94	55.03
"	BL	HG	CD			-30.83	0.28	0.43	0.49			0.95	25.71
"	BL	HG	CD	CW		-29.07	0.27	0.41	0.24	0.39		0.96	20.27
"	BL	HG	HW	CW	CD	-28.46	0.30	0.44	-0.065	0.22	0.38	0.96	17.09
3PPI	HG					-38.69	0.98					0.978	54.33
"	HG	CW				-32.86	0.83	0.36				0.98	22.11
"	HG	CW	NL			-32.97	0.81	0.31	0.09			0.98	13.95
4PPI	HG					-37.12	0.95					0.94	62.95
"	HG	CW				-24.09	0.63	0.73				0.96	15.29
"	BL	HG	CW			-23.39	0.17	0.47	0.72			0.97	10.34
"	BL	HG	CW	NL		-24.35	0.20	0.42	0.76	0.11		0.97	5.03

1PPI= one pair permanent incisor, 2PPI= 2pair of permanent incisor, 3PPI= 3pair of permanent incisor, 4PPI=4pair of permanent incisor, BL= body length; HG= heart girth; WH = height at withers; PW =pelvic width; RH = rump height; RL=rump length; CD= chest depth; CW= chest width; NL=neck length, I= intercept, R^2=R-square, C (P) = the mallows C parameters

For practical purposes in the field, the body weight of male and female goats can be predicted with heart girth alone using the following formula

Male Y = -38.3+0.97x

Female Y = -36.7+0.95x

Y = body weight, x = heart girth,

4.14. Structural and functional indices

From measured quantitative traits, fifteen structural and functional indices were calculated for the goat populations of the area (Table 33). The structural indices result showed that the body index of goats in the study area was 0.87 that would classify them as medigline. Height slope value of goats in the study district was indicates that wither height is smaller than rump height suggesting these goats types are shorter in front than backward. Relative body or length index was 0.94, which is in agreement with Chiemela *et al.* (2016) who reported 0.93 for central highland goats in South Wollo. The relative body index and balance indices indicate the carcass yield capacity of live animals. The lower value of the relative body index in the present study compared to the report of Chacón *et al*. (2011) and Chiemela *et al.* (2016) indicates that the carcass yield of the goats in the district is expected to be lower than Cuban creole goats, but slightly consistent with central highland goat in South Wollo.

The compact index is a useful indicator of the overall value of the animals because it combines morphology and structure and provides an accurate picture of the type and function of livestock breed (Chiemela *et al*., 2016). Since the compact index value of the current study was 4.6, the local goats in the study area can be classified as meat type animals.

Chiemela *et al.,* (2016) and Chacón *et al*. (2011) also reported a compact index value of 3.91 and 5.40 for central highland goats in South Wollo and for adult Cuban Creole goats, respectively.

Table 33. Average values of structural indices for Indigenous goat types in the study area.

Structural Indices	Means	SE	CV
Cephalic index	90.6	0.25	5.07
Body index	0.87	0.001	3.03
Relative thorax depth index	40.2	0.13	5.82
Proportionality index	107	0.25	4.29
Longitudinal index	0.28	0.002	9.57
Length index or relative body index	0.94	0.002	4.36
Pectoral index	1.74	0.004	4.56
Thorax development	1.07	0.002	3.28
Body ratio	0.97	0.000	.79
Compact index	4.60	0.02	7.68
Fore leg index	38.9	0.145	6.9
Conformation index	76.6	0.28	6.53
Area index	4148	23.6	10.2
Pelvic index	73.6	0.57	14.4
Height slope index	2.09	0.03	24.7

SE= Standard error, CV=Coefficient of variation

Thoracic development of goat in the study area was 1.07, which is less than 1.2, indicating their poor thoracic development. This result was in agreement with the reports of Chiemela *et al*., (2016), who reported a value of 1.08. The body ratio of goats in the study area was 0.97, which is in good agreement with that of Chacón *et al*. (2011) who reported 0.97 for Cuban Creole goats. Proportionality index relates the body height to the body length and denotes the shape of

the animal. Proportionality index of goat type in the current study was 107, which would classify them into dairy type. The relative depth of the thorax index indicates a relationship between chest depth and the leg's length. The relative depth of thorax index of goats in the study area was 40.2, which is comparable to that of Chiemela *et al*. (2016), who reported a value of 43.8 for central highland goats in South Wollo. Animals with a higher relative depth of thorax values have higher moving capacity, being more adapted to plains and long treks with bodies further from the ground to avoid radiation during hot weather. Generally, the structural indices result showed that the general body conformation of these goat types matched up with the intermediary meat type animal. However, according to proportionality and relative depth thorax indexes, they could also be classified as dairy type. Therefore, as there has not been any structured selection for neither of the traits, the animals might be considered as dual-purpose breed.

5. SUMMARY AND CONCULISION

5.1. Summary

One of the basic tools for successful goat production and productivity is to improve the genetic makeup of the animal and its environment. In order to make this sector more profitable, identification, characterization and records of the existing goat populations and their production system has vital importance. The study aimed to generate well-organized information on morphological characteristics, selective breeding objectives, trait preferences and production system of native goat types under farmers' production environment in Hidabu Abote district. Survey based and morphological data were collected from 120 households who owned goats. Moreover, for morphological data, a total of 342 goats of both sexes from 1PPI to 4PPI were used.

The results indicated that the main feed resources during the wet season was communal grazing in highland followed by natural plants and fallow land. In the midland, communal grazing was the most important feed source followed by natural plants and fallow land. In the lowland, natural plants ranked as the first feed source followed by communal grazing and fallow land. The main feed resources during dry seasons in the highland were crop residues followed by acacia plants. In the midland, acacia plants followed by crop residues and natural plants were identified as major feed resources. In lowland, acacia ranked first as major feed resource followed by crop residues and natural plants. The majority (65.8%) of farmers in the study area were herding their goats alone and almost male and female goats were herded together and the kids were separated from adults.

During the dry season, the main water source for all agroecologies were river water, while in wet season, the main water source for highland, midland and lowland agroecologies were rainwater with variable proportions. Separate housing was the main dominant housing practices in the study area. Farmers have multiple breeding objectives and they considered both subjective and objective selection criteria with slightly more emphasis on qualitative traits for does selection than buck selection. The majority of smallholders in the study area did not keep breeding bucks because of selling them at an early age. The main reason of uncontrolled breeding is lack of awareness about the effect of inbreeding.

Goats in the study area were characterized by having plain, pied and spotted coat color pattern. The main dominant coat color types were white followed by brown and light red color. The goat population in the study area was also characterized by possessing a concave and straight head profiles. Most of the goats were further characterized by the absence of beard, presence of wattle and horn. The most dominant ear form was semi-pendulous followed by pendulous.

Goats reared in the lowland had higher ($p<0.05$) body length, chest depth and rump length values compared with those raised in other agroecologies. Similarly, scrotal circumference was higher ($p<0.05$) in lowland goats than in the highland. Among quantitative traits measured on both sexes, body weight was ($p<0.001$) and positively correlated with heart girth, body length, height at wither, chest depth and chest width. Among these variables, the highest correlation of body weight with heart girth was observed for both sex groups ($r=0.97$). All variables were fitted into the regression model and through stepwise elimination procedures, the optimum model was identified. The best fitted prediction models (explanatory variables) were further selected with smaller C (P) and higher R^2 values and simplicity of measurement under field condition were also considered. The results of the multiple regression analysis revealed that heart girth was the

single important variable in the prediction of body weight in both sexes. The body index of goats in the study classified the local goats of the study area as medigline. According to the compact index value of the current study, the local goats can be classified as meat type animals. On the other hand, according to the proportionality index value of goat type in the current study, they could be classified as dairy type.

5.2. Conclusion

The main constraints of goat production in the study area were feed and water shortage. The main breeding practices were directed at improving the subjective and objective type of traits including coat color, size, and mothering ability. The dominant coat color types were white followed by brown and light red color. Most of the goats were further characterized by the absence of beard, presence of wattle and horn. Goats reared in the lowland were much better in most morphometrical traits than those reared in highland and midland agroecologies. Among the measured linear measurement traits, the highest regressed was observed between body weight and heart girth. As a result, heart girth was found to be a single important variable in the prediction of body weight in both sexes. The estimated morphometric indices suggested classification of goats in the study area as a medium-sized with a marked orientation for both meat and milk production along with signs of adaptation to its environment. The meat and milk production potentials of goats could be thus a topic of future research within the stratified agroecologies.

Based on the current study, the following recommendations are forwarded:

- In the study area during the rainy season only fallow land was left for grazing which was difficult for keeping a goat. Thus, advising farmers to establish simple pasture land could solve such problems.
- Farmers mainly rear goats for cash generation and their selection criteria were mainly based on subjective traits. It would be beneficial if appropriate trainings are provided to farmers on the importance of objective type traits.
- To prevent uncontrolled mating, to increase productivity and to reduce the inbreeding, awareness about the negative effect of inbreeding might be essential.
- Farmers sold their potential bucks for generate cash and the one left in the flock is the one with poor performance. Thus, farmers should be advised to reduce such practices through simple training.

6. REFERENCES

Afolayan, R. A., Adeyinka, I.A., and Lakpini, C.A.M. 2006. The estimation of live weight from body measurements in Yankasa sheep. *Journal of Animal Sciences* 51 (8): 343–348.

Ahmed Seid, Kefelegn Kebede and Kefena Effa.2016. Morphological characterization of indigenous goats in Western Ethiopia: implication for community-based breeding programmes. *Animal Genetic Resources,* 1 (2): 1–10.

Ahmed Seid.2017. Breeding practices and strategies for genetic improvement of indigenous goats in Ethiopia. *Journal Animal Genetics and Breeding,* 2(4):334–341.

Alefe Takele. 2016. Phenotypic characterization of indigenous goat types and their production system in Shebelle zone, south eastern Ethiopia. M.Sc. Thesis, Haramaya University. pp 234–252.

Alemayehu Tadesse and Tikabo Gebremariam. 2010. Application of Linear Body Measurements for Live Body Weight Estimation of Highland Sheep in Tigray Region, North-Ethiopia**.** *Journal of the Dry lands* 3(2): 203–207.

Alemayehu Tadesse, Tikabo Gebremariam and Gangwar, S.K. 2012. Application of linear body measurements for predicting body weight of Abergelle goat breed in Tigray region, northern Ethiopia. *Global Journal Biosciences.* 1 (2): 314–319.

Anaeto, M., J. A., Adeyeye, G. O. Chioma, A.O. Olarinmoye and G. O. Tayo. 2010. Goat products: Meeting the challenges of human health and nutrition. *Agri. And bio. J. of North America*. 1(6)1231–1236.

Anderson, D.M .2010. Geospatial methods and data analysis for assessing distribution of grazing livestock. In Proceedings of the 4th Grazing Livestock Nutrition Conference, pp. 57–92.

Arse Gebeyehu, Feyisa Hundessa, Gurmessa Umeta, Merga Muleta and Girma Debele. 2013. Assessment on challenges and opportunities of goat farming system in Adami Tulu, Arsi Negelle and Fantale districts of Oromia Regional State, Ethiopia. *Afr. J. Agric. Res*. 8(1):26–31

Asfaw Yimegnuhal and Tamrat Degefa. 2003. Farm Animal Biodiversity in Ethiopia: Status and Prospects. In: Proceedings of the 11th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 28–30, 2003.

Assan, N. 2013. Bio prediction of body weight and carcass parameters from morphometric measurements in livestock and poultry. *Sciences Journal* 2(6): 140–150.

Bagley, M.N. 2006. Meat Goat Breeds, Breeding Management, and 4-H Market Goat Management.

Behnke R. 2010. The Contribution of Livestock to the Economies of IGAD Member States: Study Findings, Application of the Methodology in Ethiopia.

Belay Deribe and Mengistie Taye. 2013. Reproductive Performance of Abergelle Goats Raised under Traditional Management Systems in Sekota District, Ethiopia. *Iranian Journal of Applied Animal Science* 1(4): 59–63.

Belete Assefa. 2013. On Farm Phenotypic Characterization of Indigenous Goat Types and Their Production System in Bale Zone of Oromia Region, Ethiopia. M.Sc. Thesis Presented to the School of Graduate Studies of Haramaya University, Haramaya. p116.

Belete Shenkute. 2009. Production and Marketing Systems of Small Ruminants in Goma District of Jimma Zone, Western Ethiopia. M.Sc. Thesis Submitted to School of Graduate Studies. Hawassa University, Awassa, Ethiopia. p144.

Bello A.A and Adama T.Z. 2012. Studies on body weight and linear body measurements of castrates and non-castrate Savannah Brown goats. *Asian Journal Animal Sciences*. 6:140–146.

Chacón E., Macedo, F., Velazquez, F., Paiva, S.R., Pineda, E., Mcmanus, C. 2011. Morphological measurements and body indices for Cuban Creole goats and their crossbreds. *Revista Brasileira de Zootecnia.* 3(5):1–19

Chiemela, P.N., Sandip, B., Mestawet, T.A., Egbu, C.F., Ugbo, E.H., Akpolu E.S. and Umanah I.J. 2016. Structural indices of Boer, central highland and their F1 crossbred goats reared at Ataye farm, Ethiopia. *J. of Agri. and Res*. 2(1):1–19.

CSA. 2013. Agricultural sample survey. 2012/13. Volume II, report on livestock and livestock characteristics (private peasant holdings.2013. Addis Ababa, Ethiopia, Statistical bulletin. p 570.

CSA. 2018. Agricultural sample survey. 2017/18 (2010 E.C). Volume II, report on livestock and livestock characteristics (private peasant holdings.2018. Addis Ababa, Ethiopia, Statistical bulletin.

Dereje Tsegay, Berhanu Belay, and Aynalem Haile. 2013. Linear Body Measurements as Predictor of Body Weight in Hararghe Highland Goats under Farmers Environment in Ethiopia. *Global Veterinarian journal* 11: 649–656.

Domestic Animal Genetic Resources Information System (DAGRIS). 2007. W. Ayalew, E. Getahun, O. Hanotte and T. Dessie). International Livestock Research Institute, Addis Ababa, Ethiopia. Online data base http://dagris.ilri.cgiar.org/

Endeshaw Assefa. 2007. Assessment of Production and Marketing System of Goats in Dal District, Sidama Zone. M.Sc. Thesis. Hawassa University, Hawassa Ethiopia. p 84.

Ethiopian Agricultural Research Organization (EARO). 2000. National Small Ruminants Research Strategy Document. EARO, Addis Ababa, Ethiopia. p 30.

Ethiopian Sheep and Goat Productivity Improvement Project (ESGPIP). 2009. Estimation of weight and age of sheep and goats. Technical Bull., No. 23. 24 p

FAO. 2007. The state of the world's animal genetic resources for food and agriculture, edited by B. Rischkowsky & D. Pilling. Rome. p523.

FAO. 2012. Molecular characterization of animal genetic resources. FAO Animal Production and Health Guidelines, Number, 9. Rome, Italy. p 83

FAO. 2018. Report on feed inventory and feed balance 2018, Ethiopia, Addis Ababa p 160

FAO STAT.2012. Food and Agricultural organization of the United Nations, statistical division. http://faostat3.fao.org/browse/Q/Q/E.(accessed on 8, February, 2012)

Farhad H.S., Bolghasem L. and Asad A. 2013. Estimation of body weight from body measurements in four breeds of Iranian sheep. *Songklanakarin Journal Sciences Technology*. 35: 507–511.

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. p76.

Galal Salah. 2005. Biodiversity in goats. http://DOI: 10.1016/j.smallrumres.2005.06.021, *Small Ruminant Res. 60(1-2): 75–81*.

Gebrekiros Hagos, Kefelegn Kebede, Banerjee, A.K. and Zinabu W. 2016. On-Farm Phenotypic Characterization of Begait Goat and Their Production System in Western Zone of Tigray, Ethiopia. *International Journal Res. Innovat. Earth Sciences* 3(1):78–80.

Girma Abebe, Merkel, R. C. and Sahlu Tekla. 2008. Enhancing food security and income generation potential of families in Southern Ethiopia through improved goat production and extension In: Proceeding of a conference. Langston Univ., OK (USA). E (Kika) da la Garza Inst. for Goat Research; Debub Univ. 10-12 Nov. 2000, Awassa, Ethiopia. pp 113–117.

Grum Gebreyesus. 2010. Community-based participatory characterization of the short eared Somali goat population around Dire Dawa. M.Sc. Thesis. Haramaya University. p 146.

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

HADLFRO (Hidabu Abote District Livestock and Fishery Resources office). 2018. Annual report, Oromia, Ethiopia.

Halderman, M. 2004. The political economy of pro-poor livestock policy making in Ethiopia. Working Paper 19. Rome, FAO.

Halima Hassan, Michael, B., Barbara, R., and Markos Tibbo. 2012. Phenotypic characterization of Ethiopian indigenous goat population. *African journal of biotechnology*, 11(73): 13838–13846.

Hanford, K.J., van Vleck, L.D. and Snowder, G.D. 2006. Estimates of genetic parameters and genetic trend for reproduction, weight, and wool characteristics of Polypay sheep. *Livestock Sciences* 102: 72–82.

Hulunim Gatew, Halima Hassan, Kefelegn Kebede and Aynalem Haile. 2015. Characterization of Indigenous Goat Populations in Selected Areas of Ethiopia**.** *American-Eurasian J. Sci. Res.* 10 (5): 287–298.

International Livestock Center for Africa (ILCA). 1990. Livestock Research System Manual. ILCA, Addis Ababa, Ethiopia. Part I. p287.

Jabbar, M. A., Ehui, S. and Fitzhugh, H. 1995. The contribution of livestock to food security and sustainable development. In: Proceedings of the joint ILRI round table on livestock development strategies for low income countries, 27 February 02 March, 1995, Nairobi, Kenya. p 56

Jainudeen, M.R., H. Wahid, E.S.E., and Hafez, B. 2000. Sheep and goats. In: Hafez, E.S.E., Hafez, B. (Eds.), Reproduction in Farm Animals, 7th ed. Lippincott, Williams & Wilkins, Maryland, pp172–181.

Kashoma, I.P.B., Luziga C., Werema C.W., Shirima G.A. and Ndossi D. 2011. Predicting body weight of Tanzania shorthorn zebu cattle using heart girth measurements. *Livest. Res. Rural Develop*. 23(4):42–47.

Kassahun Awgichew. 2000. Comparative performance evaluation of Horro and Menz sheep of Ethiopia under grazing and intensive feeding conditions. PhD. Dissertation. Berlin. p 173.

Kassahun Gurmessa, Taye Teklemariam, Adugna Tolera, Fekadu Beyene and Solmon Demeke.2015. Feed Resources and Livestock Production Situation in the Highland and

Mid Altitude Areas of Horro and Guduru districts Oromia Regional State, Western Ethiopia. *Sci.Technol.Arts Res.J.*, 4(3):111–116.

Kgosikoma, O. E. and Batisani, N. 2014. Livestock population dynamics and pastoral communities' adaptation to rainfall variability in communal lands of Kgalagardi South, Botswana. *Pastoralism* 4(1): 1–9

Khan, H., Muhammad F., Ahmad R., Nawaz G., Rahimullah G. and Zubair M. 2006. Relationship of body weight with linear body measurements in goat. *J. Agric. Biol. Sci*., 1(3): 51–54.

Koehler- Rollefson I. 2005. Indigenous breeds, local communities. Documenting animal breeds and breeding from a community perspective. Lokhit Pashu-Palak Sansthan, Sadri, India. 80p.

Kosum, N., Taskin, T., and Akbas, Y. 2004. Heritability estimation of birth and weaning weights in Saanen, Bornova and Saanen x Kilis goats. Pakistan. *J. Biol. Sci*. (7): 196–196.

Lenstra, J.A., Groeneveld, L.F., Kantanen, J., Williams, J.L., Taberlet, P. and Nicolazzi, E. 2012. Molecular tools and analytical approaches for the characterization of farm animal genetic diversity. *Animal Genetics* 43(5):483–502.

Mahilet Dawit. 2012. Live characterization of Hararghe highland goat and their production system in eastern Hararghe. M.Sc. Thesis presented to School of Graduate Study of Haramaya University.

Mandal, A., Neser, F.W.C., Rout, P.K., and Roy, R. 2006. Estimation of direct and maternal (co)variance components for pre-weaning growth traits in Muzaffarnagari sheep. *Livest. Sci*., 99: 79–89.

Mbuku, S.M., Kosgey, I.S. and Kahi, A.K. 2006. Identification systems and selection criteria of pastoral goat keepers in northern Kenya–implications for a breeding programme.

Meghen, C., McHugh, D. E. and Bradley, D. G. 1994. Genetic characterization and West Africa cattle. *World Animal Review* 78(1): 59–66.

Mekuriaw .2016. Molecular characterization of Ethiopian indigenous goat populations: genetic diversity and structure, demographic dynamics and assessment of the kisspeptin gene polymorphism. PhD. Dissertation. Addis Ababa University, Addis Ababa. Pp219

Menendez-Buxadera, A., G. Alexander and N. Mandonnet. 2004. Discussion on the importance, definition and genetic components of the number of animals born in the litter with particular emphasis on small ruminants in tropical conditions. *Small Rumin. Res*.54:1–11

Mueller, J.P. 2006. Breeding and conservation programs with local communities. FAO-workshop "Sustainable utilization as a support to the further development of the global strategy for animal genetic resources management", Ferentillo, Italia, June 28 – July 6, 2006.

Mukasa-Mugerwa, E., Anindo, D., Sovani, S., 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 season s in the Highlands of Ethiopia. *Small Ruminant Research* 45: 261–271.

NBC (Netherlands Africa Business Council).2010. Livestock in Ethiopia and opportunity analyses for Dutch investment.

Netsanet Zergaw, Tadele Dessie, and Kefelegn Kebede. 2016. Growth performance of WoytoGuji and central highland goat breeds under traditional management system in Ethiopia. *Livestock Research for Rural Development*. 28(1):213–219.

Nigatu Alemayehu. 1994. Characterization of Indigenous Goat types & husbandry Practices in Southern Ethiopia. M.Sc. Thesis. Alemaya University of Agriculture. Alemaya, Ethiopia. p 84.

Okpeku, M., Yakubu, A., Olusolas, P. Ozoje, O. M. Ikeobi, C. O. Adebambo, O. A. and Imumorin, I, G. 2011. Application of multivariate principal component analysis to morphological characterization of indigenous goats in Southern Nigeria. *Act Agriculture Slovenia*. 98: 101–109.

Pesmen G. and M. Yardimci. 2008. Estimating the live weight using somebody measurements in Saanen goats. Afyon Kocatepe University, Faculty of Veterinary Medicine, Department of Animal Husbandry, *Archiva Zootechnica* 11(4): 30–40.

Philipsson, J., Rege, J.E. O. and Okeyo, A.M. 2006. Sustainable breeding for tropical farming systems. In: Ojango, J.M., Malmfors, B., and Okeyo, A.M. (Eds.). 2006. International Livestock Research Institute, Nairobi, Kenya, and Swedish University of Agricultural Sciences, Uppsala, Sweden. p 212.

Portolano, B., Todaro, M., and Finocchiaro, R. 2002. Estimation of the genetic and phenotypic variance of several growth traits of the Sicilian Girgentana goat. *Small Rumin. Res.*, 45: 247–253.

Rege, J.E.O., Kahi A.K., Okomo-Adhiambo M., Mwacharo, J. and Hanotte O. 2001. Zebu cattle in Kenya: Uses, performance, farmer preferences, measures of genetic diversity and

options for improved use. International Livestock Research Institute, Nairobi, Kenya. 103p.

Salako, A. E. 2006. Application of morphological indices in the assessment of type and function in sheep. *Int. J. Morphology* 24(1):13–18

Salako, A.E. and L.O. Ngere. 2002. Application of multifactorial structural discriminant analysis in the morphometric structural differentiation of West African Dwarf and Yankassa sheep in South West Nigeria. Niger. *Journal Animal Production* 29(2): 163–167

Samuel Member. 2005. Characterization of livestock production system: a case study of Yerer watershed, ada'a liben Woreda of east shoa, Ethiopia, A Thesis Submitted to the Department of Animal Science, School of Graduate Studies, Haramaya University June 2005, Dire Dawa.

Semakula J, Mutetikka D, Kugonza DR, Mpairwe D. 2010. Variability in Body Morphometric Measurements and their Application in Predicting Live Body Weight of Mubende and Small East African Goat Breeds in Uganda. *East Journal of Scientific Research* 5: 98–105.

Singh, P.N. and A.K. Mishra. 2004. Prediction of body weight using conformation traits in Barbari goats. *Indian J. Small Rumin*. 10: 173–173.

Solomon Abegaz and Kassahun Awgichew. 2008. Genetic Improvement of Sheep and Goats. Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP).

Solomon Abegaz, Girma Abebe and Kassahun Awgichew. 2008. Sheep and goat production handbook for Ethiopia. Sheep and goat production systems in Ethiopia. p27.

Solomon Abegaz, Solomon Gizaw, Tadelle Dessie and Aynalem Haile. 2013. Description of production systems and morphological characteristics of Abergelle and Western lowland goat breeds in Ethiopia:

Solomon Gizaw and Tesfaye Getachew. 2009. The Awassi × Menz sheep crossbreeding project in Ethiopia: Achievements, challenges and lessons learned. In: Proceedings of the mid-term conference of the Ethiopian sheep and goat productivity improvement program (ESGPIP), March 13–14, 2009. Hawassa, Ethiopia. pp 53–62.

Solomon Gizaw, Azage Tegegne, Gebremedhin, B., and Hoekstra, D. 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.

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

Solomon Gizaw, Tesfaye Getachew, Zewdu Edea, Tadele Mirkena, Markos Tibbo, Rischkowsky, B., Mwai, O., Tadelle Dessie, Wurzinger, M., Solkner, J. and Aynalem Haile. 2013. Characterization of indigenous breeding strategies of the sheep farming communities of Ethiopia. 47p.

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

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

Tesfaye Getachew, Zewdu Edea, Aynalem Haile and Markos Tibbo. 2009. Use of linear body measurements for performance recording and genetic evaluation of Menz and Afar sheep breeds under village condition. In: Challenges, opportunities, and the way forward: Proceedings of the 17th Annual Conference of the Ethiopian Society of Animal Production held in Addis Ababa, Ethiopia, September 24–26, 2009. pp 113–122.

Tesfaye Getachew. 2008. Characterization of Menz and Afar indigenous sheep breeds of smallholders and pastoralists for designing community-based breeding strategies in Ethiopia. M.Sc. Thesis .Haramaya University, Ethiopia. 75p.

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. M.Sc. Thesis. Haramaya University, Ethiopia. 108P.

Tewodros Muluneh, Meseret Molla and Merkebu Getachew. 2017. Assessment of livestock genetic resource diversity in Ethiopia: An implication for conservation; *journal of Genetic and Environmental Resources Conservation* 3(2): 150–163.

Thiruvenkadan, A.K. 2005. Determination of best-fitted regression model for estimation of body weight in Kanni Adu Kids under farmer's management system. *Livest. Res. Rural Develop*. 17: 1–11.

Tsedeke kocho. 2007. Production and marketing of sheep and goats in Alaba, southern nation and nationalities and peoples region. M.Sc. Thesis. Hawassa University, Hawassa .pp 82–84

Tsegahun, A., Lemma, S., Ameha, S., Abebe, M. and Zinash, S. 2000. National goat research strategy in Ethiopia. In: proceeding of a conference held at Debub University, Awassa, Ethiopia November 10-12, 2000. p15

Tsigabu Gebereselassie.2015. Phenotypic characterization of goat type and their husbandry practices in Nuer zone of Gambella people regional state, south western Ethiopia. M.Sc. Thesis, Haramaya, p.93.

Workneh Ayalew .1992. Preliminary survey of indigenous goat types and goat husbandry practices in southern Ethiopia. M.Sc. Thesis, Alemaya University of Agriculture. Alemaya, Ethiopia. 156pp.

Workneh Ayalew, Rischkowsky, B. and King, J.M. 2004a. The Concept and Calculation of Net Benefits from Goats in Ethiopian Smallholdings. *Eth. J. Anim. Prod* 4(1):123–128.

Workneh Ayalew, van Dorland, A. and Rowlands, J. 2004b. Design, execution and analysis of the livestock breed survey in Oromia Regional State, Ethiopia. (Oromia Agricultural Development Bureau), Addis Ababa, Ethiopia, and ILRI (International Livestock Research Institute), Nairobi, Kenya. 260 p.

Yaekob, L., Kirman, M.A. and Birhanu Belay. 2015. Morphological Characterization of Indigenous Woyito Guji goat type in Loma district, Southern Ethiopia. *Afr. J. Agric. Res*., 10(20): 2141–2151.

Yakubu, A. and Ibrahim Isa. 2011. Multivariate analysis of morph structural characteristics in Nigerian indigenous sheep. *Italian J. Anim. Sci*. 10 (2): 83–86.

Yang, H., Lin, H., Huang, M., Li, L., Pan, W., Wu, J. and Chen, Y. 2010. Anew analysis tool for individual level allele frequency for genomic studies. *BMC Genomics* 11(1):1–14.

Yoshida, T., Ellner, S. P., Jones, L. E., Bohannan, Brendan, J.M., Lenski, Richard, E., Hairston, Nelson G. 2007. Cryptic population dynamics: Rapid evolution masks trophic interactions. *PLoS Biology* 5(9):1868–1879.

Zewdu Edea B., Bikila N. G, and Gurmesa T. D. 2009. Morphometric and Physical Characterization of Borana Indigenous Goats in Southern Oromia, Ethiopia. *Universal Journal of Agricultural Research,* 7(1): 25–31.

7. APPENDICES

Appendix A. Data collection sheet

I. Data collection sheet for qualitative traits

Region ____ Zone ____ District _____ Kebele_____ Date ____ Name of enumerator____

S\No	Farmer's name	Color pattern	Color type	Skin color	Horn shape	Horn orient.	Ear orient.	Head profile	wattles	beard
1										
2										
3										
4										

II. Data collection format for quantitative traits

Region ____ Zone ____ District _____ Kebele_____ Date ____ Name of enumerator____

				Value of LBM in CM and Live body weight in Kg							
S\No	Farmer's name	Ag	Sex	BW	BL	HG	HW	RH	RL	CD	CW
1											
2											
3											
S\No	Farmer's name	Ag	Sex	NL	HOL	SC	He. W	He. L	EL	PW	TL
1											
2											
3											

BL=Body length, HG=Heart Girth, HW=height at wither, BW=Body weight, CHD =chest depth, CHL=chest length, NL= neck length, HL=Horn length, SC =Scrotum circumstance, HW= head width, HL = head length, PW= pelvic width, EL= ear length, TL =teat length

Appendix B. Tables

Appendix table 1 : Description of qualitative traits and their respective code

Parameters	Code/ Description/
Agroecology	1= Highland, 2= Midland, 3=Lowland
Sex	1=Male , 2=Female
Coat color pattern	1= plain 2=pied 3= spotted
Coat color type	1= white 2= black, 3= dark red, 4= light red 5=fawn 6=grey,7=brown
Hair coat type	1= Glossy, 2=short & smooth, 3=long straight ,4=curly 5=dull
Body skin pigment	1=pigmented, 2=no pigment
Horn	1 =present, 2=absent
Horn shape	1= Scurs, 2= straight, 3= curved, 4=spiral, 5=corkscrew
Horn orientation	1=Lateral, 2= oblique upward , 3= backward
Ear orientation	1= erect, 2= semi pendulous , 3=pendulous, 4= carried horizontal
Head profile	1=straight, 2= concave , 3= convex
Beard	1= present, 2= absent
Wattles	1= present, 2= absent
Dentation class	
1PPI	1Pair of permanent incisor
2PPI	2 Pair of permanent incisor
3PPI	3 Pair of permanent incisor
4PPI	4 Pair of permanent incisor

Appendix table 2 : Description of quantitative traits recorded for each sampled animal

Parameter	Unit	Description
Body weight	Kg	Taken early in the morning using 50 kg spring balance
Body length	Cm	The horizontal distance from the point of shoulder to the pin bone
Heart girth	Cm	The height from the bottom of the front foot to the highest point of the shoulder between the withers to the nearest centimeter
Wither height	Cm	The distance around the animal measured directly behind the front leg to the nearest centimeter
Rump height	Cm	Height from the bottom of the hind leg to the highest point of rump when the animal was standing upright
Rump length	Cm	Measured from the back of the rump to the hook bones
Chest depth	Cm	The dorsal ventral distance between the most dorsal point of the withers and the ventral surface of the sternum
Horn length	Cm	Length of the horn on its exterior side from its root at the poll to the tip
Pelvic width	Cm	The distance between the pelvic bones across dorsum
Ear length	Cm	The length of the ear on its exterior side from root at the poll to the tip
Head width	Cm	The point between the two broadest parts of the skull adjacent to the ear
Head length	Cm	The length of the face from the poll of the animal to the end of muzzle
Horn length	Cm	Length of the horn on its exterior side from its root at the poll to the tip

Appendix table 3. ANOVA table of morphometric traits

Sources of variation	DF	Body Length	Heart Girth	Withers Height	Rump Height
Agroecology	2	114.2836257**	145.040936**	117.418129**	129.013158**
Sex	1	510.619248**	572.060359**	245.688630**	246.051203**
Dentation	3	83.791262**	42.181770**	14.939740*	15.661327*

Sources of variation	DF	Rump Length	Body Weight	Chest Width	Chest Depth
Agroecology	2	154.709064**	171.381579**	33.9195906**	92.356725**
Sex	1	195.379248**	570.678571**	163.8027068**	250.605923**
Dentation	3	20.304259*	38.043022*	7.4678172*	18.295167**

Sources of variation	DF	Neck Length	Horn Length	Scrotum Circumstances	Head Width
Agroecology	2	82.368421	72.842105**	1.78363^{ns}	75.347953**
Sex	1	64.193684**	296.854812**	NA	330.842515**
Dentation	3	5.821603^{ns}	84.137728**	208.74512**	292.854101**

Sources of variation	DF	Head Length	Ear Length	Pelvic Width	Teat Length
Agroecology	2	93.615497**	7.7558480^{ns}	30.4283626**	1.1023392^{ns}
Sex	1	376.701963**	3.9544194^{ns}	50.2281036**	NA
Dentation	3	317.281198**	3.5853387^{ns}	7.8247354**	7.3680815**

Appendix C. Figure

Figure in appendix1.Atypical male and female goat in the study area (Left male, Right female)

Figure in appendix 2.Feeding habit of the goats in the study area (left midland, right highland)

BIOGRAPHICAL SKETCH

The author of this Thesis, Mr. Genanew Abera was born on May 21, 1990 in Hidabu Abote Woreda, North Shoa Zone of Oromia National Regional State from his father Ato Abera Teshome and mother W/ro Ayelech Haile. He attended his primary education in Alemgena elementary school (1998-2006) and his secondary in General Tadesse Biru secondary school (2007-2008) and his preparatory education in Gebre Guracha preparatory and high school (2009-2010). He joined Meda Walabu University College of Agriculture and Environmental Sciences (2011-2013) and awarded a BSc degree in Agriculture (Animal and Range Sciences), and graduated with Bachelor degree in Animal and Range Sciences on June 2013. After his graduation, he was employed as Instructor in Alage ATVET College in Animal Sciences department. He joined the School of Graduate Studies (SGS) of Hawassa University to pursue his MSc study in Animal Breeding and Genetics in the School of Animal and Range Sciences.

.