ON-FARM PHENOTYPIC CHARACTERIZATION AND PERFORMANCE EVALUATION OF BATI, BORENA AND SHORT EARED SOMALI GOAT POPULATIONS OF ETHIOPIA

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ON-FARM PHENOTYIC CHARACTERIZATION AND PERFORMANCE EVLUATION OF BATI, BORENA AND SHORT EARED SOMALI GOAT POPULATIONS OF ETHIOPIA

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By

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As Thesis Research advisors, we hereby certify that we have read and evaluated this thesis prepared, under our guidance, by **Hulunim Gatew** *entitled* **On-Farm Phenotypic Characterization and Performance Evaluation of Bati, Borena and Short-Eared Somali Goat Populations of Ethiopia.** *We recommend that it be submitted as fulfilling the Thesis requirement.*

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DEDICATION

I dedicate this Thesis manuscript to my mother W/ro **ASCHAL MEHARI,** my father Ato **GATEW TARIKU** and my lovely sister **BEGOADRAGOT GATEW** whom I lost when I was first year of MSc student**. BEGO** GOD rest your soul in absolute peace.

STATEMENT OF AUTHOR

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BIOGRAPHICAL SKETCH

The author of this thesis, Mr. Hulunim Gatew, was born on July 23, 1985 at Machakel District, East Gojjam Zone, Amhara Regional State, Ethiopia from his father Ato Gatew Tariku and mother W/ro Aschal Mehari. He attended his primary education at Medebebegn Elementary School; and his secondary education at Amanuel Senior Secondary and Debre Markos Higher Education Preparatory Schools. He then joined Haramaya University, College of Agriculture department of Animal Production in 2007 and awarded a B.Sc. degree in Agriculture (Animal Production) in July 2009.

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ACRONYMS AND ABBERVATIONS

ADG	Average Daily Gain
AFK	Age at First Kidding
AFLP	Amplified Fragment Length Polymorphism
AIC	Akaike Information Criteria
AnGR	Animal Genetic Resources
BC	Body Condition
BIC	Bayesian Information Criteria
BL	Body Length
BL	Body Length
BW	Body Weight
CAHWs	Community Animal Health Workers
CANDISC	Canonical Discriminant Analysis
CCPP	Contagious Caprine Pleuro Pneumonia
CG	Chest Girth
CP	Conceptual Predictive
CSA	Central Statistics Agency
CTA	Technical Center for Agricultural and Rural Co-operation
CV	Coefficient of Variation
CW	Chest Width
DISCRIM	Discriminant analysis
DNA	Deoxyribonucleic Acid
DPPA	Disaster Preparedness and Prevention Agency
EL	Ear Length
EL	Ear Length
F1	First Filial Generation
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistical Database
FMD	Foot and Mouth Disease
GLM	General linear model
GTZ	German Organization for Technical Cooperation
HL	Horn Length
HW	Height at Withers

ACRONYMS AND ABBERVATIONS (*Continued*)

IBC	Institute of Biodiversity Conservation
ICARDA	International Center for Agricultural Research in the Dry Areas
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
KI	Kidding Interval
LPAR	Livelihood Profile of Amhara Region
LS	Litter Size
masl	meters above sea level
mtDNA	mitochondrial Deoxyribonucleic Acid
NGOs	None Governmental Organizations
PCR	Polymerase Chain Reaction
PPI	Pair of Permanent Incisor
PPR	Pest des Petit Ruminants
PW	Pelvic Width
PW	Pelvic Width
R^2	Coefficient of Determination
RAPD	Random Amplified Polymorphic Deoxyribonucleic Acid
RFLP	Restriction Fragment Length Polymorphism
RL	Rump Length
SAS	Statistical Analysis System
SC	Scrotum Circumference
SCUK	Save the Children United Kingdom
SES	Short-Eared Somali
SNP	Single Nucleotide Polymorphism
SSR	Simple Sequence Repeats
STEPDISC	Stepwise Discriminant Analysis

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ON-FARM PHENOTYPIC CHARACTERIZATION AND PERFORMANCE EVALUATION OF BATI, BORENA AND SHORT EARED SOMALI GOAT POPULATIONS OF ETHIOPIA

ABSTRACT

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The objectives of this study were to describe the production systems, the morphological features, and growth and reproductive performances of Bati (Central Highland ecotype), Borena (Long eared Somali ecotype) and Short-eared Somali indigenous goat populations in their home tract, Ethiopia. The study covered Bati and Kalu districts for Bati goats in Oromiya and South Wollo zones (Amhara Region), respectively; Yabello for Borena goats in Borena zone (Oromia Region); and Shinille and Erer from Siti (the previous Shinille zone, in Somali Region) for Short-Eared Somali goats. For production systems description and morphological characterization of the three goat breeds a total of 601 heads of adult goats comprising 162 Bati (128 females and 34 males), 246 Borena (201 females and 45 males) and 193 Short-eared Somali (139 females and 54 males) were selected. In addition, flock monitoring were carried out and two PAs for each goat population were selected and a total of 125 household flocks (46 Bati, 48 Borena and 31 Short-Eared Somali) were monitored (beginning of April, 2013 to end December, 2013) to generate growth performance data. In terms of number, goats were the predominant species in all surveyed areas. The average (±SE) goat flock size (44.02±3.33) owned per household of Siti was significantly ($p<0.05$) higher followed by Borena (23.08±1.94). Source of cash was a primary objective of goat rearing in Borena and Bati areas, while milk production was ranked 1st in Siti. A range of traits: body size, fast growth rate, milk yield, reproduction rate, drought tolerance and disease resistance were some of the important performance and adaptive traits preferred by the producers across study areas. Natural pasture (shrubs and bushes) was found to be the major source of goat feed across the study areas. Age at 1st kidding in Bati, Borena and Siti areas averaged 14.98±0.24, 15.86±0.22 and 20.15±0.12 months and average kidding intervals of 7.95±0.19, 8.42±0.17 and 8.81±0.18monthswere also noted, respectively. The major challenges of goat husbandry include feed and water shortage, disease incidence and recurrent drought with different *prioritization across areas. The common goat diseases reported in the study areas were pneumonia, pasteurellosis, babesiosis, anthrax and goat pox, external parasites, contagious caprine pleuro pneumonia (CCPP), coenurosis, diarrhea and pest des petit ruminants (PPR). The studied goat populations have a wide range of coat colors including plain brown (dark and light) (51.85%) which were the predominant coat color observed on Bati goats of both sexes. Meanwhile, plain white coat color was most frequently observed on Borena goats (71.54%) and only 36.27% in Short-eared Somali goat populations. Though most quantitative traits showed slightly higher average values in the Bati goats, differences with Borena goats were not significant ($p>0.05$),whereas Short-eared Somali goats remained significantly ($p<0.05$) lower for most of the body measurement characteristics. Average live weight of Bati, Borena and Short-eared Somali does were 33.97±0.4, 31.49±0.36 and 24.67±0.28kg, respectively and the corresponding values for bucks were 41.30±0.85, 40.04±1.21 and 30.62±0.67kg. Correlation coefficient was consistently highest between live weight and chest girth in both sexes across the goat populations. As a result, the stepwise multiple regression analysis revealed that chest girth was the single variable of utmost importance in the prediction of live body weight except for Short-eared Somali bucks, where body condition accounted the larger variation in body weight. Though K-Nearest Neighbor Discriminant Function Analysis classified most individuals of both sexes into their source population in all areas, the highest hit rate was found in Borena does (96.02%) and in Short-eared Somali bucks (94.4%). The canonical discriminant analysis depicted the largest Mahalanobis' distance between Borena and Short-eared Somali goats while the least differentiation was observed between Bati and Borena goats. Non-genetic factors (sex and parity of dam) and genetic factor (goat ecotype) had significant ($p<0.05$) effect on the average live weight and daily weight gain of young goats at different ages. However, type of birth had non-significant effect on daily weight gain of all goat types and on live weight of Short-eared Somali kids at different ages (birth, 30, 90 and 180 days). Bati kids had the heaviest overall live weight at birth (2.70±0.05kg) followed by Borena (2.42±0.05 kg). Therefore, the growth performance of these goat ecotypes is encouraging and can be further improved genetically through selection.*

Key words: Constraint · Discriminant analysis · live weight · Management practices · Morphological features ·

1. INTRODUCTION

The World Development Report (2010) estimated that about 410 million people in Sub-Saharan Africa live in absolute poverty, surviving on less than one dollar per day. The poor have no access to the basic necessities of life such as food, clothing and decent shelter, are unable to meet social and economic obligations, lack the skills for gainful employment, and have few if any economic assets and a general lack of self-esteem. However, rearing of small ruminants (sheep and goats) would have lasting effects in bringing about social change by improving the incomes of these people (Okpecku *et al.*, 2011).

Small ruminants provide their owners with a vast range of products and services. They contribute to landless, rural farming, peri-urban and increasingly to urban households by providing food, income, manure and clothing (Pollott and Wilson, 2009; Oluwatayo and Oluwatayo, 2012; Kurnianto *et al*., 2013). According to these authors, they also make important indirect contributions to households through the use of crop by-products, integration with other farming enterprises, and in the social, cultural and religious aspects of everyday life. In addition to these, there are no banking facilities in rural areas and an easy way to store cash for future needs are through the purchase of small ruminants (IBC, 2004).

In Ethiopia, goats kept in different parts of the country for the purpose of food source, income generation, socio-cultural wealth and source of other valuable non-food products used as raw materials for various traditional household products manufactured in local cottage industries. Goats in the lowlands of the country kept both for milk and meat production, whereas in the highlands they are mainly kept for meat and income generation (Aschalew *et al.*, 2000; Tesfaye, 2009). Goat milk is used as food and medicine both in special preparations by traditional healers as well in its raw state by ordinary people.

The wide ranging production systems of Ethiopia have further contributed to the existence of a large diversity of farm animal genetic resources (IBC, 2004). According to the livestock survey result (CSA, 2013), the country has an estimated 24.06 million heads of goats. This puts the country eighth among the top ten countries (China, India, Pakistan, Bangladesh, Nigeria, Sudan, Iran, Ethiopia, Mongolia and Indonesia) in the world and third in Africa (next to Nigeria and Sudan) those possesses the largest number of goat populations (FAOSTAT, 2013). As a result, the indigenous goat types are widely distributed and are found in all administrative regions of the country.

Despite the wide distribution and large size of the Ethiopian goat population, the productivity per unit of animal and the contribution of this sector to the national economy is relatively low. This may be due to different factors such as poor nutrition, prevalence of diseases, lack of appropriate breeding strategies and poor understanding of the production system as a whole (Tesfaye, 2009). Therefore, characterization of the production systems and the available genetic resources is necessary to design improvement programs in the future.

Designing of improvement programs will only be successful when accompanied by a good understanding of the different farming systems and when simultaneously addressing several constraints e.g., feeding, health control, management, and cost and availability of credit and marketing infrastructure (Baker and Gray, 2003). Understanding the existing small-scale goat keepers' diversity of management strategies (feeding, breeding, housing, watering, health control) and the challenges they face enable to develop effective intervention strategies. The characterization of local genetic resources (based on morphological traits) plays a very fundamental role in classification of animals based on size and shape in turn which can be to some extent reasonable economic indicator (Okpeku *et al*., 2011). Improved utilization of the local genetic resources and prioritization for conservation will be added advantages.

Improvements were also too slow due to lack of identifying the actual on-farm situations and weighting the socio-economic and cultural benefits of the animals for the poor farmers (Workneh *et al*., 2003). To design improvement measures relevant to specific systems and thereby properly respond to the growing domestic and foreign demands for live goats and goat products; characterizing distinct goat breeds/populations, describing their external production characteristics in a given environment and management, identifying the social and economic constraints are important.

However, before the last decade, goat research was limited in certain areas and issues in Ethiopia, due to lack of enough man power, limited budget allocation, limited funds from donors. (Aschalew *et al*., 2000; Halima and Tessema personal communication). But these days, the Ethiopian government gave more attention and the scenario has been changed. As a result, different research works (particularly phenotypic and genetic characterizations research activities) had been executed in different parts of the country by different organizations and individuals (FARM Africa, 1996; Tesfaye, 2004; Tesfaye, 2009; Tesfaye, 2010; Grum, 2010; Halima *et al*., 2012a; Halima *et al*., 2012b). Despite the researches done, information on phenotypic characteristics, production systems and reproductive performances of different indigenous goat populations is still scanty.

Although there are now considerable published researches on indigenous goat performance in Ethiopia, much of the works published has the disadvantage of having been carried out only under controlled conditions at research stations where the results may not reflect the performance of goats' in the communal (traditional) production systems in rural areas. In addition, most of the performance results do not explained in relation with phenotypic characteristics of the populations.

The majority of Ethiopian goat populations (70%) are kept by pastoralists and agro-pastoralists in arid and semi-arid lowlands (Alemayehu, 1993). South Wollo (eastern part) and Oromiya Administrative Zones of Amhara Region, Siti zone of Somali Region and Borena Zone of Oromia Region are lowland parts of the country, where Bati, Short-eared Somali and Borena goat populations found respectively. Characterizing these goat populations and describing their production environment will be very essential to design management and utilization strategies. Therefore, this study was designed with the following objectives:

- To carry out systematic survey and generate information on indigenous goat populations utilization, management practices and challenges
- To describe and characterize the physical characteristics of indigenous goat populations
- To characterize the growth and reproductive performances of the selected indigenous goat populations in their production system and environment

2. LITERATURE REVIEW

2.1. Origin and Domestication of Goats

The domestic goat (*Capra hircus*) is an important livestock species throughout the entire Asian and African continents (Missohou *et al*., 2006). They are the earliest domestic animal and probably the first ruminant livestock, after the wolf was domesticated (Zeder and Hasse, 2000). There are two reasons for this: firstly, the wild goat was reported to be present in the regions of southwest Asia during the time when agriculture was developing. Secondly, the goat is an extremely hardy animal, hence, could have withstood the rigors of being reduced to the state of domestication better than other ruminants.

Despite their importance, the origins of goats remain uncertain, controversial and poorly understood (Luikart *et al.,* 2001). However, archaeological evidence indicates that goats were one of the first animals to be domesticated by man around 10,000 years ago, in the Ganj-Darch in the Zagros mountain pastures (Iran) (Zeder and Hasse, 2000). Luikart *et al.* (2001) sequenced the first hyper-variable segment of the mtDNA control region of 406 goats representing 88 breeds originating from 44 countries throughout Europe, Asia, Africa, and the Middle East. Phylogeographic analysis revealed that three highly divergent goat lineages (estimated divergence >200,000 years ago), with one lineage occurring only in eastern and southern Asia. These results, combined with archaeological findings, suggest that goats and other farm animals have multiple maternal origins with a possible center of origin in Asia in the region known as Fertile Crescent (Jordan, Syria, Turkey, Iraq and Iran including Tigris and Euphrates rivers as well as Zagros Mountain) (Zeder and Hasse, 2000). In their study, from the pattern of goat mtDNA diversity suggested that all three lineages have undergone population expansions, but the expansion was relatively recent for two of the lineages (including the Asian lineage). Whereas some studies have suggested that an independent domestication in Pakistan gave rise to the Cashmere breeds (Porter, 1996).

The wild ancestors of domestic goats were believed to include the Ibex (*Capra ibex*) and the Bezoar (*Capra aegagrus*), animals of steep hills and mountain sides in Asia Minor. Later, domesticated goats spread to North Africa and Southern Europe. The lands they inhabited were either hot and dry, or cold and barren with few plants (Machugh and Bradley, 2001).

The wild endemic species of walia ibex (*Capra ibex walie*) has been maintained in a wildlife reserve area in Ethiopia Simien mountains national park, (SMNP). Due to closer genetic similarity between Walia ibex (*Capra ibex walie*) and domestic goat (*Capra hircus*) and the location of the park around the vicinity of human settlements, there was a fear of interbreeding between domestic goat (*Capra hircus*) and Walia ibex (*Capra ibex walie*) (Alemayehu *et al*. 2011). However, these authors concluded that there is no genetic introgression between Walia ibex (*Capra ibex walie*) and domestic goats (*Capra hircus*).

2.2. Indigenous Goat Genetic Resources and Distribution in Africa

Indigenous goats of Africa have been described as large, small and dwarf type (Table 1). Large types, which may also have disproportionately long legs, are found along the southern fringe of the Sahara and in Southern Africa. The small type is mainly distributed in Eastern Africa whereas the dwarf types, which are also to some extent tolerance of trypanosomiasis and more prolific, are found mainly in humid Western Africa (FAO, 1985).

From the world goat population (861.9 million), the largest number is found in Asia, followed by Africa, representing about 59.7% and 33.8%, respectively (FAOSTAT, 2008). In Africa, these animals are spanned in Nigeria, Ethiopia, Sudan and Somalia. From a total of 351 goat breeds of the world, about 146 goat breeds are found in Asia and 59 in Africa (Devendra, 1998).

Table 1. Types and distribution of some African goats

Goat types/breeds	Distribution	Reference
Large goats (Africander, Pafuri, Tswana, Swazi, Ndebele, Landim, Shukria, Sudan Desert, West African Long-Legged)	Southern fringe of Sahara and in Southern Africa	FAO, 1985
Small goats (Red Sokoto, Afar, Mubende, Kigezi, Boran,Masai, Rwanda and Burind, Malawi, Zimbabwe (Mashona))	Eastern Africa	
Dwarf goats(West African dwarf)	Western Africa	

2.3. Ethiopian Indigenous Goat Genetic Resources and Distribution

Ethiopia has diverse topographic, climatic conditions and wide production systems (IBC, 2004). The country has long been recognized as source of large diversity of farm animal genetic resources (*e.g.*, goat, sheep, and cattle) in which an estimated 24.06 million heads of goats are reared (CSA, 2013). Based on the goat physical, morphological and functional characteristics descriptors, the Ethiopian goats have been phenotypically classified into 12 types (Table 2). Tesfaye (2004) has classified these indigenous goat types of Ethiopia in to 8 distinct genetic entities using genetic DNA markers, These are:- Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergalle, Afar, Highland goats (previously separated as Central and North West Highland) and the goats from the previously known Hararghe, South eastern Bale and Southern Sidamo provinces (Hararghe Highland, Short-eared Somali and Long-eared Somali goats). Based on their morphological characteristics, Halima *et al.* (2012a) characterized six goat ecotypes (Gumuz, Begia-Medir, Agew (West Amhara Region goat population) and Bati, Central Abergelle and Abergelle (east Amhara Region goat population) found in Amhara Region of Ethiopia and clustered in to two main groups. Gumuz, Agew and Begie-Medir the first group and Bati, Abergelle and Central Abergelle as the second group. These goat populations also genetically characterized using 15 microsatellite markers and revealed reseanable amount of genetic diversity within and between populations (Halima *et al*., 2012b).

Table 2. Distribution of documented indigenous goat types in Ethiopia

Goat types	Synonym	Distribution
Barka	Bellenay, Beni Amer	Northern and northwestern Ethiopia near the border with Eritrea and the Sudan
Long eared Somali	Digodi, Melebo, Boran Somali, Benadir, Gigwain	Rangel and of thesouthern Ogaden, Bale,Borana and Southern Sidamo With the Somali and Borana Pastoralists
Short eared Somali	Ogaden, Mudugh, Dighier,Abgal, Issa-Somali, Bimal	Northern and Eastern Ogaden and around Dire Dawa
Western Highland	Agew	Highlands of Western Ethiopia (Gonder,Gojjam, Wollega and Shoa)
Western Low land	Gumuz	Lowlands of Western Ethiopia (Metekel, Assosa, and Gambella)
Woyto-Guji	Woyto, Guji, Konso	North Omo, South Omo, Sidamo, Borana
Abergelle	Na	Southern Tigray, North Wollo, and South Gonder
Afar	Adal, Assaorta, Denakil	Afar region and parts of Eritrea and Djibouti with the Afar Pastoralists
Central Highland	Brown Goat, Kaye	Highland of Central Ethiopia from Tigray through Wollo, Gonder to Shoa
Hararghe Highland	Kotu-Oromo	Highlands of Eastern and Western Hararghe
Keffa	NA	Keffa and adjoining parts of Kembata and Hadiya
Arsi-Bale	Gishe, Sidama	Arsi and Bale, higher altitudes of Sidamo and West Shewa

Source: FARM-Africa; NA= Not Available

In lowland areas, goats rely on browsing and grazing whereas in the highlands they depend on communal grazing, fallow lands and crop residues (Aschalew *et al.*, 2000). Therefore, based on the availability of land, feed and reliability of crop production, flock sizes of goat vary with the production system and the production environment. Due to availability of grazing area in lowlands and crop residues in moist highlands, larger flocks are found in lowlands and moist highlands than highly populated and sub-moist highlands areas (Solomon *et al*., 2010).

2.4. Socio-Economic Importance of Goats

Small ruminants have economic importance to small-holder farmers including female-headed households. The total income share from small ruminants tends to be inversely related to size of land-holding, suggesting that small ruminants are of particular importance for landless people especially for rural women (Oluwatayo and Oluwatayo, 2012). In some cultural settings, women are often not entitled to own land. For instance, African rural women (such as in Nigeria, Kenya, and Tanzania) have limited access to household's land and receive limited land use rights from their husbands (Quisumbing *et al*., 2001). As a result, crop production provides seasonal employment; hence, rearing of small ruminants would provide an employment opportunity and income throughout the year.

In Ethiopia, livestock in general goats in particular plays a very important role in the lives of households. They have a great role in the economy of farming community of the country. Sale of goats and goat products (meat, skin and milk) by farming communities is the major source of cash for purchase of clothes, grains and other essential household commodities (Deribe, 2009; Tesfaye, 2009). In addition, goats are raised mostly to safeguard against crop failure and unfavorable crop prices in intensive cropping areas. In Ethiopia, the purpose of keeping goats by smallholder farmers is to generate income, for labor, wage payment followed by food crop purchase, input purchase, school fee and as means of tax in that order (Deribe, 2009; Tesfaye, 2009).

2.5. Methods of Animal Genetic Resources Characterization

Characterization, inventory and monitoring of the trends of AnGR diversity were among the strategic priority areas of Global Plan of Action for Animal Genetic Resources (FAO, 2007).

Most breeds originating from industrialized countries are well-defined and phenotypically distinct and were genetically isolated throughout the course of their development. In contrast, Asian and African livestock breeds most often correspond to local populations that differ only gradually according to geographical separation. In addition, breeds with different names may sometimes have a recent common origin, while in other cases their uniqueness has been eroded by cross-breeding (FAO, 2011).

Characterization is defined as the description of a character or trait of an individual. The word 'characterize' is also a synonym of 'distinguish', that is, to mark as separate or different, or to separate into kinds, classes or categories. Thus, characterization of genetic resources refers to the process by which populations or ecotypes are identified or differentiated. Characterization of AnGR encompasses all activities associated with the identification, quantitative and qualitative description, and documentation of breed populations and the natural habitats and production systems to which they are or are not adapted. The aim is to obtain better knowledge of AnGR, of their present and potential future uses for food and agriculture in defined environments, and their current state as distinct breed populations (FAO, 2007). The weight given to each depends on the country (e.g. whether it is developed or developing) and the objective (*e.g*. improvement, conservation or breed differentiation) (FAO, 2012).

2.5.1. Description/characterization of production systems

Production environments, intensities and purposes of production, vary greatly within and across countries. The majority of small ruminant populations (70%) found in the developing countries are in grazing system. The grazing systems are primarily found in the more marginal areas which are unfit for cropping because of topography, low temperature or low rainfall (Steinfeld *et al*., 2006).

In Ethiopia, depending on the environmental and social conditions different management systems are prevailing in goat production. The majority of systems are described under low input production system which characterized by land scarcity, severe resources degradation and recurrent drought. It accommodates more than 95% of the livestock population (IBC, 2004). Based on the prevalent agricultural activity, Getahun (2008) reported four production system categories. This includes, annual crop-based systems (Northern, North-Western and central Ethiopia), perennial crop-based systems (mainly Southern and South-Western highlands), cattle-based systems (agro-pastoral and arid areas), and small ruminant dominated systems (pastoral, Eastern and North-Eastern areas). Considering degree of integration with crop production and contribution to livelihood, level of input and intensity of production, agro-ecology, length of growing period and relation to land and type of commodity to be produced, Solomon *et al.* (2008) also put the prevailing production systems in to three major categories. These are: highland sheep–barley system, mixed crop–livestock system, and pastoral and agro-pastoral production systems. Understanding and description of the production systems is useful in the design of development strategies, in particular for identifying target populations and priorities and opportunities for development (Fernandez-Rivera *et al*., 2004).

According to Steinfeld *et al*., (2006), due to rapidly evolving socio-economic conditions; many of the systems that are the result of a long evolution are under pressure to adjust to large intensive livestock production units. In Ethiopia, Solomon *et al*., (2008) also stated that ranching, urban and peri-urban (landless) sheep and goat production systems are the other production systems that are not practiced widely in the country but have a future.

2.5.2. Phenotypic characterization

Phenotypic characterization of AnGR is the process of identifying distinct breeds or populations by describing their external and production characteristics in a given environment and under given management, taking into account the social and economic factors. The information generated by characterization studies is essential for planning the management of AnGR at local, national, regional and global levels (FAO, 2012). The Global Plan of Action for Animal Genetic Resources (FAO, 2007) recognizes that "a good understanding of breed characteristics is necessary to guide decision-making in livestock development and breeding programs".

Nowadays, there is a great interest worldwide in conservation and improved utilization of goat genetic resources. Phenotypic characterization is essential in mapping out an inventory of characteristics peculiar to a group of animals and sustainable use of its animal genetic resources. Lack of information on characterization of genetic resource may lead to underutilization of that resource, its replacement and dilution through cross breeding despite their local adaptation to prevailing environmental constraints (Manzi *et al*., 2011).

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

Breed characterization through phenotype, is based on the description of qualitative and quantitative traits. Qualitative traits to be recorded during phenotypic characterization of goat breeds are sex, estimated age (dentition), coat color pattern and type, horn shape, horn and ear orientation, facial (head) and back profile as well as presence or absence of wattles, beard, and ruff. Whereas quantitative traits include the measurements of body length , height at withers, chest girth, chest depth, shoulder point width, head length, head width, rump length, pelvic width, horn length , ear length, shin circumference and scrotum circumference for males (FAO,2012).

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

2.5.3. Molecular Genetic characterization

Phenotypic characterization provides a crude estimate of the average of the functional variants of genes carried by a given individual or population. Now a day, genomic and bioinformatics advances have created opportunities to characterize livestock in terms of the function of their genes. Molecular genetic characterization, by itself or in conjunction with other data (phenotypic traits or geo-referenced data), provides reliable information to assess the amount of genetic diversity. Information about the genetic make-up of populations also helps decision making for conservation activities (Boettcher *et al*., 2010).

Protein polymorphisms were the first molecular markers used in livestock. A large number of studies, particularly during the 1970's, have documented the characterization of blood group and allozyme systems of livestock (Baker and Manwell, 1980). However, the level of polymorphism observed in proteins is often low which has reduced the general applicability of protein typing in diversity studies. With the development of Polymerase Chain Reaction (PCR) and sequencing technologies associated with automatic and/or semi-automatic large scale screening system, several molecular markers have been widely used for genetic diversity and phylogenetic analyses (Charoensook *et al*., 2013) in livestock breeds or populations. A number of molecular markers are available to detect polymorphisms at the DNA level. The most popular markers in genetic diversity studies are simple sequence repeats (SSR) or microsatellites, restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD), amplified fragment length polymorphism (AFLP), single nucleotide polymorphism (SNP) and mitochondrial DNA (mtDNA) analysis (Charoensook *et al*., 2013). They can be used to build up genetic maps and to evaluate differences between markers in the expression of particular traits that might indicate a direct effect of these differences in terms of genetic determination on the trait (Vignal *et al.*, 2002). The advantages and limitations of most popular molecular markers are summarized in Table 3.

Even though, the commercial applicability of genetic markers has been relatively limited due to limitations of the technologies available (Dekkers, 2004), the entire genomic sequences of several livestock species are now offered. The increased quantity of genomic information considerably facilitates candidate gene analysis and makes genomic scans more accurate.

Consequently, Candidate genes can be chosen based on both their biological function and their genomic position (Schulman *et al*., 2009). Since the costs for DNA sequencing have decreased (Shendure and Ji, 2008), in the coming years, even more effective sequencing systems will be available and allow very low cost whole genome sequencing. However, due to the faster increasing of tools for molecular characterization of livestock breeds, storing, organizing, analyzing, and exploitation will be the future challenge for researchers.

The Food and Agricultural Organization (FAO) of the United Nations has proposed a global program for the management of genetic resources using molecular methodology for breed characterization (Bjornstad and Roed, 2001). However, in Ethiopia, only limited goat genetic characterization activities (Tesfaye, 2004; Halima, 2012b) had been conducted on some goat breeds using microsatellite markers.

Table 3. Advantages and disadvantages of most popular molecular markers

Marker	Advantages	Disadvantages	References
RFLP	Produces co-dominant, stable and reproducible and selective neutrality	Long methodology, labour intensive and require high quality and large quantities of DNA	Mburu and Hanotte, 2005
RAPD	Cost effective, simple and quick, large number of bands are produced and no prior sequence knowledge is necessary	Detection of polymorphism is limited, reproducibility of results maybe be inconsistent and dominant markers	Mburu and Hanotte, 2005; Charoensook *et al*., 2013
AFLP	Sensitive, large number of polymorphisms is generated and no prior sequence information or probe generation is needed	Expensive, dominant markers and technically demanding	Mburu and Hanotte, 2005
SSR	Low quantities of template DNA required, high genomic abundance, random distribution, high level of polymorphism, different microsatellite can be multiplied, co-dominant markers, high reproducibility, wide range of applicability, amenable to automation etc.	Expensive, homoplasy due to different forward and backward mutations may underestimate genetic divergence, underlying mutation model largely unknown time consuming, etc.	Mburu and Hanotte, 2005
SNP	Highly reproducible and very informative	Expensive and previous know ledge of sequence required	Mburu and Hanotte, 2005; Charoensook *et al*., 2013
mtDNA	Applicable to all biological source material, very high sensitivity and maternal inheritance	Expensive, heteroplasmy (few single base pair difference might be there in different cells of the same individual unlike the nuclear DNA	Kisa, 2006; Mburu and Hanotte, 2005

RFLP = restriction fragment length polymorphism, RAPD = random amplified polymorphic deoxyribonucleic acid, AFLP = amplified fragment length polymorphism, SSR = simple sequence repeats, SNP = single nucleotide polymorphism, mtDNA = mitochondrial Deoxyribonucleic Acid

2.6. AnGR Conservation and Utilization Strategies

Animal genetic resource conservation involves all human activities including strategies, plans, and actions undertaken to ensure that the diversity of farm animal genetic resource is being maintained to contribute to the food and agriculture production and productivity, now and in the future (Kohler-Rollefson, 2004). Conservation strategies can be categorized as either *in-situ* conservation where the breed is maintained in the environment in which it is developing, or *ex-situ* conservation for all other cases. The latter can be further divided into *ex-situ in vivo* conservation where breeds are kept in a different environment including farm parks, and as *ex-situ in vitro*, utilizing cryogenic storage of semen, oocytes, embryos or DNA (FAO, 1999).

Conserving breeds is comparable to the conservation and maintenance of cultural-historical aspects, buildings and environments (Maijala *et al*, 1984). Results from cross bred goats in an upgrading program in Ethiopia showed no increased benefits compared to indigenous goats under improved management (FAO, 2002). It seems that the emphasis is on the improvement of local breeds rather than on the conservation of the breeds. Failure to conserve domesticated genetic resources will definitely lead to a situation where a large portion of goat's genome will be on the verge of being lost. Understanding the diversity, distribution, basic characteristics, comparative performance and the current status of animal genetic resources is essential for efficient, and sustainable use, development and conservation, which enables farmers to determine which breed to use under prevailing production conditions (FAO, 2007). Therefore, effective conservation and use of animal genetic resources is vital for creating and maintaining sustainable increases in the productivity of healthy food for mankind, as well as contributing to the increased resilience of biodiversity. Nevertheless, the rates of AnGR losses in developing countries have notably increasing at higher rates (Anderson, 2003).

2.7. Reproductive Performance of Goats

Reproduction efficiency is one of the most important economic traits in terms of livestock production. Maintaining good reproductive functions in the herd is pivotal to the success of any livestock production system and has to be given priority (Barding *et al*., 2000). Productivity and profitability of a goat flock are measured by age of goats at first kidding,

kidding interval, type of birth or litter size and mass of kids at birth, weaning (Song *et al*., 2006) and rate of morbidity and mortality. The evaluation of the reproductive performance of a local breed of goats can provide important information to understand its' productive potential using local resources. Such information is very important to undertake any breed improvement work in the rural areas.

Performance testing is the comparative evaluation of animals for production and reproduction traits of economic importance that plays pivotal role in sustainable animal production industry. The level of reproductive performance is dependent on the interaction of genetic and environmental factors (Greyling, 2000) and has to be given priority (Barding *et al*., 2000). Song *et al*. (2006) stated that reproductive efficiency of goats is determined by age of goats at first kidding, kidding interval, birth type (litter size), mass of kids at birth and weaning.

2.7.1. Age at first kidding

Age at first kidding can be defined as the age at which does give birth for the first time. It is a function of puberty, age at first breeding and conception and successful completeness of pregnancy. These reproductive characteristics including age at first kidding (AFK) are influenced by many factors such as genetic makeup of an individual, physical environment, nutrition and time of birth (Alexander *et al.*, 1999). The age at which animals first begin to breed is important for two reasons: early breeding can improve the rate of turnover of generations of animals and so speed up genetic progress as well as lifetime reproductive efficiency is greatly increased by early breeding. Age at first kidding can be expressed either percentage of mature body weight or in months (Table 4).

Warui *et al*. (2007) reported age at first kidding for Gabra and Rendille Kenya goats ranged from 12 to 36 months. According to the same authors, age differences at first birth for Gabra and Rendille goats in Kenya were significant in the dry years ($p<0.001$) and in the wet years ($p<0.05$). During the dry years, many of the does had their first birth at an age older than 18 months, whereas in wet years at younger age than 18 months.

Table 4. Age at 1st kidding of Ethiopian goats under traditional management conditions

Goat type	Age at 1st kidding (months)	References
Arsi-Bale (Alaba)	12.1	Tsedeke, 2007
Afar	24	Wilson, 1991
Arsi-Bale	13	Samuel, 2005
Arsi-Bale (Loka Abaya)	14.8±0.3	Endeshew, 2007
Keffa	12.5	Belete, 2009
Somali/Boran	30	Wilson, 1991
Unspecified (Metema)	13.6±2.44	Tesfaye, 2009

2.7.2. Kidding interval and Litter Size

Kidding interval (KI) refers to the number of days between successive parturitions. Whereas litter size (LS) or number of kids in the litter as defined by Alexandre *et al*. (1999) is a total number of born kids per kidding per goat. Kidding frequency and litter size are important components of an efficient kid production system. The former is an important predictor of life time productivity (Awemu *et al*., 1999) whereas the latter is an important trait for selection of goats to produce next generation and increase of meat and milk production and it seemed to be the most useful selection criterion for genetic improvement of meat production.

Amoah and Gelaye (1990) stated that litter size was under significant influence of goat age and parity, whereas Awemu *et al*. (1999) reported parity, year and season as factors of importance for goat litter size. According to Greyling (2000), there was no significant difference in the post-partum anoestrus interval for does giving birth to different numbers of offspring. Amoah *et al*. (1996) have showed litter size, breed and parity can affect gestation period.

The prolonged kidding interval was responsible for a decrease in productivity of goats (Awemu *et al*., 1999). At least three times kidding is expected per two years under normal circumstances (Girma, 2008). It was suggested kidding interval should not exceed 8 months

(245 days); however, the average kidding interval for the long legged West African goat in pastoral system was reported as 328 days (Wilson, 1991).

Akpa *et al*. (2011) reported litter size ranged from 1 to 4 with the mean of 1.7 in Nigeria goats under traditional management condition. Litter size in this study showed a tendency to increase from 1st to 5th parity and a reduction in the 6th. These results indicates that the parity level in which doe's prolific ability reaches its peak is between the 4th and 5th parity, thus culling of does from the herd can starts beyond the 5th parity. It may be economically unwise to cull a doe at the early parities (except for ill-health) when the full genetic potential of their reproductive rate has not yet been fully expressed. Multiple births were common in this study in wich 44% (single), 40.5% (twins) and 14.7% (triplets) (Akpa *et al*., 2000). However, comparable results were also reported by Amoah *et al*. (1996) that the most frequent litter size was twin (48.1%) followed by single (34.6%) births. Litter size varies between 1.08 and 1.75 with an average of 1.38 for tropical breeds (Girma, 2008). Kidding interval and LS for some Ethiopian goat types under traditional management conditions is presented in Table 5.

Table 5. Kidding interval and litter size for Ethiopian goat types under traditional management conditions

Goat types	KI (months)	LS	References
Arsi-Bale (Alaba)	6.9	1.75	Tsedeke, 2007
Arsi-Bale	8.07	NA	Samuel, 2005
Arsi-Bale (Boka Abaya)	6±0.2	2.07	Endeshew, 2007
Keffa	7.9	1.7	Belete, 2009
Unspecified (Metema)	8.4±1.37	NA	Tesfaye, 2009
Unspecified (Alaba)	9.05±0.08	1.47±0.04	Deribe, 2009

NA-Not available

2.8. Production Performance of Goats

Growth in animals is defined as a differentiation and increase in body cells (Bathaei and Leroy, 1996). Growth rate, body size and changes in body composition are of economic importance for efficient production of meat animals. According to Bathaei and Leroy (1996), animal growth can be expressed as the positive change in body weight per unit of time or by plotting body weight against age. The increase in body weight of farm animals is mainly a reflection of the growth of carcass tissues consisting of lean meat, bone and fat. Growth rate of lambs or kids, particularly during the early ages of growth, is strongly influenced by breed type, milk production potential of the female animals, the environment under which the animals are maintained, including the availability of adequate feed sources both in quantity and quality (Bathaei and Leroy, 1996; Kassahun, 2000). Growth rate can be observed into pre-weaning average daily gain and post-weaning daily gain (Luginbuhl, 2002).

2.8.1. Birth weight

Birth weight is the starting point to determine pre-weaning growth rate. It can be affected by season of the year, breed type, sex and litter size (Browning, 2007). Madibela *et al*. (2002) reported about Tswana goats' birth weight as was positively correlated with the growth rate of the animals. Negative association between birth weight and litter size had also been reported (Song *et al*. 2001; Deribe, 2009; Banerjee and Jana, 2010). Song *et al*. (2001) reported the mean birth weight of the Korean native goat kid of 2.04 kg, which varies from single (2.28kg), twin (2.11kg) and triplet (1.64kg) birth types. Other similar studies were also reported about birth weight as significantly affected by breed and sex types (Lusweti, 2000; Zhou *et al*., 2003). Bushara *et al*. (2013) reported the birth weights of kids in Sudan (Southern Kordofan State) goats were 2.10, 2.02 and 1.79 kg for single, twin and triplets, respectively. Birth weights of some Ethiopian goats under different management conditions are also presented in Table 6.

2.8.2. Pre-weaning growth rate and average daily gain

The pre-weaning average daily gain period reflects the genetic potential of the growing animal and an important production trait to be considered (Luginbuhl, 2002). Rapid growth is a crucial criterion for the improvement of meat production in goats (McGowan and Nurce, 2000) and other livestock species. Growth during the pre-weaning period is largely influenced by the maternal milk production potential and competition for it amongst litter mates. In addition, it can be also influenced by the energy level offered to the doe during lactation (Sibanda *et al*., 1999).

Research results (Zahraddeen *et al.,* 2008; Belay and Mengistie, 2013) on goats in Nigeria and Ethiopia, respectively indicated that single born kids exhibited a higher growth rate than twins from birth to weaning. Different authors (Das and Sendalo, 1990; Akpa *et al*., 2011) reported male goats were significantly heavier and grew faster than female goats. According to Andries (2013) working on Kentukey meat goats, sex of goat kids had a significant effect on weaning weight and pre-weaning average daily gain. Inyangala *et al*. (1990) reported that parity was a significant source of variation for growth rate.

For meat production goats, heavier body weights and faster growth rates are the most important traits (Lu, 2001; Bushara *et al*., 2013). Boer goats are known to have a higher growth rate compared to other goat breeds (Malan, 2000). Boer goats can grow in the first 12 months 200 g/day or more under good management conditions. Average growth rates for male Boer goats were recorded as 291, 272, 245 and 250 g/day from birth to 100, 150, 210 and 270 days, respectively and corresponding rates were 272, 240, 204, and 186 g/day in females (Campbell, 2003; Cited by King, 2009). In Ethiopia, this breed has been used in crossing with the indigenous goat breeds to improve their productivity. The Abergelle goat breed is one of the breeds that are used for crossing with Boer goats. Average live weight change recorded at three month, six month and one year for first filial generation (F1) of male Boer-Abergelle crossbreds were 104, 96.3 and 73.8 g/day while 102, 91.1 and 64.6 g/day were in females (Belay *et al*., 2014). Weaning weight and pre-weaning average daily gain of some Ethiopian goat types under different management condition is presented in Table 6.

Table 6 . Birth weight, weaning weight and pre-weaning average daily gain of some Ethiopian goat types under different management conditions

Goat type	Management Type	Birth weight (Kg)	Weaning weight(kg)	Pre-weaning average daily gain(g/day)	References
Abergelle	Intensive	2.4-2.6	6.0-8.9	33-55	Birhane and Eirk, 2006
Arsi-Bale	Intensive	2.45	9.2	71.76	Mehlet, 2008
Arsi-Bale	Traditional	2.28	8.39	72.21	Tatek *et.al.,* 2004
Arsi-Bale (Loka Abaya)	Traditional	2.52	9.56	NA	Endashew, 2007
Keffa	Traditional	2.78	9.0	NA	Belete, 2009
Somali	Station	3.19	11.67	61.25	Zeleke, 2007
Toggenberg X Arsi-Bale	Station	2.57	9.43	NA	Girma, 2002

NA-Not available

2.8.3. Weaning weight

In some production systems, kids are sold at weaning (Luginbuhl, 2002); hence, weaning weight is crucial and has great economic importance in meat goat production. Deribe (2009) carried out an on-farm performance evaluation study on indigenous sheep and goats in Alaba, Southern Ethiopia and reported that because of dependency of weaning on growth rate of kids, there is no definite time of weaning. Growth rate is determinant for weaning than age; hence, dams with good mothering ability are dried earlier than from those with poor mothering ability. Weaning weight indicate the mothering ability of the herd as well as the growth potential of the kids (Coffey, 2002). According to Boggs and Merkel (1993) weaning weight can be used to estimate growth rate, and it is an excellent indicator of productivity because it reflects litter size, mothering ability and milking ability too.

Weaning weight of Kacang and Peranakan Etawah goat was significantly affected by parity, type of birth and litter weight at birth (Sodiq, 2004). According to the result of this author, averages of weaning weight of both breeds tend to increase with the advance in parity up to the 4th parity and slightly decrease thereafter. Averages of litter weight at weaning of both breeds increased progressively with the advance in type of birth. The regression of birth weight on weaning weight was highly significant, and with each 1 gram (gm) increase in birth weight there is an increase of 4.48 gm and 3.37 gm weaning weight of Kacang and Peranakan Etawah goats, respectively. The weaning weights of some Ethiopian goat types under different management system are presented in Table 6 above.

2.8.4. Goat Milk

Goat milk has played a very important role in health and nutrition of young and elderly. It has also been known for its beneficial and therapeutic effects on the people who have cow milk allergy. These nutritional, health and therapeutic benefits enlighten the potentials and values of goat milk and its specialty products (Yangilar, 2013). It is more advantageous over cow or human milk having better digestibility, alkalinity, buffering capacity, and certain therapeutic values in medicine and human nutrition, as a result the need of goat milk as infant diet is growing rapidly worldwide (Bosworth and Slyke, 2009) and it commands higher price than cow milk. According to these authors goat milk is very close in composition to breast milk.

3. MATERIAL AND METHODS

3.1. Description of the Study Areas

The study covered five districts in four administrative zones: representing Bati and Kalu for Bati goats in Oromiya and South Wollo zones (Amhara Region) respectively; Yabello for Borena goats in Borena zone (Oromia Reggion); Erer and Shinille from Siti (the previous Shinille zone) for Short-Eared Somali goats (Somali Region) (Figure 1).

Site 1: Oromiya and eastern part of South-Wollo

Oromiya and South-Wollo zones are two of 11 administrative zones of Amhara Regional State. Kemisie and Dessie are the capital towns of Oromiya and South Wollo zones which are located 325km and 400km away north of Addis Ababa, respectively (Negussu, 2006). South Wollo has a varied topography, from the dry plains at 1000 masl altitude in the east to the high peaks above 3500masl altitude in the west whereas the elevation of Oromiya administrative zone ranges 1000-2500masl. The economy is based on crop production but livestock rearing has significant importance in the areas. The main rain is received in the "*kremt "(*July-September). On average the area receives a long-term mean annual rainfall of 726mm (LPAR, 2007).

Site 2: Borena

Borena zone is one of the 18 administrative zones of Oromiya Regional State. It is located in the Southern part of the state (between 3°36′- 6°38′ N latitude and 3°43′- 39°30′ E longitude) and borders Kenya. Yabello is the capital town of the zone which is located 570 km away south of Addis Ababa. The zone is divided into 8 districts namely, Gelana, Abaya, Bule Hora (the previous Hagere Mariam), Borena, Arero, Moyale, Dire and Teltele (Daniel, 2008). The altitude ranges from 970 masl in the south bordering Kenya to 1693 masl in the North east. Drought is a common phenomenon in many parts of the zone. Erratic bi-modal rainfall regime is prominent in most of the districts. Annual average rainfall ranges from 400mm in the south to 600mm in the north. The main rainy season is from (March-May) locally known as "*Ganna"* and the short rains from October-November called "*Hagaya". "Adollasa"* season is characterized by dry and cool temperature which occurs between the main rains and short rainy season. The annual mean temperature ranges from13-28.6 ^{o}C (Lasage *et al*., 2010).

Site 3: Siti

Siti zone is one of the 9 administrative zones of Somali National Regional State. Situating in the Northern most tip of the region, it bordered with Djibouti in the North, Somalia in the North-East, Jigjiga Zone in the South-East, Dire Dawa and Oromiya Regions in the South and Afar Region in the West. It is located between 8°44′- 1°00′ N latitude and 40°22′- 44°00′ E longitude. Shinille is the largest town of the zone and located 353 km East of Addis Ababa. The zone has 6 districts namely Aysha, Shinille, Afdem, Dembel, Erer and Meisso (Eshetu, 2003; cited in Amare, 2004).

The altitude in Siti zone ranges from 950 to 1350masl. The annual mean temperature ranges between 22.5 and 32.5°C, depending on the location within the zone. There are two rainy seasons, namely "*Diraa" or "Gu"* (short rain) from mid-March to mid-May and the "*Karan* "(long rain) from mid-July to mid-October. The average annual rainfall ranges between 500 to 700 mm (Save the Children UK and Disaster Preparedness and Prevention Agency, 2008).

3.2. Livestock Demography in the Study Areas

In the study areas, particularly in Borena and Siti zones population livelihood mainly depends on livestock production. Cattle, goat, sheep, camel and donkey are the major livestock species in the areas. Based on CSA (2013) livestock sample survey report, total numbers of different livestock by type of animal for Oromiya, South Wollo, Borena and Siti zones are summarized in Table 7.

Table 7. Total number of livestock by type and zone

Zone	Cattle	Sheep	Goats	Horses	Mules	Donkeys	Camels	Poultry	Beehives
Oromiya	278,789	86,780	164,891	436	-	43,315	14244	265,447	6,416
S.W.	1,564,091	1,948,943	720,700	86,221	29,229	380,608	13,101	1,662,389	112,656
Borena	1,048,909	396,819	989,691	840	2,726	73,224	62,789	556,466	98,829
Siti	21,627	59,482	194,362	-	-	9,256	12,333	5,010	22

Source: CSA (2013); S.W. = South Wollo

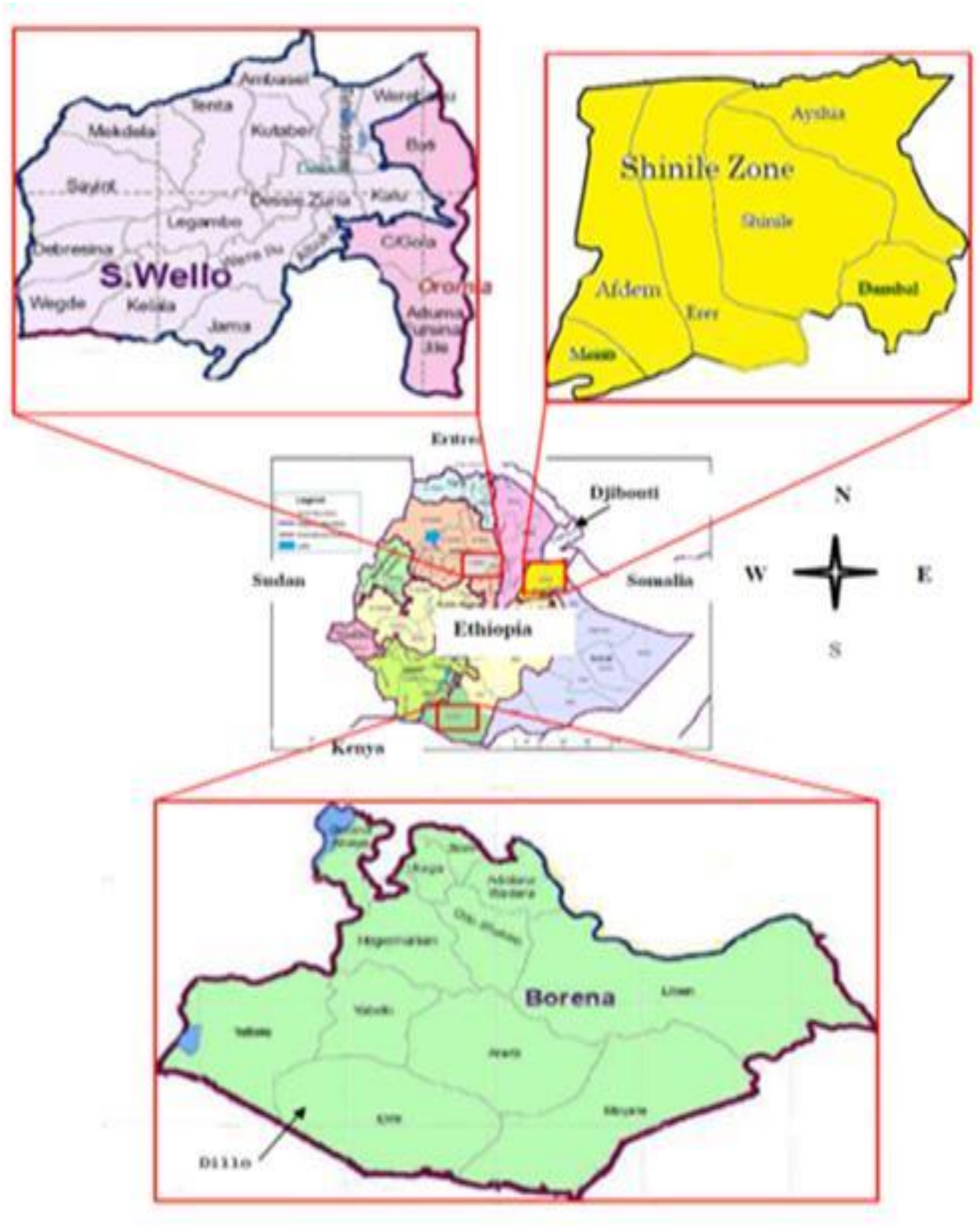


Figure 1. Map of Ethiopia and selected provinces for the baseline survey and performance monitoring studies

3.3. Sampling Strategy

A hierarchical sampling procedure was followed where the big sampling frames were administrative zones. A rapid informal field survey and discussion with the zonal agricultural bureau experts was made before the main data collection to know the distribution of the targeted goat populations in each study areas.

Based on the outcome of the rapid informal field survey and discussion with the zonal agricultural bureau experts, districts which were accessible, representative and had indigenous goat production potential were purposively selected. After further discussion with the districts agricultural development agents and key informants a total of 14 Peasant Associations (PA) (5 in Bati Area; 5 in Siti; 4 in Borena) were selected. During selection of PAs, the distribution and density of the respective goat types and accessibility were considered.

At the final stage, the lists of households who own at least two adult goats with a minimum of one year experience in goat husbandry practice were prepared in each PA with the help of PA development agents and leaders. A total of 345 households (98 from Kalu and Bati, 132 from Yabello and 115 from Erer and Shinille districts) were selected from the prepared list for interview using systematic random sampling procedure. Starting from the first, respondents were selected by a fixed interval until the desired sample size was obtained from each PA in each district. The selection interval was determined by ratio of total number of listed goat owners with the number of required respondents (35) per PA.

3.4. Data Collection and Management

3.4.1. Description of production systems

The site selection and the household baseline surveys were conducted from 21 January to 14 March 2013 in Eastern South Wollo and Oromiya administrative zone of Amhara National Regional State for Bati goats, Borena administrative zone of Oromiya National Regional State for Borena goats and Siti administrative zone of Somali National Regional State for short-eared Somalia goats. A checklist and semi-structured questionnaire, prepared by adopting a questionnaire prepared by International Livestock Research Institute and Oromiya Agricultural

Development Bureau for survey of livestock breeds in Oromiya (Workneh and Rowlands, 2004) was used. Some of the questioners were pre-tested with a few households to check whether it is designed in the way understandable to participants or not. The questionnaire was administered to the selected respondents by a team of enumerators that spoke the language of the respondents and trained on methods and approaches on phenotypic characterization of AnGRs. The data collection teams were composed of researchers from Jigjiga, Sirinka, Debre Berhan and Yabello agricultural and livestock research centers and experts from zonal and district offices.

Information on household socioeconomic characteristics, socio-cultural importance of goats, management practices, breeding system, unique adaptive character, goat feeding and watering, production constraints and other related issues were collected using semi-structured questionnaires (Appendix B). Participatory focus group discussions were held with livestock keepers and key informants to generate additional information regarding the targeted goat breeds importance and management practices.

Temperature, precipitation, agro ecology and livestock and livestock population demography of the study areas were collected from published and unpublished secondary data sources (Kothari, 2004).

3.4.2. Morphometric data collection

Based on breed morphological characteristics descriptor list of FAO (2012) for morphological characterization of goats, both qualitative and quantitative data were collected from 601 heads of adult (4pair of permanent incisors) goats comprising 162 Bati (128 females and 34 males), 246 Borena (201 females and 45 males) and 193 Short-eared Somali (139 females and 54 males). However, because of difficulty of finding adequate number of 4PPI males, measurements were taken from 2PPI and above males. To avoid genetic similarity of goats, 1 to 4 animals per household (based on number of goats) were used for both qualitative and quantitative traits recording.

Discrete or qualitative traits such as: sex, coat color pattern, coat color type, horn presence, horn shape, horn orientation, ear orientation, facial (head) profile, wattles presence, beard presence, ruff presence and back profile were recorded. Quantitative traits such as: Body Length (BL), Chest Width (CW) Height at Withers (HW), Chest Girth (CG), Rump Length (RL), Pelvic Width (PW), Horn Length (HL), Ear Length (EL) and Scrotum Circumference (SC) for males were measured using textile measuring tape. Body weight measurements were measured using suspending balance having 50 kg capacity with 0.2 kg precision in the morning to avoid the effect of feeding and watering on the animal's size (FAO, 2012). Pregnant does were excluded from sampling. Body Condition (BC) scoring was done based on description of FAO (2012) body condition scoring of goats (Appendix (F).

3.4.3. On-farm flock monitoring and evaluation

Flock monitoring was carried from the beginning of April to end of December, 2013 (9 months). Two PAs for each goat population (Birra and Arabo for Bati, Dahrito and El-Woye for Borena and Degha-Jebis and Gaad for Short-Eared Somali) were selected for monitoring activities. A total of 125 household flocks (46 Bati, 48 Borena and 31 Short-Eared Somali) were involved in the monitoring activity. The targeted goat population possession and willingness of goat owner to participate in the study were the criteria of selection.

At the beginning of the study (April, 2013), a total of 350 breeding does (113 Bati, 137 Borena and 100 Short-Eared Somali goats) were randomly selected and identified with numbered plastic ear tags from the selected flocks. However, most of the selected pastoralists/agro-pastoralists in Siti area were reluctant to continue in flock monitoring activity fearing body condition loss due to ear tagging and weighting activities. Consequently, only 11 household flocks growth performance were monitored for Short-eared Somali goats' growth performance study. An enumerator trained on how to take records was recruited in each PA and routinely checked by the representatives from the nearest research centers.

During the time of monitoring: sex, birth date, type of birth (single or twin), live weight (at birth, 30, 90 and 180 days) of kids and parity of dam were recorded under the existing management conditions by recruited enumerators. Birth date, birth weight, type of birth, sex of kid, and parity of dam were recorded within 24 hours of the new birth.

3.5. Data Analyses

All quantitative and coded qualitative data were entered into Microsoft Office Excel, 2013 for further analysis using Statistical Analysis System Version 9.2 (SAS, 2008).

Basic statistics (mean, standard deviation, frequency and percentage) for body measurements such as qualitative and quantitative traits were carried out. Indices were calculated for all ranking data according to a formula: Index = sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) given for an individual attribute divided by the sum of (3 for rank 1 + 2 for rank 2 + 1for rank 3) for overall attributes. A General Linear Model (GLM) procedure of SAS was used to analyze the quantitative data of adult goats and growth traits of kids. For morphological characterization of adult goats, the data were analyzed fitting linear body measurements as independent variables and goat population as fixed factor whereas the growth performance traits of kids were analyzed taking sex of kids, type of birth and parity of dam as fixed effects. The magnitudes of quantitative variables were expressed as Least Square Means (±SE). Chi-square test was used to test whether there is a significant difference at 5% level of significance between the observed frequencies in two or more categories and F test was used to compare means between study areas or populations. Means were separated using Tukey's HSD method. The following fixed effect models were used to analyze morphological body measurements on adult goats and growth traits of kids.

Model I: It was used to analyze quantitative traits of adult goats separately for both sexes

$Yij = \mu + B_i + \varepsilon_{ij}$

Where: Y_{ij} = observed quantitative measurement of trait of interest

μ = population mean

B_i = i^{th} goat population effect (i = 1, 2, 3)

ε_{ij} = random error associated with quantitative body measurements

Model II: It was used to analyze growth traits

$Yijkl = \mu + Si + Pj + Tk + \varepsilon ijkl$

Where: $Yijkl$ = observed live weight and weight gain ($Yijkl^{th}$ individual)

μ = Overall mean

Si= the effect due to i^{th} sex (I = 1, 2)

Pj = the effect due to j^{th} parity number (j = 1, 2, 3, 4, ≥5)

Tk= the effect due to k^{th} type of birth (k = single, twin)

$\varepsilon ijkl$ = random residual error associated to $Yijkl^{th}$ observation

Pearson's correlation coefficient was estimated between body weight and other linear body measurements for each population. This was done separately for the two sexes including Scrotum Circumference (SC) for males.

The stepwise multiple regression procedure of SAS was used to obtain models for estimation of body weight from linear measurements. The smaller values of Conceptual predictive (*Cp*), Akaike Information Criteria (AIC), Schwarz Bayesian Criteria (SBC) and RMSE and the higher value of R^2 were used to determine those traits that contribute much to the response variable (Kaps and Lamberson, 2004). The following model was used for the estimation of body weight from linear body measurements.

$Yj = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon j$

Where: Y_j = the dependent variable; body weight

α = the regression intercept

$X_1, X_2 \ldots X_n$ are the explanatory traits (BC, BL, HW, CG, CW, RL, PW, HL, EL and SC for males only)

$\beta_1, \beta_2, \ldots \beta_n$ are partial regression coefficients of the traits

ε_j= the residual random error

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

4. RESULTS AND DISCUSSION

4.1. Description of Production Systems

4.1.1. General Household Characteristics

The study households gender, age category and level of education are presented in Table 8. The percentages of male headed households were 93.88, 68.18 and 79.13 in Bati, Borena and Siti areas, respectively. The number of female household heads who owned goats in all study sites was significantly ($p<0.05$) smaller as compared to male household heads. However, female household heads at Borena district had relatively higher proportion (31.82%) as compared with female headed households at Bati and Siti areas. The female household heads were single mothers either the husband died or they divorced. The small proportion of female household heads indicated that men play a dominant role in decision making over livestock production management and the use of benefits from live animal sale.

In Bati area, the average family size (±SE) of the sample households (6.5±0.30) was significantly ($p<0.05$) lower than Borena (8.07±0.26) and Siti (7.68±0.26) area, but there was no significance difference ($p>0.05$) between Borena and Siti area average family size. The proportion of goat owners' aged between 31-40 years was higher across the study areas, accounting 31.63% in Bati; 24.4% in Borena and 34.78%. It can be conclude that most of the farmers/pastoralists have productive power in the study area. However, in Borena the proportion of respondents in the age of 20-30 years old were equally higher with the respondents between 31-40 years old (24.4%), indicating that goat acquisition in early age is higher in the area as compared with the other two study areas. This might attribute to the existence of goat possession culture thorough dowry and kinship.

Different studies in different part of Ethiopia (Lishan, 2007; Tesfaye, 2009; Tesfaye, 2010; Grum, 2010) reported that majority of goat owners were unable to read and write. Similarly, the current study revealed that most of goat owners (>75%) in Borena and Siti areas were illiterate. Whereas in Bati area, about 37.76% and 18.37% of sampled goat owners were attending religious and/or adult education and primary education, respectively. This indicates about 56.13% of sampled goat owners in the area were at least able to read and write. This would be a good opportunity to practice household based performance recording system and breed improvement interventions.

Table 8. Households' gender, age category and level of education in the study areas

Descriptor	Bati area		Borena		Siti	
	N	%	N	%	N	%
Sex of respondent						
Male	92*	93.88	90*	68.18	91*	79.13
Female	6	6.12	42	31.82	24	20.87
X^2-value	*75.47*		*17.45*		*39.03*	
Age group (years)						
<20	3	3.06	4	3.3	4	3.48
20-30	13	13.27	32*	24.24	19	16.52
31-40	31*	31.63	32*	24.24	40*	34.78
41-50	29	29.59	21	15.91	25	21.74
51-60	11	11.22	22	16.67	16	13.91
>60	11	11.22	21	15.91	11	9.57
X^2-value	*38.04*		*23.91*		*40.43*	
Educational level						
Illiterate	43*	43.88	101*	76.52	95*	82.61
Religious and/or adult education	37	37.76	9	6.82	13	11.30
Primary school(1-8)	18	18.37	20	15.15	7	6.09
Secondary school (9- 12)	0	0	2	1.52	0	0
X^2-value	*10.43*		*191.82*		*126.12*	
Family size (mean ±SE)	6.5 ± 0.30^b		8.07 ± 0.26^a		7.68 ± 0.26^a	

**$p<0.05$; x^2 = Pearson Chi-square; N = Number of observation*

4.1.2. Farming and non-farming activities

The mixed crop-livestock production system is the predominant system (96.94%) in Bati area. The major crops such as sorghum, maize, teff, sesame, chick pea and pulses are growing during the short and long rain seasons of the year. Cattle, goat, sheep, donkey and camel are major livestock species reared in the area (Table 9).

Over 60% of Ethiopian land area is semi-arid lowland, dominated by a livestock economy (IFAD, 2009). Due to low and highly variable rainfall conditions as well as extreme temperature, crop cultivation is limited in Borena and Siti areas. As a result, majority of the sampled households (74.78% in Siti and 52.27% in Borena) reported livestock production as a main farming activity while the remaining households (47.73% in Borena and 25.22% in Siti) were practiced crop cultivation in addition to livestock rearing. The main crops that have been cultivated by Borena agro-pastoralist were maize, teff, haricot been, sorghum, bean and wheat during the main rainy season "*Gaana*". Whereas in Siti area maize and sorghum were the main crops cultivated and rarely vegetables are also grown when there is enough rain. Similar findings were also reported by Grum (2010) that the two most cultivated crops in the rural PAs of Dire Dawa Administration council were maize and sorghum. According to the information obtained from respondents in Borena crop cultivation is expanding and the demand to get a plot of land for cropping locally called "*obru"* is increasing. Due to the recent trend of the expansion of croplands the respondents have been worried to the future that the grazing lands to keep animals may shrink. Intensification of the livestock production system so that the pastoralists can rear livestock in certain plot of land in parallel with food crop cultivation could minimize the pastoralists' doubt.

During the slack season (when there is no crop cultivation activity) 32.62 % of the interviewed farmers in Bati area are participating in off-farm activities such as local livestock trading (15.31%), daily laborer (11.22%) and hand craft (6.12%). Similarly in Borena, out of the interviewed households 17.42% were participated on local livestock trading and 6.06% were as daily laborer along with crop farming activities. In Siti zone, only 5.22% of the respondents participate in local livestock trading and daily laborer on non-farming activities. Though local administration at Siti banned making of charcoal and collection of fuel wood for sale, relatively high percentage of respondents (33.04%) were still practiced charcoal making and fire wood selling which mentioned as one of the cause for having low income, which can be used to purchase household needs such as feed and other too. Similarly, Beyene (2008) was reported the main reasons (limited income and seasonal nature of agriculture activities and large family size) why farmers in rural Ethiopia are participated on off-farm activities..

The contributions of farming and non-farming activities for households' source of food and income generation are presented in Appendix Table 1. In Bati area crop production (index = 0.565) ranked first as households food source supplemented by the sale of livestock and livestock product (index = 0.375). In the meantime, when cash is needed the highest share is from livestock and livestock product selling (index = 0.549). In both Borena and Siti areas the highest proportion of households' food and cash need were derived from livestock sale. Azage *et al.* (2009) reported that pastoralists derive over 90% of their cash income from livestock.

During normal season (when rain is available) some agro-pastoral community of Borena cultivated crops like maize, sorghum and teff for household consumption (index = 0.470) and purchase of commodities such as cloth, sugar and animal and human health care besides livestock rearing. The reported contributions of crop as food source and income generation of households' in Siti area were very limited.

4.1.3. Livestock composition and holding pattern

The reported overall average and percentage of livestock species owned per household is given in Table 9. The major livestock species observed in the study areas were small ruminants (goats and sheep), cattle, camels and donkeys. Goats were the predominant population in number across the study areas accounting 72.01% (Siti), 50.93% (Bati) and 47.38% (Borena) of other livestock species. Livestock species which constitute the largest share in the value of livestock assets of a household are defined as the principal animal (Fredu *et al.,* 2009). The cause of relatively smaller share of goats in total livestock possession in Borena might be due to significantly higher ($p<0.05$) average cattle possession (10.42) than Bati and Siti areas. The survey result revealed that significant ($p<0.05$) deviation in average goat possession of households among the study areas. The higher mean (±SE) goat flock size per household was found in Siti area (44.02±3.33) followed by Borena (23.08±1.94) and Bati area (8.99±0.59). The reason of lower average number of goat possession of Bati farmers might be due to the limitation of grazing/browsing area which is happened due to the expansion of arable land in Bati.

The average number of goats owned per household found in the present study around Bati area was comparable with the previous study of Tesfaye *et al*. (2006) who reported 7.79 goats per household for the same area. On the other hand, the average goat holding per household in the present study at Siti was relatively higher than the work of Grum (2010) and Sisay*et al*. (2006) who reported 34 and 10.08 heads per household for the same goat breed in rural PAs of Dire Dawa Administration Council and Siti, respectively. This suggested that the existence of variation in average goat holding per household across the districts, years and seasons as a result of occurrence of drought and incidences of diseases .

Table 9. Mean (±SE) and percentage of livestock species owned per household

Species	Bati area (N=98)		Borena (N=132)		Siti (N=115)	
	Mean ± SE	% of other livestock	Mean ± SE	% of other livestock	Mean ± SE	% of other livestock
Goat	8.99±0.59^{c}	50.93	23.08±1.94^{b}	47.38	44.02±3.33^{a}	72.01
Cattle	3.94±0.29^{b}	22.33	10.42±1.21^{a}	21.39	1.70±0.26^{c}	2.78
Sheep	1.27±0.22^{c}	7.16	7.82±0.82^{b}	16.05	11.89±1.14^{a}	19.45
Chicken	2.43±0.36^{a}	13.77	3.70±0.49^{a}	7.60	0.16±0.13^{b}	0.26
Camel	0.31±0.07^{b}	1.77	1.64±0.32^{a}	3.37	1.88±0.29^{a}	3.08
Donkey	0.40±0.08^{b}	2.27	0.78±0.17^{b}	1.60	1.47±0.14^{a}	2.40
Beehive	0.31±0.13^{ab}	1.77	1.27±0.49^{a}	2.61	0.01±0.01^{b}	0.07

$^{a, b, c}$: means with different superscript in the same row are significantly different ($p<0.05$).
SE= Standard Error
N= Number of respondents

4.1.4. Flock structure

The proportion of the different classes of animals reflects 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 breeding does made a major share followed by kids less than 6 months in all areas (Figure 2). The mean (±SE) breeding doe ownership per household was 3.51±0.91, 9.30±0.78 and 13.30±0.84 in Bati, Borena and Siti areas, respectively. The higher proportion of breeding females in the flock followed by suckling age group in all study sites was in agreement with finding of other researchers in Ethiopia (Tsedeke, 2007; Tesfaye, 2009; Belete, 2009). The higher proportion of adult females than other age groups across all study areas indicates that practice of retaining females for breeding. The average goat flock size (44.02) as well as adult females (13.3) and kids less than 6 months (13.03) owned per household in Siti was significantly higher ($P<0.05$) than Bati and Borena areas. However, the proportion of adult females (30.23%) and kids less than 6 months (29.62%) in Siti area were slightly smaller than the contribution of their counterparts in Bati and Borena. On the other hand, comparing with Bati and Borena areas, the share of kids between 6-12 months age (23.86%) and intact males older than 1 year (12.64%) in Siti area were higher in the flock. From this result, it can be concluded that pastoralists/agro-pastoralists in the area keep weaned kids for a long period of time which might be attributed to poor growth rate performance of goats.

The contribution of castrates in Siti, Bati and Borena were 3.65%, 3.52% and 0.95% respectively. The percentage of castrate found in Siti flocks was close to Grum (2010) for Short-eared Somali goats and FARM-Africa (1996) for Arsi-Bale goats who reported 3.8% and 3.5% respectively. Relatively, smaller proportion of castrates in Borena goat flocks indicated that the existence of low practice of buck castration activity in the area as compared with Bati and Siti areas due to the high demand of intact males by the exporters in the area.

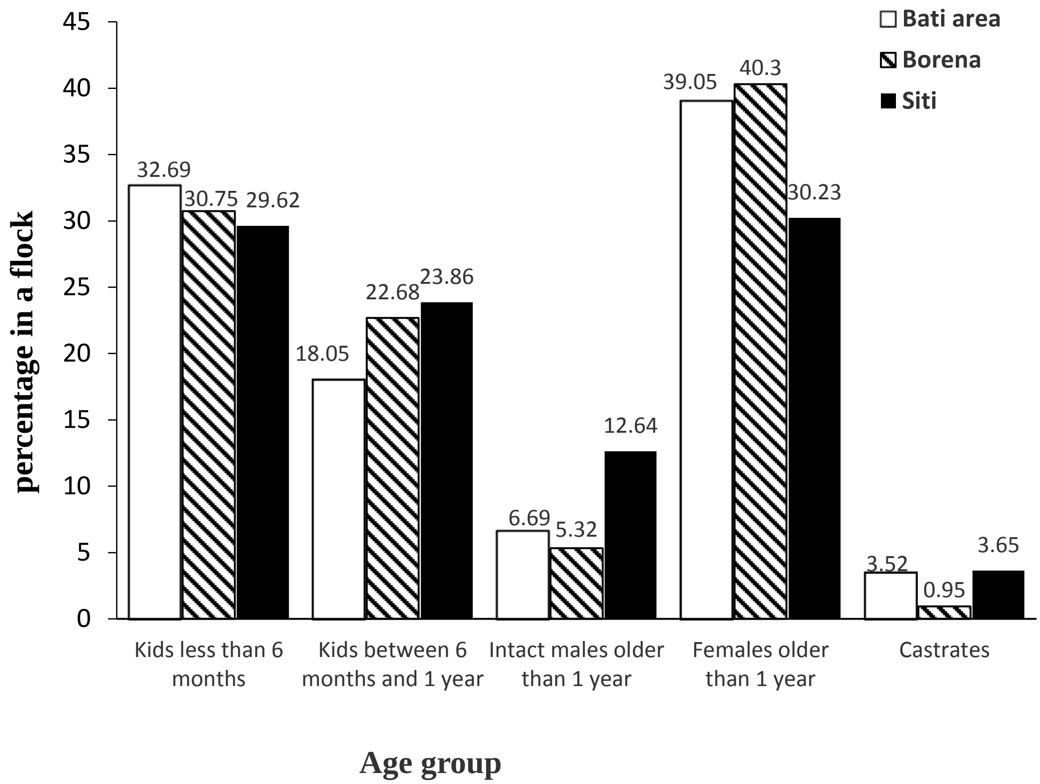


Figure 2. Goat flock structures in Bati, Borena and Siti areas

4.1.5. Purpose of goat keeping

Indigenous goat breeds have a wide range of functions that differ from place to place. Identification of the reasons is prerequisite for deriving operational breeding goals (Jaitner *et al*., 2001). Analogous to the reports of other researchers in Ethiopia ((Tsedeke, 2007; Getahun, 2008; Tesfaye, 2009; Grum, 2010), goat keepers in the present study mentioned cash income, milk production and meat consumption are important reasons of goat keeping (Table 10). Many of households in Borena and Bati area ranked income generation as a primary reason of goat rearing followed by milk production and meat consumption, respectively. But in Siti area milk production was ranked as a main reason of goat keeping followed by income generation and meat consumption. Additionally, goats play important roles in the socio-economy of the societies. This includes saving, for the payment of social dues, ceremonial feastings, to show wealth strength and skin for home use and sale. None of the respondent ranked skin as a reason of goat keeping in Siti, but confirming the results of

Grum (2010) and FARM-Africa (1996) who reported the traditional uses of skin by the goat keepers in the area is as water containers locally made from goat skins known as "*qerbid"* were observed (Figure 3). According to the respondents, locally made water container from goat skin is locally appreciated in keeping drinking water cool for a long time.

Besides producing animal products, goats also provide manure to maintain soil fertility in mixed crop-livestock and agro-pastoral production systems. The use of manure as fertilizer was ranked only around Bati area with the index of 0.077. In Borena and Siti areas the use of manure as a fertilizer of cropping land was not mentioned. According to the agro-pastoralist respondents, since soil fertility is not serious issue in the areas and cropping land is located far away from the residence simply they disposed it outside the barn.

Figure 3. Locally made goat skin water container (*qerbid*) in Siti area

Table 10. Purpose of goat keeping in the study areas

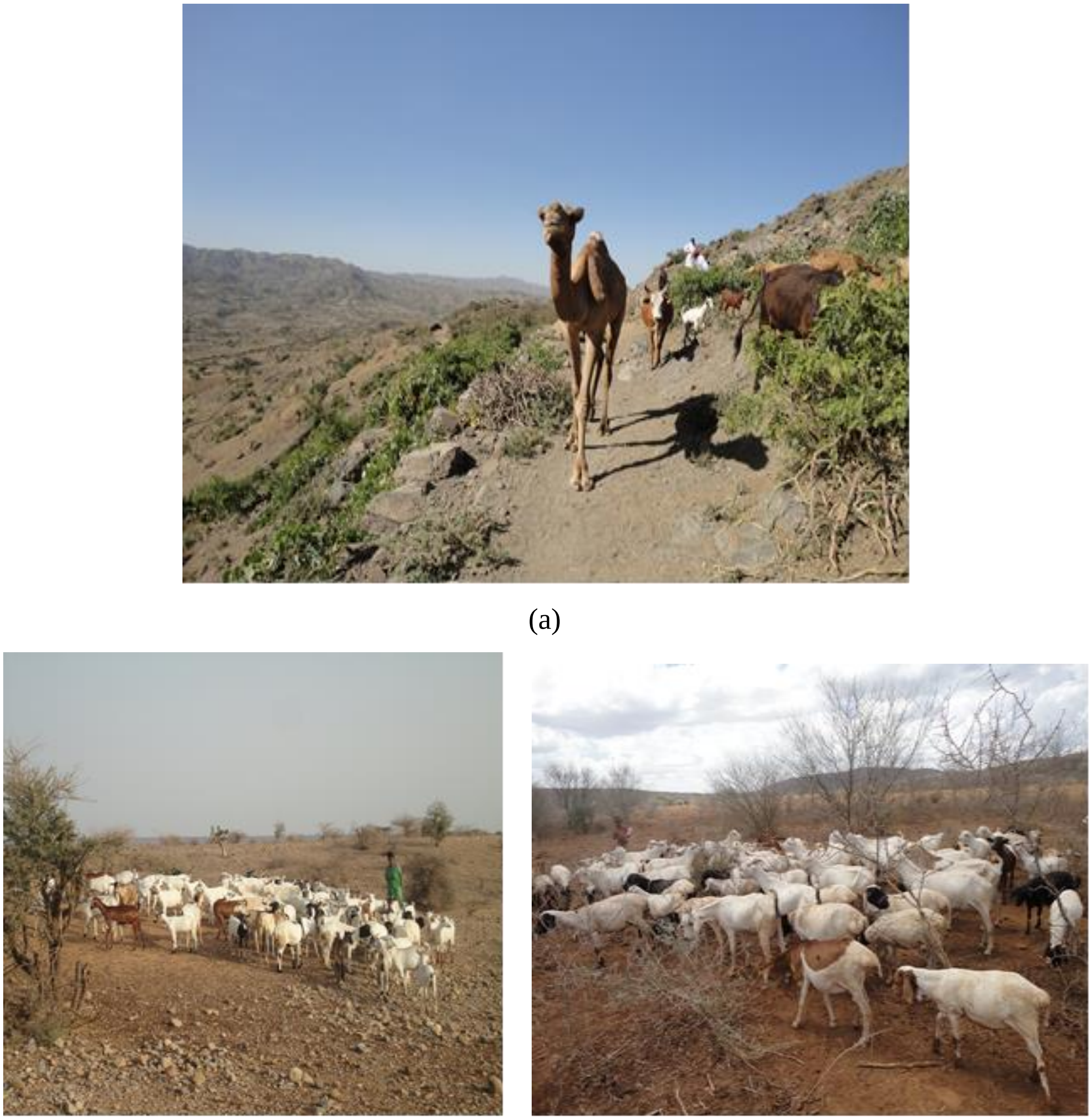
	Ranking											
	Bati area				Borena				Siti/Shinille			
Purpose	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Source of income	86	11	17	0.348	92	26	11	0.426	40	60	11	0.356
meat	40	64	12	0.305	2	30	65	0.165	-	19	56	0.134
Milk	2	30	20	0.101	34	54	35	0.309	72	23	13	0.397
Wealth strength	0	3	2	0.009	6	18	18	0.091	1	2	4	0.016
Ceremony	1	7	29	0.051	0	1	0	0.003	0	0	2	0.003
Manure	0	21	24	0.077	0	0	1	0.001	0	0	0	0
Skin	0	2	4	0.009	0	0	0	0	0	0	0	0
Saving	11	23	3	0.096	0	0	0	0	3	1	8	0.027
Gift	0	0	3	0.004	0	2	0	0.005	0	13	22	0.067

Index= sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each purpose divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all purpose of keeping goats in a study site; R= Rank

4.1.6. Herding practices

Mixed species stocking is managing two or more animal species simultaneously. In the present study, about 45% of households in Bati area practiced mixed-species stocking (herding goats with sheep, cattle, equine and camel) (Figure 4a) while 17.24% of respondents reported mixing with sheep only. The remaining 37.76% of respondents herd their goats separately without mixing with any livestock species. The privatization of communal grazing/browsing areas for the purpose of better protection and shortage of laborer were among the reasons for practicing of multi-species grazing system around Bati area. In Borena and Siti areas the number of households who keep their goats with cattle, equine and camel were 1.25% and 4.35%, respectively while 96.21% in Borena and 50.43% in Siti area herd their goats by mixing with sheep (Figure 4b and 4c). The rest 2.27% in Borena and 45.22% in Siti zone keep their goats separately. Despite the type and number of species mixed with goats in a specific area, the three areas herding system can be characterized as herded mixed species grazing system.

According to Anderson *et al*. (2011 mixed species grazing system may be one of the most biologically and economically viable systems available to producers, especially on landscapes that support heterogeneous plant species. Although the simultaneous management of more than one animal species has challenges in management (Animut and Goetsch, 2008), researchers stated as biological and economic benefits overshadow the challenges. A major advantage is the better overall utilization of the standing plant, that is, animal species prefer different plant species and can foster sound landscape management



(a)

(b) (c)

Figure 4. Mixed species stocking/herding systems: Bati (a), Siti (b) and Borena (c)

About 7, 38 and 10% of households in Bati, Siti and Borena area, respectively reported flock mixing with their neighbors' flocks throughout the year. The rest of households in each area herded their flock separately from other flocks, except the probability of mixing with the adjacent flocks at watering points. In Bati area the farmers herded their flock on the private grazing/browsing land, while Borena and Siti pastoralists/agro-pastoralists herded the flocks on the communal rangelands where flocks are allowed to browse freely. Fear of communicable diseases and uncontrolled mating were the important reasons of keeping flocks separately around Borena and Siti. But in Bati area privatization of grazing/browsing area was the additional reason reported.

4.1.7. Feed resources and feeding practice

4.1.7.1. Feed resources

The ranking of available feed resources in wet and dry seasons of the year by study site are shown in Table 11. The reported available feed resources utilization slightly varies with study site and season (dry and wet). The overall reported feed resources were natural shrubs and bushes, conserved hay and crop residues. Established forage trees such as sesbania (*Sesbania sesban*), leucaena (*Leucaena leucocephala)* and the commonly "*kurkura*" (*Ziziphis spina-christi*) planted on soil conservation structures and stock exclusion areas were reported source of goat feed used through cut-and-carry system around Bati area. Natural pasture (shrubs and bushes) were the predominant feed resource in both dry and wet seasons for all study areas. Most of the respondents stated crop residues were for large animals. Meanwhile, some of respondents also ranked crop residues as goat feed particularly during dry season when there is feed shortage. Among the crop residues used sorghum and maize stover were the prominent.

Table 11. Available feed resources during the dry and wet seasons of the year

Feed resources	Ranking											
	Bati Area				Borena				Siti			
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Wet season												
Natural pasture	93	2	2	0.831	132	0	0	0.959	115	0	0	1.00
Established forage trees	1	12	2	0.085	0	0	0	0	0	0	0	0
Conserved feeds (hay)	1	1	3	0.023	0	2	0	0.010	0	0	0	0
Crop residue	3	5	2	0.061	0	6	1	0.031	0	0	0	0
Dry season												
Natural pasture	90	4	3	0.774	123	9	0	0.746	115	0	0	0.885
Established pasture/forage	1	10	0	0.063	0	0	4	0.008	0	0	0	0
Conserved feeds (hay)	1	4	3	0.039	6	11	-	0.077	0	0	0	0
Crop residue	2	15	7	0.118	5	31	9	0.166	15	0	0	0.115

Index= sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each feed source divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all feed sources in a study site

4.1.7.2. Feed shortage and supplementary feeding

Though goats have wide range of plant species browsing and good feed searching habit, feed shortage during dry season was reported as one of the constraint in all the study sites, differences were that causes and months of the year when there is feed shortage. Clear identification of periods of feed shortages is required for effective feed management and conservation. In the present study, mentioned seasons of feed shortage in Bati, Borena, and Siti areas cover from January-mid of June, December-March and September-June, respectively. Within this ranges May, June and February for Bati area; February, March and January for Borena and February, January and March for Siti area were the most frequently mentioned months of pick feed shortage (Figure 5).

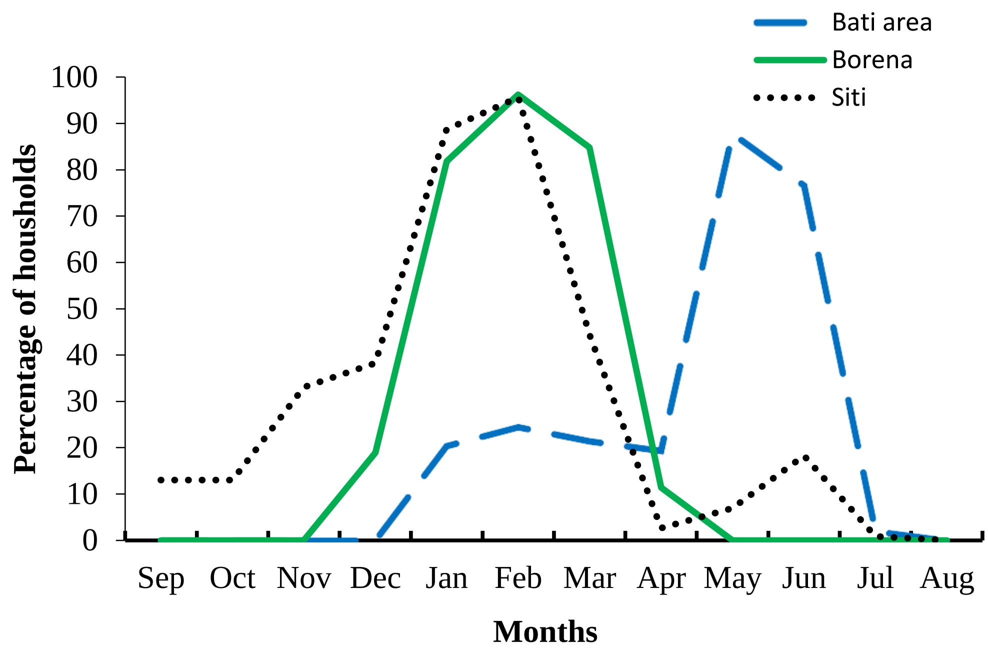


Figure 5. Period of feed shortage across study sites

Different ways of response to feed shortage were listed by the respondents in the study areas. The major feed shortage resonances include collecting and providing of green leaves and pod from perennial plants, crop residues (based on availability), collected or stand hay in Bati and migration of adult and healthy animals in Borena and Siti areas. Due to large flock size in Borena and Siti areas, suckling kids and milking does were the most likely to be provided green leaves and pod from perennial plants. The migration of animals can be to relatives in other area or the family member (mostly adult males) may take the animals to the areas where better feed and water resources are available. About 55.1% of Bati area owners also reported additional supplementations such as kitchen and milling residues, homemade grain, local grain grinding houses remains and oil seed cake "*fagullo*" based on availability. Very few (3.8%) goat owners in Borena practice kitchen and milling residues supplementation but almost none of goat owners in Siti reported such types of supplementation except mineral (salt) supplementation.

Mineral (table salt) supplementation was reported across all areas and seasons but majority of the respondents, 69.4% in Bati area, 78.8% in Borena and 62.6% in Siti supplemented their goats during wet season only when there is sufficient amount of feed. The remaining proportions in each study area supplemented their goats both in dry and wet seasons.

4.1.8. Water resources, watering frequencies and watering point

4.1.8.1. Common sources of water

The availability of different water sources varied between study sites and seasons of the year. Table 12 presents common water sources reported by respondents in dry season. The important sources of water comprise traditional hand dug wells, rivers/streams, ponds and pump water. The most frequently stated water source in Bati area was permanent rivers/streams (76.53%) followed by pump water, spring, ponds and hand dug wells in order of importance. The traditional hand dug wells found the most important sources of water supply in Borena (98.48%) and Siti (87.8%) followed by ponds and rivers/streams, respectively. Each traditional hand dug well is governed by a complex set of rules and regulations that are administered by a group of elected community members. Similar to the study of Belay *et al*. (2011) in Ginchi watershed, respondents in this survey stated that during rainy seasons in addition to permanent water sources, temporary water sources (rain water collected in depression on grazing lands) used irregularly to satisfy the thirst of livestock in the study areas.

Table 12. Common water sources in dry season

Source of water	Bati area		Borena		Siti	
	N	%	N	%	N	%
Traditional hand dug wells	11	11.22	130	98.48	101	87.8
Rivers/streams	75	76.53	0	0	25	21.74
Spring	14	14.29	0	0	15	13.04
Pond	12	12.24	51	52.04	5	4.35
Pump water	17	17.35	2	1.56	0	0

One individual may respond more than one; N= Number of respondents

4.1.8.2. Watering frequencies and distance

Livestock must have free access to plenty of clean, fresh water at all times to be productive. However, none of the respondents reported *adlibitum* access of water for livestock across surveyed areas except in wet season from temporary sources. During the time of the survey two types of watering system were observed across the three sites. They were watering at home (kids and sick animals) and taking animals to water source for direct access. Water for domestic use and home watering of kids and sick animals was fetched using donkey back. As presented in Table 13 majority of goat owners (>90%) in Bati area watered their goats every day and few individuals (6.12%) every one day interval. Because of lack of watering points in Borena most of the owners took their goats to the watering point once in three (50.76%) and two (46.97%) days. Whereas in Siti area the owners took their goats to the watering point once in three days (11.30%) and once in two days (58.26%) and every day (30.43%). Accessibility (distance) and the number of households used per traditional hand dug well were found to be factors determining frequency of watering. According to Mengistu (2007), Short-eared Somali goats deprived water for about three days in dry season showed 22% milk production reduction as compared to goats watered every day. Since watering is an important management component, researches required to be carried out to see the impact of watering frequency on productivity of goats in the dry areas.

It was found that during the dry season 94.9, 54.55 and 76.53% of interviewed households in Bati, Borena and Siti area, respectively, have access to water within 5 km distance and 5.10, 45.45 and 23.48% of households in that order should walk over 6 km to find water. The results revealed that livestock water accessibility is better in Bati area as compared with Borena and Siti areas.

Table 13. Watering frequency and distance during dry season in the study areas (%)

Particulars	Bati area		Borena		Siti	
Watering frequency	N	%	N	%	N	%
Once a day	92	93.88	3	2.27	35	30.43
Once in 2 days	6	6.12	62	46.97	67	58.26
Once in 3 days	0	0	67	50.76	13	11.30
Distance to Watering point (km)						
< 1	43	43.88	13	9.85	33	28.70
1-5	50	51.02	59	44.70	55	47.83
6-10	5	5.10	48	36.36	27	23.48
>10	0	0	12	9.09	0	0

N= Number of respondents

4.1.9. Housing

All of the interviewed respondents in Siti and about 80.3% in Borena shelter their goats in separated enclosure made of either wooden or thorny bushes without roof across the seasons (Figure 6). The remaining 19.7% of respondents in Borena used roofed corral. In general, most of the observed adult goats' traditional housing systems in Borena and Siti areas do not protect animals from predation, theft, climate extremes (particularly in rainy season) except less extent predation protection. This could result low productivity of the animals. Therefore, the pastoralists should be aware in the role of improved housing in the productivity of goats.

In Bati area all of the respondents reported roofed goat shelter in both dry and wet seasons. The form of houses differed between households. Fifty two percent of the respondents use separated roofed corral, the remaining 13.27% and 34.69% shelter their goats inside and adjacent (locally known as "*goreno"*) to the family house, respectively. Housing goats inside family house in this area indicates the probability of outbreak of zoonotic diseases and spread of external parasites.

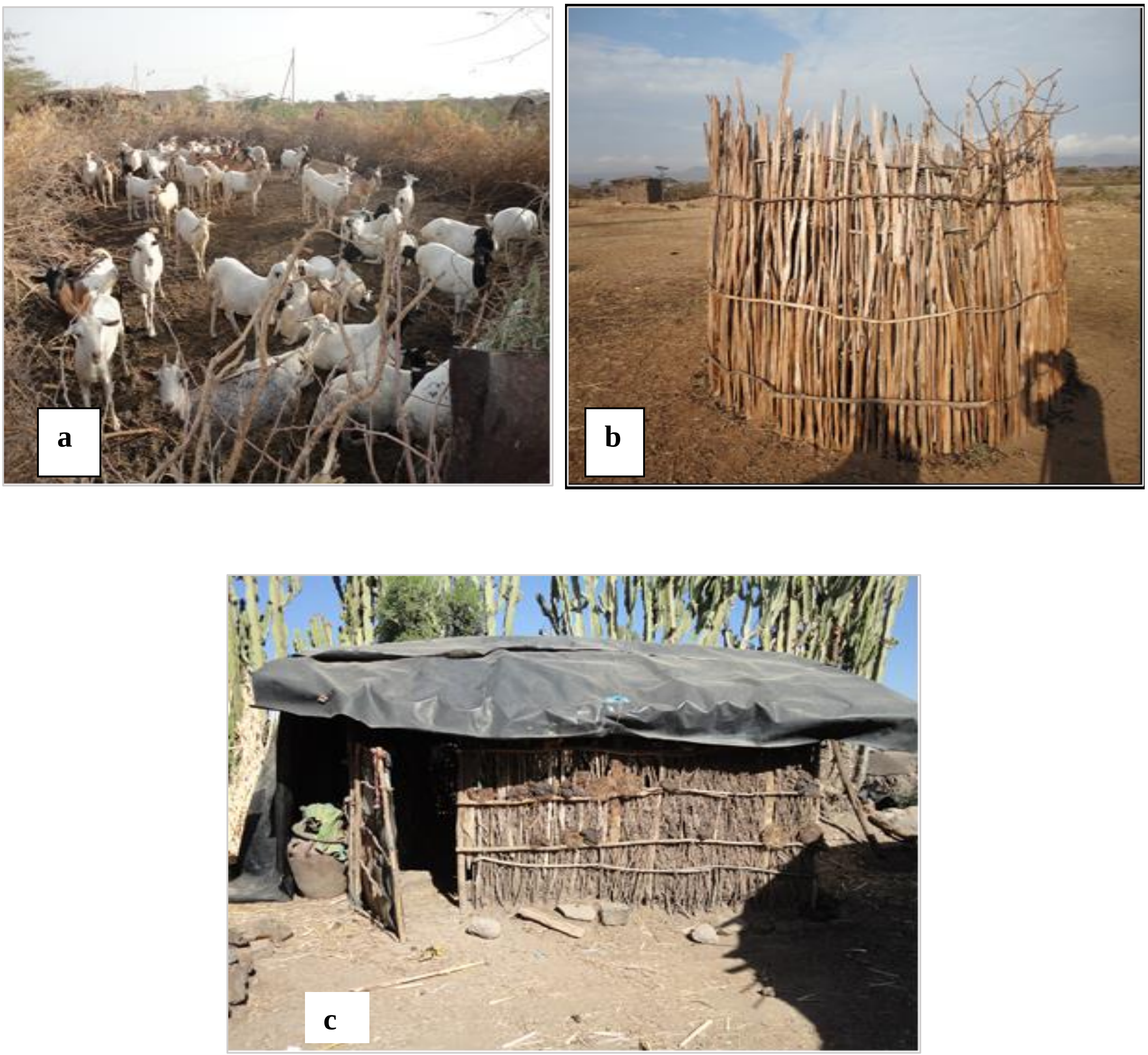


Figure 6. Traditional adult goats shelter in Siti (a), Borena (b) and Bati (c) areas

All of the respondents in Borena and Siti and most in Bati area (64.29%) housed kids separately from the adult flock. In the former two sites kids sheltered within well roofed and walled kids pen, while in Bati area kids separated from the flock and sheltered inside the family house. Differences were observed between Borena and Siti area kids pen walling and roofing materials (Figure 7). For instance, in Borena the pens were constructed suspended from the ground and walled and roofed with wood materials and covered with cattle dung to protect kids from predator biting as well as weather extremes. Whereas in Siti the pens could be walled with stone or wood and roofed with thorny bush. Most of the owners who have sheep in the three study areas sheltered with goats.

Figure 7. Traditional kids house type in Siti (left) and Borena (right)

4.1.10. Castration

The percentage of households who practiced buck castration and method of castration used are presented in Appendix Table 2. The proportion of households who practiced castration and the average age of castration varied from place to place. Nearly all of goat keepers in Siti (97.39%), above half of Bati area (69.39%) and bellow half of Borena (21.97%) practiced castration. As explained under section 4.1.4 of this study, the reason for low rate of castration in Borena area was due to low demand of castrated goats by the livestock exporters.

Above 50% of respondents who castrate their bucks reported traditional method of castration in all study areas. In Siti and Borena areas bend wooden material locally known as '*wormatume*' by Somali people and "*tuma*" by Borena people was used for traditional closed castration. Whereas around Bati area smooth and round river stone locally known as '*alello*' was used for similar purpose. However, traditional open castration (*i.e.* removal of tests using knife) was reported as alternative method in Borena. Similar methods of traditional sheep castration using the wooden materials were reported by Tassew (2012) and Tesfaye, (2008). The reported average (±SE) age of castration (years) in Bati area (1.72±0.11) was significantly (p<0.05) smaller than in Borena (2.2±0.11) which was significantly (p<0.05) smaller than in Siti (3.17±0.09).

The motivation for the castration of goats across the three surveyed areas was mainly to improve fattening and reduce bad smell from bucks so that it can fetch better price in local markets. In addition 9.2% in Bati area; 8.3% in Borena and 52.2% in Siti performed castration to control pregnancy from unwanted buck.

4.1.11. Trait preferences

Goat owners across the selected areas were highly interested in body size (conformation), fast growth rate, milk yield, and drought tolerance (adaptability) and disease resistance and reproduction rate (Table 14). Body size was the most preferred and frequently ranked trait in Bati (index=0.272) and Borena (index=0.224) areas. In Siti it was ranked next to milk yield (0.277) equally with growth rate (index=index=0.157). Unlike Siti and Borena areas, in Bati area goat owners ranked milk yield after body size, growth rate, disease resistance, reproduction rate and coat color with the index of 0.084. This indicates that around Bati area goat milk is the least preferred than Borena and Siti areas; as a result goat keepers gave more weight for cash income generation (meat production/growth) traits than milk yield. This implies that designing goat improvement strategy in the area should primarily target towards meat production traits. Whereas, in Borena and Siti areas both meat and milk production traits are important and should be considered together.

The most important coat color preferences in Bati area for both sexes were brown but plain white coat color was the most preferred one by both Borena and Siti pastoralist and agro-pastoralists. Similar to Halima *et al*. (2012a) observation, black coat color was not preferred by the producers in all study areas. In general, slight trait preference discrepancies in different areas were observed. Therefore, goat breed improvement intervention program should be designed considering these differences accordingly.

Table 14. Ranking of goat trait preference of producers

Trait	Bati area				Borena				Siti			
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Body size/ conformation	42	12	6	0.272	48	11	8	0.224	12	28	15	0.157
Reproduction rate	11	6	27	0.126	11	15	24	0.112	8	16	10	0.097
Milk yield	8	2	20	0.084	15	23	29	0.155	51	15	6	0.277
Growth rate	15	32	7	0.203	16	32	21	0.172	11	21	32	0.157
Coat Color	3	21	11	0.108	7	12	10	0.071	4	7	7	0.048
Disease resistance	13	7	25	0.136	13	18	15	0.116	14	12	18	0.123
Drought resistance	2	4	8	0.038	12	14	18	0.106	11	13	20	0.116
Longevity	0	8	2	0.033	6	5	6	0.044	3	2	4	0.028

Index= sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each trait divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all traits in a study site; R= Rank

4.1.12. Breeding management

4.1.12.1. Breeding stock selection

In the present study goat owners' selection of breeding stock gave more weight for body conformation and color type than production characteristics. Unfortunately, they cannot tell much about the future productivity of an animal simply by looking at it. Ideally, selection should be a combination of visual appraisal and evaluation of performance records.

The proportion of owners who practiced selection by study site is presented in Table 15. Majority of the respondents across the study areas practiced selection for both breeding males and females while few of respondents practiced either for females or males only. The rest very few owners also did not practice selection. Though age is an important factor in the selection of breeding stock, farmers/pastoralists did not have specific age of selection, simply they select and sale when they are in financial crisis or in need of substantial money and save the others which they want to be the parents of the next generation. However, according to the respondents, since males are early maturing there were possibilities to decide which male to be the replacement sire in earlier age than females.

Table 15. The proportion of producers who practiced breeding stock selection

Selection of breeding stock	Bati area		Borena		Sit	
	N	%	N	%	N	%
Both male and female	87	88.78	102	77.17	76	66.09
Female only	8	8.16	22	16.67	4	3.48
Male only	1	1.02	5	3.79	28	24.35
No selection	2	2.04	3	2.27	7	6.09

N= Number of respondents

4.1.12.2. Breeding buck ownership and mating system

Half of (50%) goat keepers in Bati and majority of Borena (64.39%) and Siti (83.48% had their own breeding buck. About 22% of Bati and 7% of Borena goat owners obtained their breeding bucks from market through purchase and the rest from their own flock/ breeding stock. It was observed that the average breeding buck and doe ratio was 1:5.3 in Bati, 1.8.6 in Borena and 1:9.4 in Siti. The result revealed that buck scarcity was not the problem in all areas. The mean (±SE) number of breeding buck per flock within the interviewed households was 0.66±0.12, 1.08±0.11 and 1.42±0.11 for Bati, Borena and Siti areas, respectively. This showed that the existence of more than one breeding buck ownership custom across the study sites. Reserve for the death of main buck, large flock size, demonstration of wealth accumulation, socio-cultural purposes were among the major reasons raised by the respondents for keeping more than one breeding buck in a flock. Because of the presence of large number (50%) of households who did not have own breeding buck in Bati area, the average breeding buck per household was smaller as compared with Borena and Siti area goat owners. This might be due to the extensive castration and fattening practice in the area. The extensive castration practice could reduce problem of inbreeding and pregnancy from uncontrolled mating. On the other hand, early age castration may lead to scarcity of bucks in the flock.

About 50% Bati area, 35.61% Borena and 16.52% Siti goat producers who do not have breeding buck stated that they tend to borrow neighbor buck or mating took place at random with bucks present in the flocks in communal browsing area and watering point. Very few owners in Bati area (4.08%) were used communal (group) bucks given by extension office.

In the present study, in all the three areas uncontrolled natural mating system was surpassed while controlled natural mating (using breeding bucks individually) was very unpopular (Table 16). According to Kosgey (2004), an advantage of natural uncontrolled mating is that it allows for all year round breeding. On the other hand, uncontrolled mating together with small flock sizes and poor/absent record keeping on pedigree are expected to result in severe inbreeding which leads to poor growth rates (Saico and Abul, 2007).

Table 16. Type of natural mating systems

Natural mating system	Bati area		Borena		Siti	
	N	%	N	%	N	%
Controlled	11	11.22	2	1.52	2	1.74
Uncontrolled	87	88.78	130	98.48	113	98.26

N= Number of respondents

4.1.12.3. Breeding buck management and duration in the flock

Even though the impact of high-quality bucks in extensive goat production system is low due to uncontrolled natural mating practice, in Bati area about 44.9% of buck owners give additional supplements such as homemade grain, kitchen and food residues and sometimes purchased concentrates. Very fewer breeding buck keepers in Borena (7.06%) and Siti (6.25%) areas also provide special management for their breeding bucks. Therefore, investment in breeding bucks was not common in these areas. There was a significance ($p<0.05$) difference in duration (years) of bucks in a flock across the study areas. As shown in

Table 17, Borena and Siti goat producers kept bucks for a long period of time in a flock. According to Jimmy *et al*. (2010), such long duration depicts non quantifiable inbreeding in a flock.

Table 17. Bucks' average years of service recalled by owners

Study site	Mean ± SE	Minimum	Maximum
Bati area (N=47)	2.35 ± 0.11^{c}	1	4
Borena (N=85)	4.91 ± 0.15^{b}	2	8
Siti (N=96)	5.81 ± 0.21^{a}	2	10

a, b, c means with different superscript are significantly different (P<0.05); N=Number of respondents, SE =Standard Error

4.1.12.4. Breeding doe selection criteria

Table 18 summarized ranking of the owners' selection criteria for breeding does in the three surveyed areas. Siti pastoralist/agro-pastoralists were concerned more about milk production potential of does (index=0.374) followed by body size/conformation and litter size with the indices of 0.279 and 0.224, respectively. Unlike Siti pastoralist/agro-pastoralists, Borena pastoralist/agro-pastoralists ranked milk yield 2nd with the index of 0.214 next to body size/conformation (index = 0.314) followed by coat color (index = 0.174) and kid survival (index= 0.140), while in Bati area milk yield was ranked 4th with the index of 0.133 next to body size/conformation (index = 0.313), coat color (index = 0.207) and litter size (index= 0.182).

Table 18. Ranking producers selection criteria for breeding doe in the study areas

Selection criteria	Bati area				Borena				Siti			
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Color type	13	28	22	0.207	13	41	25	0.174	1	2	0	0.016
Body size/ conformation	41	21	10	0.313	59	27	25	0.314	26	13	17	0.279
Kid survival	3	2	8	0.037	1	2	4	0.14	0	1	0	0.004
Paternal history	1	2	2	0.016	1	0	1	0.009	0	0	2	0.005
Maternal history	1	2	8	0.027	12	6	15	0.073	1	3	10	0.044
Age at 1st sexual maturity	0	4	1	0.016	0	0	1	0.001	0	2	3	0.016
kidding interval	1	3	5	0.025	0	0	0	0	2	2	4	0.033
Litter size	16	19	17	0.182	7	11	19	0.074	7	23	30	0.224
Milk yield	15	11	8	0.133	26	34	32	0.214	34	25	8	0.374
Temperament	2	2	5	0.023	0	0	1	0.001	0	2	0	0.005
Horn presence and shape	0	1	3	0.009	0	0	0	0	0	0	0	0
Adaptability	1	1	2	0.012	0	0	0	0	0	0	0	0

Index= sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each selection criteria divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all selection criteria in a study site; R= Rank

4.1.12.5. Breeding buck selection criteria

Buck is the most important animal in the flock. It contributes 50% of the genetic makeup of kid born and determines overall pregnancy rate of the flock. The choice of good breeding buck is an important factor and fundamental in goat production. As indicated in Table 19, characterstics like conformation, growth rate, coat color, libido, maternal history were considered as important in all of the study areas and given due emphasis in selecting breeding buck.

Table 19. Ranking producers' selection criteria for breeding buck in the study areas

Selection criteria	Bati area				Borena				Siti/Shinille			
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Color type	33	27	21	0.330	11	40	50	0.244	3	17	22	0.107
Conformation	48	29	7	0.396	67	21	19	0.394	51	30	11	0.368
Fertility	0	4	6	0.027	0	0	1	0.001	0	5	8	0.030
Paternal history	1	0	0	0.006	0	0	4	0.006	1	3	8	0.027
Maternal history	1	0	6	0.017	2	2	7	0.025	8	23	18	0.145
Libido	2	0	3	0.017	4	5	3	0.037	14	4	23	0.120
Growth rate	6	25	26	0.178	25	42	28	0.289	24	20	7	0.196
Adaptability	0	2	3	0.013	0	0	0	0	0	0	0	0
Horn presence and shape	0	1	7	0.016	0	0	2	0.004	0	1	2	0.007

Index= sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each selection criteria divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all selection criteria in a study site; R= Rank

Th body conformation of breeding buck ranked first by all Bati, Borena and Siti goat owners with an index values of 0.396 , 0.394 and 0.368, respectively. In Bati area next to body size; coat color, growth rate and fertility was ranked as the most important, while sexual desire, growth rate and coat color type in Borena; and growth rate, maternal history and sexual desire for Siti received the higher index next to body size in order of appearance.

Generally the utilization of physical and performance characteristics as a selection criteria by the households revealed that the selection decision made by them followed stepwise mode *i.e.* the first screening is based on physical appraisal in early stage and further selections are based on production and reproduction characteristics at matured stage (after first kidding for females and mating for males).

4.1.13. Reproductive performances

The age at sexual maturity of male goats at Bati, Borena and Siti areas were found to be 8.21±0.28, 9.49±0.27and 13.43±0.45 months, respectively, in the meantime female goats were first mated at age of 8.77±0.23, 10.13±0.27 and 14.83±0.45 months in that order (Table 20). The average age at puberty was significantly (p<0.05) different for both sexes across the three study sites being the lowest in Bati area. The variation might be due to breed, availability of forage, environment and presence of buck in the flock (for females).

The age at first kidding for Bati, Borena and Siti area goats averaged at 14.98±0.24, 15.86±0.22 and 20.15±0.12 months old, respectively, which was statistically (p<0.05) higher for Siti area but for Bati and Borena areas did not have significance difference. The present findings on Bati area was comparable with the report of Endeshaw (2007) and Rume *et al.* (2011) who reported 14.88±0.3 and 14.25±0.69 months age at first kidding for Arsi-Bale (Loka Abaya in Ethiopia) and Patuakahli (Bangladesh) goat types, respectively. But Tsedeke (2007) and Belete (2009) reported smaller age at first kidding for Arsi-Bale (12 months) and Keffa (12.5 months) goat types, respectively. Age at first kidding in Siti area found in the present study was close to the report of Grum (2010) who reported 19.9 months for the same goat type. Alexander *et al.*, (1999) stated that reproductive characteristics including age at first kidding are influenced by many factors such as the genetic makeup of an individual, physical environment, nutrition and time of birth.

According to the respondents in Bati, Borena and Sit, area breeding does can serve in the flock for 8.02±0.23, 8.44±0.18 and 10.2±0.17 years, kidding in average every 7.95±0.19, 8.42±0.17 and 8.81±0.18 months, respectively. For the corresponding areas mean (±SE) of 11.08±0.25, 9.77±0.15 and 9.04±0.16 kidding per life time of a doe were reported. The inverse relation of average life time service and number of kidding per life time of a doe in the studied areas indicates goats around Bati area have better reproduction performance than goats in Borena and Siti area which might be attributed to either genetic and/or management variation.

Table 20. Some reproductive performances as estimated by respondents

Characters	Bati area		Borena		Siti	
	Mean±SE	Range	Mean±SE	Range	Mean±SE	Range
Age at 1st sexual maturity males (months)	8.21±0.28 [c]	6-18	9.49±0.27[b]	6-20	13.43±0.45[a]	6-30
Age at 1st sexual maturity females (months)	8.21±0.28 [c]	6-18	10.13±0.27[b]	6-24	14.83±0.45[a]	6-30
Age at 1st kidding (months)	14.98±0.24[b]	12-24	15.86±0.22[b]	12-24	20.15±0.12[a]	12-36
Kidding interval (months)	7.95±0.19[b]	6-12	8.42±0.17[ab]	6-12	8.81±0.18[a]	6-12
Average reproductive life time (years)	8.02±0.23[b]	4-13	8.44±0.18[b]	5-15	10.2±0.17[a]	8-17
Number of kidding/ life time /doe	11.08±0.25[a]	8-18	9.77±0.15[b]	6-15	9.04±0.16[c]	5-13

[a, b, c]: means with different superscript in the same row are significantly different ($p<0.05$); Min. = Minimum, Max. = Maximum, SE =Standard Error

4.1.14. Goat milking

In the present study higher percentage of respondents in Siti (98.26%) and Borena (94.70%), and below half of the respondents around Bati area (28.57%) reported goat milking and consumption (Table 21). This result also reflected that the consumption of goat milk is surpassed in pastoral areas of the country. Therefore, there is more practical significance to research and promote the goat milk nutritional content and acceptability in other goat producing areas of the country. All of the respondents use goat's milk for household consumption except Siti pastoralists who reported sale of goat milk during the wet season when there is more milk yield which exceeds from household consumption. According to the respondents boiled goat milk alone or with tea principally given to children and sick household members as a medicine and then if there is extra the other household members will access it.

Milk utilization, milking frequency and average lactation length (days) of goats in each study site are summarized in Table 21. From the report of interviewed participants, frequency of milking was dependent on mode of milking in the household and feed availability (season). Some owners milked their does in the morning and left the afternoon milk for the kids, the others who reported milking twice a day milked only one teat during time of milking and left the second for the kids to suck. As is, frequency of milking based on feed availability could be either only in the morning during dry season and twice during wet seasons or only in the morning both in wet and dry seasons (Table 21). Despite the availability of feed, very few respondents in Borena and Siti (11.54 and 5.26%, respectively) and over 40% in Bati area stated morning and dusk milking in both seasons and some others only wet season milking.

As shown in Table 21 disparities observed in lactation length of the three areas. The reported mean (± SE) lactation length of goats in Bati, Borena and Siti areas were 81.43±5.10, 64.44±2.12 and 100.62±2.31days, respectively. These variations might be due to the availability of other milking livestock (cow and camel) for households, physical environment and type/breed of goats.

Table 21. Milk utilization, milking frequency and lactation length (days)

	Bati area		Borena		Siti	
Parameter	N	%	N	%	N	%
Do you use goat's milk?						
Yes	28	28.57	125	94.7	113	98.26
No	70	71.43	7	5.3	2	1.74
Frequency of milking in wet season						
Once per day	13	46.43	42	33.6	5	4.42
Twice per day	15	53.57	83	66.4	108	95.58
Frequency of milking in dry season						
Once per day	12	54.55	23	88.46	54	94.74
Twice per day	10	45.45	3	11.54	3	5.26
Lactation length (mean ± SE)	28	81.43 ± 5.1^{b}	125	64.44 ± 2.12^{c}	113	100.62 ± 2.31^{a}

$^{a,\ b,\ c}$: means with different superscript in the same row are significantly different (P<0.05); N= Number of respondents, SE =Standard Error

4.1.15. Producers perception on some adaptability traits of their goats

In the present survey most of the goat keepers in all the study areas stated that their indigenous goat types had good level of drought, heat and feed shortage tolerance adaptive traits combination. On the other hand, high percentage of respondents (76.29, 91.67, 93.04% for Bati, Borena, Siti areas respectively) reported that their goats had low level of cold tolerance capability (Table 22). Both Borena and Siti respondents showed similarities by suggesting medium level of disease resistance and external parasite tolerance of their goats, while Bati area participants perceived good level of disease resistance and external parasite tolerance.

Finally, the perception of goat owners in this study implied that the goat populations in the respective studied areas have developed varied adaptable characteristics to be able to survive and reproduce in those environments. Thus, perceptions' of producers about adaptive traits of their animals in those environments should be supported with genetic analysis studies. So that it can be exploited for future climate change adaptation breeding programs for these communities.

Table 22. Percentage of respondents in leveling goats' adaptive trait by study area

Tolerance	Bati area			Borena			Siti		
	Good	Med.	Less	Good	Med.	Less	Good	Med.	Less
Disease	47.42	44.33	8.25	13.64	72.73	13.64	27.83	53.04	19.13
External parasite	51.55	38.14	10.31	25.00	65.91	9.09	9.57	74.78	15.65
Heat	65.98	27.84	6.19	65.91	34.09	0	65.22	33.91	0.87
Frost/cold	3.09	20.62	76.29	0.76	7.58	91.67	0	6.96	93.04
Drought	53.61	44.33	2.06	69.70	28.79	1.52	54.78	44.35	0.87
Feed shortage	52.04	46.39	4.12	67.42	31.82	0.76	60.00	33.91	6.09
Water shortage	30.85	53.19	15.96	86.36	13.64	0	28.70	45.22	26.09

Good= No significant body condition loss and death; Med (medium) = to some extent body condition loss and death of animals; Less = high body condition loss and death

4.1.16. Marketing

As to many other locations of the country, farmers/pastoralists in the studied areas sold their animals at local markets throughout the year in times of cash need as well as feed shortage. The meat demand grows much higher during major holidays/festivals. Thus, the density of producers who sale their goats targeting the particular holidays/festivals was higher. This was to reap maximum benefit from sales. As stated by the respondents, local household consumers/breeders, butchers, small traders, brokers (*Delalas*) and permanent traders or exporters (particularly around Bati and Borena markets) were the major market participants. This result was similar with the reports of Tsedeke (2007), Belete (2009) and Tesfaye (2009) in Southern, Western and Northern part of Ethiopia, respectively.

Shinille, Erer and Dire Dawa; Beke, Yabello and El-Woye; Bati and Gerba are among the local market places where the Siti, Borena and Bati area farmers/pastoralists sold their goats respectively. During the time of survey weigh based marketing practice was observed in Borena and Bati area local markets.

Even though, there is great demand for Bati goats (locally known as "*Habesha"*) by local consumers, big traders (exporters) focused on Afar goats found in Bati area, despite their small body frames as compared with Bati goats. This clearly indicated that the demand for Bati goats by oversea consumers is low as compared with Afar goats. So that further meat quality analysis study and comparison of the two goat types will have paramount importance in designing breeding strategy which considered the preference of oversea consumers and domestic markets to. In accordance with the reports of Endeshaw (2007), Tsedeke (2007) and Belete (2009) in Ethiopia and Kosgay (2004) in Kenya, in local markets of Siti and Dire Dawa informal goat marketing practice (eye ball price setting) was noted. It is also an indication of less involvement of big traders (exporters) in this areas and loud the requirement of value chain approach (interaction of different actors at different phases).

Farmers and pastoralists/agro-pastoralists do not have specific age of selling rather simply they sold their animals whenever they need cash. Nonetheless, the interviewed individuals were asked to tell the average months when the male and female goats reached for market. The mean (±SE) age of marketing in Bati male (6.21±0.23 months) and female (6.35±0.23

months) goats were significantly ($p<0.05$) lower than that of Borena and Siti goats. There was no significance ($p>0.05$) difference between Borena and Siti area goats' age of marketing. The average age of marketing around Borena area was 8.58±0.24 months for males and 8.84±0.22 months for females. The corresponding figures at Siti were 8.35±0.19 and 8.62±0.19 months, respectively.

The selection decision of producers for sex and/or age category of goats for sale determined by the amount of cash needed and its urgency, market demand and the availability of different age categories in the flock. The most targeted four category of goats in order of importance include the following: weaned males, castrates, old does and weaned females in Bati area; weaned males, old does, old bucks and weaned females in Borena; and castrates, weaned males), old does and old bucks in Siti (Appendix Table 3).

4.1.17. Animal health management

Based on physiological symptoms, producers were asked to report the occurrence of different diseases. All of the interviewed producers across the study areas reported the incidence of symptoms commonly associated with several economically important goat diseases; depression, circling, accidental death, abortion, coughing, serious nasal discharge which block nostrils, bloody and bad odor diarrhea, lameness, mouth inflammation, formation of vesicles on mouth and foot, nodules on the lips and eyes, skin irritation and scratching with fixed objects were among reported symptoms.

It was found that about 69.79, 55.17 and 69.61% of interviewed households in Bati, Borena and Siti areas, respectively, have veterinary service access within 5 km distance and 30.21, 44.83 and 30.39% of households in that order should walk over 6 km to find veterinary service. The most commonly used veterinary services around Bati area were government and privet clinics while in Borena and Siti area producers have additional service from NGOs and CAHWs (Table 23).

Even though over 87% of producers across study areas had different veterinary service access, 62.24% of Bati area, 75.76% of Borena and 92.11% of Siti producers reported utilization of traditional prevention and treatment by traditional healers following the manifestation of the above symptoms either together with the modern veterinary medications or alone; as such the effective doses of traditional medicines are not fully known, nor the effectiveness, safety and toxicity. Branding of the swollen body part of animal, medical plants extract dosing, fumigation, releasing blood and external application of oil, gas, used motor engine oil and soot were most frequently mentioned traditional mode of disease prevention and treatments. Similar traditional mode of disease prevention and treatments methods were reported in Zimbabwe (Homman *et al*., 2007).

Table 23. Types of veterinary services accesses in the study areas

Type of veterinary service accesses	Bati area (N=98)		Borena (N=132)		Siti (N=115)	
	N	%	N	%	N	%
Government clinics	96	97.96	80	68.96	54	52.41
Privet clinics	15	15.63	29	21.97	9	8.73
NGOs	0	0	3	2.62	22	21.35
CAHWs	0	0	22	18.96	54	52.41

N.B One respondent may have more than one veterinary service access; N = Number of respondents; CAHWs = Community Animal Health Workers; NGOs = None Governmental Organizations

4.1.18. Constraints associated with goat keeping

The important goat production constraints reported by producers across the study areas summarized in Table 24. Thought the major constraints facing goat breeding systems are mostly similar, their importance varied across the study areas. Around Bati area feed shortage, disease occurrences and drought ranked 1st, 2nd and 3rd as major goat rearing constraints whilst disease occurrences, feed shortage and recurrent drought in Borena; and recurrent drought, disease occurrence, feed as well as water shortage in Siti area had been perceived by the respondents as most influencing constraints in order of importance. Both privet and communal grazing/browsing area scarcity and erratic rainfall contributed for feed shortage in Bati area, while recurrent drought in Siti and Borena areas. Bush encroachment (*Prosopis juliflora*) was also mentioned as additional cause of feed shortage in Siti. Improved rangeland management can be one alternative to minimize feed shortage by resorting and increasing the productivity of degraded natural grazing/browsing areas. To control extensive grazing/browsing land utilization integrating traditional leadership and formal administration are essential. For instance, local by-laws implemented around Bati area for the utilization of some communal grazing/browsing areas were appropriate and could have positive impact in livestock productivity and have to be adopted as a role-model even beyond Bati area.

Table 24. Goat production constraints as perceived by the respondents

Main constraint	Bati area				Borena				Siti			
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Drought	13	39	19	0.237	17	40	55	0.234	60	26	17	0.359
Feed shortage	46	21	14	0.338	26	60	38	0.296	20	41	28	0.245
Water shortage	0	3	5	0.019	5	11	16	0.067	17	6	28	0.131
Disease	26	20	31	0.260	84	18	14	0.379	19	43	31	0.251
Predator	4	4	7	0.047	1	4	7	0.023	0	2	2	0.009
Market	0	3	0	0.010	0	0	1	0.001	0	0	3	0.004
Labor shortage	10	7	7	0.089	0	0	0	0	0	0	1	0.001

Index= sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) give for each constraint divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all of the constraints for a production system; R= Rank

Predator, market and labor problem were among the minor reported as goat raising constraints by all communities. However, predator problem and labor shortage received a little higher proportion around Bati area as compared with Borena and Siti areas. In all areas, almost all of the respondents did not rank lack of appropriate genotype/breed as a constraint. This may suggest that producers have good perception about their indigenous goats' adaptability and productivity characteristics and/or it might be due to lack of awareness about improved breeds. Therefore, since the producers in all study areas are traditional goat keepers, they need to be aware on the merits of improving local goats before implementations of breed improvement programs. In the present study, ranking of goat rearing constraints (indices) by the producers reflected that their priority needs for support services. Hence, stakeholders should give diligent attention for the problems based on their prioritization to be welcomed by them.

4.1.19. Major goat health problems

In the present study, it is indicated that (Table 24), disease is among the important goat production bottlenecks as reported by goat owners. Therefore, to adopt adequate health management strategies, it is fundamental to identify causes of morbidity and mortality and to investigate the prevalence of diseases by type and dynamics (Chiejina *et al*., 2002). Existing health problems were identified and ranked by the respondents; and translated to their veterinary equivalents with the support of animal health workers in the respective area (Table 25). Similar range of disease problems were reported in Ethiopia (Tesfaye, 2009; Grum, 2010; Dereje *et al*., 2013) and most Sub-Saharan countries (Kusiluka and Kambarage, 1996). The reported health problems were mange mite, pneumonia, pasteurellosis, anthrax and goat pox were the first five goat diseases identified around Bati area, while contagious caprine pleuropneumonia (CCPP), coenurosis, pasteurellosis, mange mite and diarrhea in Borena; and babesiosis, diarrhea, CCPP, goat pox and Pest des Petit Ruminants (PPR) in Siti area were prioritized by the interviewed respondents. The prioritization of goat diseases by the respondents in each area revealed that some diseases do not have the same importance across the study areas. This local variation in health problems indicated the need of area specific animal health improvement strategy interventions (Homann *et al*., 2007).

Due to the thicker, highly flexible and clean inner surface features, goat skins from the highlands of Ethiopia are categorized as "Bati-genuine" and those from the lowlands as "Bati-type" in the international market (Mahmud, 2000). Nevertheless, Mange mite (locally known as "*Keto*") was the major goat health problem around Bati area. The prevalence of mange mite in the area will be resulted deterioration of the quality of skin, leather and leather products; in turn it will drop foreign exchange earnings from skin, leather and leather product export. Therefore, the government should strengthen community ownership dipping and spraying facilities in the area.

Table 25. Ranking of major goat health problems as reported by goat producers

Location	Vernacular name	Common name	Rank1	Rank2	Rank3	Index
Bati area	*Keto*	Mange mite	71	8	3	0.603
	Sal (Gunfan)	Pneumonia	10	12	3	0.148
	Neft	Pasteurellosis	6	13	1	0.117
	Dengetegna	Anthrax	1	10	3	0.068
	Abdra	Goat pox	2	4	3	0.044
	Bosek	Black leg	0	3	2	0.021
Borena	*Sombesa*	CCPP	77	36	8	0.408
	Qulda ,Silisa re'e	Pasteurellosis	1	28	38	0.127
	Sirgo	Coenurosis	51	53	14	0.358
	Haddo	Liver disease	0	4	10	0.024
	Albati re'e	Diarrhea	2	3	9	0.028
	Cito	Mange mite	1	12	2	0.038
	Selesa	Brucellosis (Abortion)	0	3	1	0.009
	Chirmale	Anthrax	1	1	1	0.008
Siti	*Sogudud*	Babesiosis	48	22	10	0.400
	Gedanod	Goat pox	7	19	10	0.139
	Sombob	CCPP	3	19	15	0.125
	Abeb	FMD	0	3	9	0.030
	Shuben (Xar)	Diarrhea	17	17	17	0.206
	Candugal	PPR	7	2	9	0.069
	Ampbar (Cadho)	Mange mite	1	3	6	0.030

Index= sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) given for each type of disease divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all types of diseases in a study site; CCPP=Contagious Caprine Pleuro Pneumonia, FMD= Mouth and Foot Disease, PPR= Pest des Petit Ruminants

4.2. Phenotypic Description of Bati, Borena and Short-Eared Goat Populations

4.2.1. Qualitative characteristics

The frequency and their percentage of qualitative traits of Bati, Borena and Short-eared Somali goat populations for both buck and does are presented in Table 26. The observed overall coat color patterns for both sexes were 64.20% plain, 33.33% patchy/pied and 2.47% spotted in Bati; 72.36% plain, 23.98% patchy/pied and 3.66% spotted in Borena; and 45.08% plain, 39.90% patchy/pied and 15.03% spotted in Short-eared Somali goat populations. Tesfaye *et al*. (2006) reported higher proportion (93%) of plain coat color pattern for central highland goats around South Wollo (Bati) and North Shewa (Shewa Robit and Ankober). Plain brown (dark and light) (51.85%) were the predominant coat colors observed in Bati goats of both sexes while white coat color were most frequently observed in Borena (71.54%) and only 36.27% in Short-eared Somali goat populations. In studied sample populations white mottled with different colors (dark or light red, black), uniform black and gray color animals were present with small and varied frequencies across populations. Though the frequencies of some coat colors were small in a population, the current study demonstrated that the studied goat populations have a wide range of coat colors. Similarly Halima *et al*. (2012a) and Grum (2010) reported wide range of coat colors for different Ethiopian goat populations. The small proportion of black coat colored goats (absent in males) in sampled populations confirmed the response of producers discussed under section 4.1.13 of this study.

Most of the Bati goats (87.5% females and 67.7% males) had straight head profile and about 14% (11.7% females and 23.5% males) of this goat type were with slight concave head. Almost all (99%) of male and female Borena goats had straight head profile. From the total sampled Short-eared Somali goats, 41.7 % females and 77.8% males had straight head profile. As compared with Bati and Borena goats the frequency of slightly concaved head goats was higher (48.2%) in Short-eared Somali goats. In studied populations the horned goats (does and bucks) accounted 94.4, 78.9 and 80.8% in Bati, Borena and Short-eared Somali populations, respectively. The reminder proportions in each sampled population, except 8.9% of Borena does which displayed some rudimentary horns, were polled. The proportions of polled bucks were higher than does in each population across the three populations. This might be due to either producers' interest in polled bucks or the higher frequency of short-horned allele (HoP) for males. In horned goats different horn shapes (straight, curved and spiral) and orientations (backward, forward, upward and lateral) were observed. However, goats with straight horn shape (96.7% Bati, 68.7% and 54.5% Short-eared Somali) and back ward orientation (71.9% Bati, 50% Borena and 61.5% Short-eared Somali) were dominant in all populations.

The majority of Bati and Borena goats were characterized by lateral/sideway ear orientation accounting a total of 59.9 and 78.9%, respectively, followed by hanged down ears observed in 35.8 and 12.5% of individuals in that order. Very small proportion of goats (4.3% Bati and 7.7% Borena) was also with forward erected ears. Large proportion (> 84 %) of forward and small proportion (15%) of lateral ear orientations distinguished Short-eared Somali goats from the two populations. Though straight back profile was predominant in the three goat populations, other back profiles such as slops up towards the rump, slops down from the wither and dip were noted rarely.

Table 26. Frequency (N) and percentage in brackets for each level of qualitative traits by goat population

Traits	Class level	Bati			Borena			Short-eared Somali		
		Female N (%)	Male N (%)	Total N (%)	Female N (%)	Male N (%)	Total N (%)	Female N (%)	Male N (%)	Total N (%)
Coat pattern	Plain	85(66.41)	19(55.88)	104(64.2)	144(71.64)	34(75.56)	178(72.36)	57(41.01)	30(55.56)	85(45.08)
	Patchy/pied	39(30.47)	15(44.12)	54(33.33)	48(23.88)	11(24.44)	59(23.98)	54(38.85)	23(42.59)	77(39.90)
	Spotted	4(3.13)	-	4(2.47)	9(4.48)	-	9(3.66)	28(20.14)	1(1.85)	29(15.03)
Coat color type	White	12(9.38)	6(17.65)	18(11.11)	140(69.68)	36(80.00)	176(71.54)	42(30.22)	28(51.85)	70(36.27)
	Dark red/brown	40(31.25)	8(23.53)	48(29.63)	1(0.5)	0	1(0.41)	5(3.60)	1(1.85)	8(4.15)
	Black	4(3.13)	0	4(2.47)	0	0	0	7(5.04)	1(1.85)	6(3.11)
	Gray	1(0.78)	0	1(0.62)	5(2.49)	0	5(2.03)	11(7.91)	2(3.70)	13(6.74)
	Light red	30(23.44)	6(17.65)	36(22.22)	2(1.00)	0	2(0.81)	9(6.47)	2(3.70)	11(5.70)
	White +Brown	15(11.72)	3(8.82)	18(11.11)	4(1.99)	0	4(1.63)	1(0.72)	4(7.41)	5(2.59)
	White +Black	3(2.34)	3(8.82)	6(3.7)	14(6.97)	3(6.67)	17(6.91)	30(21.58)	11(20.37)	41(21.24)
	White+ Light brown	23(17.97)	8(23.53)	31(19.14)	35(17.41)	6(13.33)	41(16.67)	34(24.46)	5(9.26)	39(20.21)
Facial profile	Straight	112(87.5)	23(67.65)	135(83.33)	199(99.00)	45(100)	244(99.19)	58(41.73)	42(77.78)	100(51.81)
	Slightly concave	15(11.72)	8(23.53)	23(14.2)	1(0.50)	0	1(0.41)	81(58.27)	12(22.22)	93(48.19)
	Slightly convex	1(0.78)	3(8.82)	4(2.47)	1(0.50)	0	1(0.41)	0	0	0
Horn	Present	126(98.44)	27(79.41)	153(94.44)	163(81.09)	31(68.89)	194(78.86)	128(92.09)	28(51.85)	156(80.83)
	Absent	2(1.56)	7(20.59)	9(5.56)	16(7.96)	14(31.11)	30(12.2)	11(7.91)	26(48.15))	37(19.17)
	Rudimentary	0	0	0	22(10.96)	0	22(8.94)	0	0	0
Horn shape	Straight	124(98.41)	24(88.89)	148(96.73)	107(65.24)	27(87.1)	134(68.72)	64(50.00)	21(75.00)	85(54.49)
	Curved	1(0.79)	3(11.11)	4(2.61)	51(31.1)	3(9.68)	54(27.69)	54(42.19)	1(3.57)	55(35.26)
	Spiral	1(0.79)	0	1(0.65)	6(3.66)	1(3.23)	7(3.59)	9(7.03)	6(21.43)	16(10.26)

Table 26. (*Continued*)

Variable	Class level	Bati			Borena			Short eared Somali		
		Female N (%)	Male N (%)	Total N (%)	Female N (%)	Male N (%)	Total N (%)	Female N (%)	Male N (%)	Total N (%)
Horn orie-ntation	Lateral	0	0	0	30(18.18)	2(6.45)	32(16.33)	9(7.03)	4(14.29)	13(8.33)
	Up ward	41(32.54)	2(7.41)	43(28.1)	37(22.42)	6(19.35)	43(21.94)	40(31.25)	4(14.29)	44(28.21)
	Back ward	85(67.46)	25(92.59)	110(71.9)	76(46.06)	22(70.97)	98(50.00)	77(60.16)	19(67.86)	96(61.54)
	Pointing forward	0	0	0	22(13.13)	1(3.23)	23(11.73)	2(1.56)	1(3.57)	3(1.92)
Ear orie-ntation	lateral	77(60.16)	20(58.82)	97(59.88)	156(77.61)	38(84.44)	194(78.86)	22(15.83)	7(12.96)	29(15.03)
	Forward Erected	1(0.78)	6(17.67)	7(4.32)	16(7.96)	3(6.67)	19(7.72)	117(84.17)	47(87.04)	164(84.97)
	Hanged down	50(39.06)	8(23.53)	58(35.8)	26(12.94)	4(8.89)	30(12.20)	0	0	0
	Pendulous	0	0		3(1.49)	-	3(1.22)	0	0	0
Back profile	Straight	76(59.38)	21(61.76)	97(59.88)	171(85.07)	41(91.11)	212(86.18)	115(82.73)	42(77.78)	157(81.35)
	Slops up towards the rump	6(4.69)	0	6(4.69)	0	0	0	16(11.51)	3(5.56)	19(9.84)
	Slops down from the wither	26(20.31)	7(20.59)	33(20.37)	0	0	0	7(5.04)	4(7.41)	11(5.70)
	Dipped	20(15.63)	6(17.65)	26(16.05)	30(14.93)	4(8.89)	34(13.82)	1(0.72)	5(9.26)	6(3.11)
Wattle	Present	0	0	0	4(1.99)	0	4(1.63)	9(6.47)	0	9(4.66)
	Absent	128(100)	34(100)	162(100)	197(98.01)	45(100)	242(98.37)	130(93.53)	54(100)	183(94.82)
Ruff	Present	0	19(55.88)	19(11.73)	0	31(68.89)	31(12.60)	0	20(37.04)	20(10.36)
	Absent	128(100)	15(44.12)	143(88.27)	201(100)	14(31.11)	215(87.40)	139(100)	34(62.96)	173(89.64)
Beard	Present	32(25)	23(67.65)	55(33.95)	51(25.37)	41(91.11)	92(37.4)	25(17.99)	49(90.74)	74(38.34)
	Absent	96(75)	11(32.35)	107(66.05)	150(74.63)	4(8.89)	154(62.60)	114(82.01)	114(82.01)	119(61.66)

Except 2% of Borena and 4.7% of Short-eared Somali does, wattle was totally absent in all bucks of the three populations and Bati does. It was found that about 56, 69 and 37 % of Bati, Borena and Short-eared Somali bucks had ruff, respectively. Over 90% of Borena and Short eared Somali and 67.7% of Bati bucks had beard while about 25% of Bati and Borena as well as 17.9% of Short-eared Somali does were bearded. This result indicated that the presence of beard was more frequent in males. Similar results were also reported by Grum (2010) for the same goat type and Dereje *et al.* (2013) in Hararghe highland goats. According to Hagan *et al.*, (2012), in addition to the thermoregulatory functions, the presence of wattle and beard associated with reproduction traits such as higher prolificacy, higher milk yield, higher litter size, fertility and conception rate.

In general, when appraised visually goats from the three areas were different (Figure 9), which might be resulted due to breed and geographical differences. Thus, further to understand the typical qualitative particularities of each goat population and transform into a graphical display, multiple correspondence analysis was carried out on the recorded qualitative traits. The bi-dimensional graph represented the associations among the different categories of qualitative traits (Figure 8). The interpretation is based on points found in approximately the same direction from the origin and in approximately the same region of the space. As shown in the bi-dimensional plot below, the first and second identified dimensions explained 8.9 and 7.1% of the total variation, respectively. On the identified dimensions, the Bati goats clustered together with light brown "*Dalcha*" and deep brown coat color type, straight and slightly convex head, dipped and sloping back, lateral and hanged down ears, straight backward horn. The Borena goats also associated with plain white coat color, presence of ruff, pendulous ear, forward pointing and rudimentary horn while the short-eared Somali goats was associated together by forward erected ear, straight back, laterally oriented, curved and spiral horn, spotted pattern, grey coat color and presence of wattle.

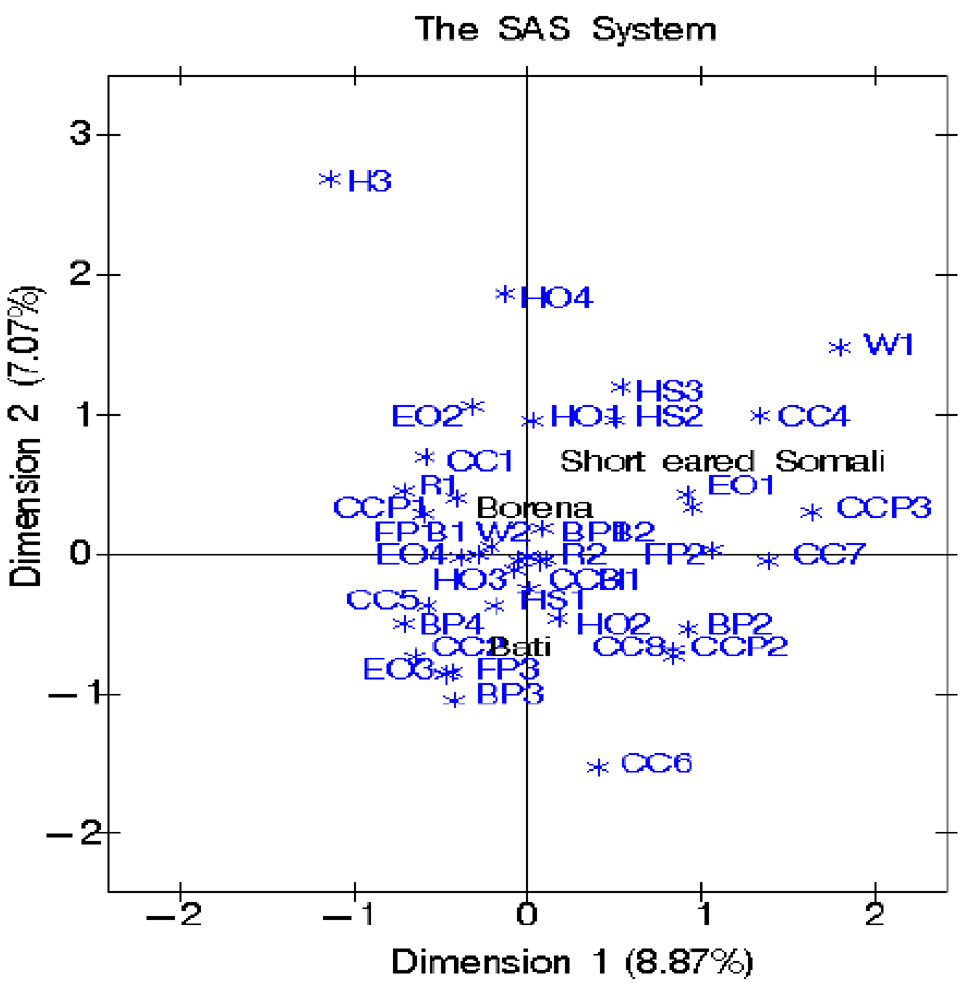


Figure 8. Association among qualitative traits categories via correspondence analysis

Legend:

Variable Name	Levels and description
Coat color pattern	CCP1=Plain CCP2=Patchy/pied CCP3=Spotted
Coat color type	CC1= White CC2= Brown CC3=Black CC4= Grey CC5= Light red CC6= White with brown CC7= White with Black CC8=White with light red
Facial/head profile	FP1= Strait FP2= Slightly concave FP3= Slightly convex
Horn presence	H1=Present H2=Absent H3= Rudimentary
Horn shape	HS1=Straight HS2=Curved HS3=Spiral
Horn orientation	HO1=Lateral HO2= Upward HO3= Back ward HO4= Pointing forward
Ear orientation	EO1=Erected forward EO2=Pendulous EO3 =Hanged down EO4=Lateral
Back profile	BP1=Straight BP2= Slops up towards the rump BP3= Slops down from the wither BP4=Dipped
Wattle	W1= Present W2= Absent
Ruff	R1= Present R2= Absent
Bear	B1= Present B2= Absent

Bati doe (left) and buck (right)

Borena doe (left) and buck (right)

Short-eared Somali does (left) and buck (right)

Figure 9. Physical appearances of indigenous Ethiopian adult goat populations

4.2.2. Quantitative characteristics

Quantitative characteristics are those that can be measured in some units. Knowledge of these quantitative characteristics is important to implement genetic improvement (selection), appreciate variations among goat populations so as to facilitate their sustainable use and estimate live body weight from simple and more easily measurable variable as well as market value in terms of cost of the animals. Therefore, general linear model procedure of SAS was employed separately for female and male sample populations in order to assess variations of continuous variables within and among populations. Least square means (± SE), coefficient of variation and magnitude of population effect of body weight, body condition score and other linear body measurements for does and bucks by population are presented in Tables 27 and 28, respectively.

4.2.2.1. Quantitative variation for does

Population-wise comparisons of least squares means of traits between populations revealed that Bati does were significantly ($p<0.05$) heavier by weighing an average of 33.97±0.49 kg and measuring widest chest (17.10±0.16cm) among the three different populations. As compared with Borena does, they varied significantly ($p<0.05$) in only three traits (body weight, chest width and horn length) of the nine measured traits and body condition score, otherwise they were comparable in most of their body dimensions (body condition score, body length, height at wither, chest girth, rump length, pelvic width and ear length).Therefore, the result implied that, differences between the Bati and Borena does were little even though most traits showed slightly higher average values in the Bati does except for height at wither and chest girth which were a little higher for Borena does.

The Short-eared Somali does remained significantly ($p<0.05$) smallest in body weight, body condition score and other leaner body measurements except horn length (Table 27). As compared with the result found in the present study, slightly lower mean values of body weight, body length, height at wither and chest girth for mature Bati does were reported by Halima *et al*. (2012a) and Tesfaye *et al.* (2006). The variations could be due to different age of animals included in the sample.

The respective overall R^2 values ranged from 0.02 for body condition score to 0.56 for horn length, indicated that about 56% of the variation in horn length was explained by the factor included in the model (population) while only 2% for body condition score variability.

Table 27. Descriptive statistics of body weight (kg), body condition score and other body measurements (cm) for does as affected by population types.

Traits	Population						Overall mean	
	Bati (N=128)		Borena (N=201)		Short-eared Somali (N=139)			
	LSM±SE	CV (%)	LSM±SE	CV (%)	LSM±SE	CV (%)	CV (%)	R^2
BC	2.65±0.08[a]	35.0	2.62±0.07[a]	38.0	2.32±0.07[b]	33.7	36.1	0.02
BW	33.97±0.49[a]	16.2	31.49±0.36[b]	16.4	24.67±0.28[c]	13.2	15.9	0.38
BL	62.97±0.27[a]	4.9	62.48±0.23[a]	5.3	57.85±0.41[b]	8.3	6.2	0.23
HW	68.74±0.29[a]	4.7	68.91±0.22[a]	4.5	62.88±0.25[b]	4.7	4.6	0.44
CG	73.55±0.36[a]	5.6	73.59±0.27[a]	5.1	67.27±0.28[b]	4.9	5.2	0.38
CW	17.10±0.16[a]	10.4	16.37±0.12[b]	10.6	15.35±0.14[c]	10.7	10.6	0.13
RL	15.25±0.08[a]	6.3	15.10±0.07[a]	6.3	14.07±0.08[b]	6.7	6.4	0.22
PW	14.36±0.09[a]	6.9	14.17±0.07[a]	6.9	13.73±0.13[b]	11.0	8.3	0.04
HL	13.87±0.24[b]	19.0	8.59±0.26[c]	40.8	17.51±0.34[a]	22.0	26.7	0.56
EL	15.65±0.12[a]	8.3	15.34±0.12[a]	10.7	12.99±0.10[b]	8.9	9.6	0.39

Means with different superscripts within the same row are statistically different (at least $p<0.05$); BC= Body Condition, BL=Body Length, HW=Height at Wither, CG=Chest Girth, CW=Chest Width, RL=Rump Length, PW=Pelvic Width, HL=Horn Length, EL=Ear Length; LSM =Least squares means, SE=standard errors, CV=Coefficient of Variations and R^2=magnitude of population effect

4.2.2.2. Quantitative variation for bucks

Though most traits showed higher average values in Bati bucks likewise in females, differences with Borena bucks were not significant ($p>0.05$) for most of body characteristics except pelvic width and horn length which were significantly ($p<0.05$) lower for Borena bucks. Most of the body measurements estimated for Short-eared Somali bucks were significantly ($p<0.05$) lower as compared with their counterparts in Bati and Borena. Despite the other measurements the average values of pelvic width and horn length between Bati and

Short-eared Somali; and body condition score in the three populations were nearly similar (Table 28). However, body condition score for Short-eared Somali bucks were slightly higher. Such variation in terms of body condition score might be due to relatively small and compact nature of the animals since the ratio of goat owners who provided special management for bucks was limited (6.25%) in the area as reported under section 4.1.11.3 of this study.

The overall trait based coefficient of variation of bucks ranged 6.4 to 28.1% for height at wither and horn length, respectively. The population effect (R^2) values ranged from 0.01 for body condition score to 0.57 for horn length. Traits with low overall R^2 with the corresponding high coefficient of variation (CV) values such as body condition score in the present study reflected that the heterogeneity was within the population while the reverse (high overall R^2 and low CV values such as height at wither) indicated heterogeneity between populations. Therefore, the varying coefficients of variation in this study attributed to both population and individual differences.

Table 28. Descriptive statistics of body weight (kg), body condition score and other body measurements (cm) for bucks as affected by population type.

Traits	Population						Overall mean	
	Bati (N=34)		Borena (N=45)		Short eared Somali (N=54)			
	LSM±SE	CV	LSM±SE	CV	LSM±SE	CV	CV	R^2
BC	3.06±0.16[a]	30.1	3.02±0.11[a]	23.9	3.22±0.10[a]	23.1	25.2	0.01
BW	41.30±0.85[a]	11.9	40.04±1.21[a]	20.3	30.62±0.67[b]	16.1	17.0	0.39
BL	65.59±0.59[a]	5.2	65.13±0.63[a]	6.5	57.28±0.69[b]	8.9	7.1	0.45
HW	76.09±0.68[a]	5.2	74.84±0.66[a]	6.0	64.98±0.67[b]	7.6	6.4	0.57
CG	81.25±0.95[a]	6.8	79.49±0.78[a]	6.6	71.24±0.73[b]	7.6	7.0	0.42
CW	18.12±0.29[a]	9.5	18.49±0.41[a]	15.0	16.37±0.30[b]	13.4	13.1	0.15
RL	16.41±0.21[a]	7.5	16.22±0.16[a]	6.8	15.44±0.23[b]	11.1	8.9	0.09
PW	15.94±0.27[a]	9.9	14.73±0.20[b]	9.1	15.91±0.30[a]	13.6	11.4	0.09
HL	18.57±0.73[a]	21.3	13.05±0.75[b]	32.2	19.92±1.10[a]	30.2	28.1	0.29
EL	14.50±0.43[a]	17.3	14.31±0.27[a]	12.9	12.01±0.32[b]	19.6	16.7	0.22
SC	27.07±0.36[a]	7.8	27.02±0.30[a]	7.5	25.81±0.37[b]	10.6	8.9	0.06

BC= Body Condition, BL=Body Length, HW=Height at Wither, CG=Chest Girth, CW=Chest Width, RL=Rump Length, PW=Pelvic Width, HL=Horn Length, EL=Ear Length, SC=Scrotum Circumference; LSM =Least squares means, SE=standard errors, CV=Coefficient of Variations and R^2=magnitude of population effect
Means with different superscripts within the same row are statistically different (at least $p<0.05$).

4.2.3. Relationships between body weight and other body measurements

Coefficients of correlation between body weight and studied traits in this study varied from strong (0.85) to low (0.18) and highly significant (p<0.01) to non-significant (Table 29). Most measurements (BC, BL, HW, CG, CW, RL PW and HL) depicted positive and highly significant (p<0.01) correlation with live body weight. Therefore, selection of one or more of these traits except horn length (biologically which is not acceptable), may increase in live body weight of these goat populations.

Correlation coefficient was consistently the highest between live body weight and chest girth in both sexes for the populations. However, for Short-eared Somali bucks equally the highest correlation coefficient was found for chest girth and height at wither with body weight. Even though the correlation of body weight with chest girth was positive and significant for both sexes, higher values were observed to be in bucks as compared with does within the same population.

Due to positive and highly significant correlation between body weight and other linear body measurements, traits in combination or individually could be measured to predict live body weight. Particularly, chest girth would provide a good estimate for predicting live body weight. Similarly, Halima *et al*. (2012a) and Grum (2010) for some Ethiopian goats; and Tesfaye (2008) for sheep reported the highest correlation between body weight and chest girth. This shows that chest girth might be the best trait to indicate live body weight for both goats and other livestock species.

Table 29. Pearson's correlation coefficients of quantitative traits for bucks (above diagonal) and does (below diagonal)

Population	Traits	BW	BC	BL	HW	CG	CW	RL	PW	HL	EL	SC
Bati	BW		0.57**	0.61**	0.58**	0.85**	0.47**	0.55**	0.47**	0.40*	-0.18^{NS}	0.55**
	BC	0.52**		0.59**	0.27^{NS}	0.54**	0.44**	0.14^{NS}	0.27^{NS}	0.21^{NS}	0.14^{NS}	0.34^{NS}
	BL	0.62**	0.35**		0.46**	0.77**	0.47**	0.41*	0.40*	0.28^{NS}	0.04^{NS}	0.40*
	HW	0.40**	0.17*	0.48**		0.54**	0.01^{NS}	0.44**	0.66**	-0.06^{NS}	-0.31^{NS}	0.54**
	CG	0.82**	0.34**	0.57**	0.51**		0.50**	0.71**	0.62**	0.42*	-0.17^{NS}	0.56**
	CW	0.68**	0.30**	0.46**	0.33**	0.61**		0.40*	0.34*	0.45*	0.07^{NS}	0.31^{NS}
	RL	0.62**	0.29**	0.43**	0.41**	0.59**	0.59**		0.57*	0.34^{NS}	-0.24^{NS}	0.60**
	PW	0.53**	0.32**	0.39**	0.32**	0.49**	0.52**	0.51**		-0.14^{NS}	-0.16^{NS}	0.60**
	HL	0.32**	0.07*	0.36**	0.18*	0.26**	0.18*	0.12*	0.15^{NS}		0.08^{NS}	0.26^{NS}
	EL	0.18*	0.04^{NS}	0.20*	0.21*	0.23*	0.12^{NS}	0.10^{NS}	0.06^{NS}	0.09^{NS}		-0.09^{NS}
Borena	BW		0.36*	0.80**	0.79**	0.86**	0.55**	0.76**	0.78**	0.69**	-0.19^{NS}	0.53**
	BC	0.40**		0.27^{NS}	0.51**	0.30*	0.10^{NS}	0.11^{NS}	0.22^{NS}	0.52**	-0.06^{NS}	0.10^{NS}
	BL	0.67**	0.27**		0.77**	0.76**	0.28^{NS}	0.66**	0.71**	0.60**	-0.15^{NS}	0.37*
	HW	0.50**	0.08^{NS}	0.50**		0.80**	0.43**	0.66**	0.75**	0.68**	-0.36*	0.35*
	CG	0.82**	0.25**	0.56**	0.54**		0.40**	0.74**	0.75**	0.84**	-0.22^{NS}	0.63**
	CW	0.71**	0.31**	0.56**	0.50**	0.67**		0.52**	0.53**	0.25^{NS}	-0.43**	0.24^{NS}
	RL	0.57**	0.19**	0.58**	0.58**	0.60**	0.62**		0.76**	0.59**	-0.32*	0.50**
	PW	0.54**	0.19**	0.53**	0.43**	0.58**	0.50**	0.54**		0.53**	-0.29^{NS}	0.49**
	HL	0.33*	0.11^{NS}	0.24**	0.29**	0.38**	0.30**	0.27**	0.21**		-0.12^{NS}	0.51**
	EL	-0.13^{NS}	-0.13^{NS}	0.31**	0.23**	0.23**	0.29**	0.23**	0.23**	0.15*		-0.26^{NS}
Short-eared Somali	BW		0.69**	0.46**	0.79**	0.79**	0.53**	0.55**	0.26^{NS}	0.69**	0.15^{NS}	0.56**
	BC	0.62**		0.49**	0.44**	0.56**	0.49**	0.28*	0.25^{NS}	0.66**	0.01^{NS}	0.43**
	BL	0.25**	0.31**		0.51**	0.50**	0.25^{NS}	0.24^{NS}	0.20^{NS}	0.38*	-0.04^{NS}	0.38**
	HW	0.37**	0.13^{NS}	0.17*		0.68**	0.40**	0.40**	0.24^{NS}	0.64**	0.26^{NS}	0.46**
	CG	0.73**	0.44**	0.25**	0.32**		0.61**	0.59**	0.43**	0.65**	0.10^{NS}	0.66**
	CW	0.40**	0.16^{NS}	0.07^{NS}	0.01^{NS}	0.53**		0.50**	0.12^{NS}	0.46*	0.22^{NS}	0.37**
	RL	0.34**	0.19*	0.11^{NS}	0.30**	0.45**	0.33**		0.42**	0.48**	-0.04^{NS}	0.52**
	PW	0.24**	0.24**	0.03^{NS}	0.12^{NS}	0.40**	0.18*	0.26**		0.27^{NS}	-0.23^{NS}	0.44**
	HL	0.14^{NS}	0.14^{NS}	0.09^{NS}	0.19*	0.37**	0.08^{NS}	0.16^{NS}	0.09^{NS}		0.02^{NS}	0.58**
	EL	0.12^{NS}	0.05^{NS}	-0.06^{NS}	0.18*	0.02^{NS}	0.12^{NS}	0.17*	0.02^{NS}	0.01^{NS}		-0.04^{NS}

BC= Body Condition, BL=Body Length, HW=Height at Wither, CG=Chest Girth, CW=Chest Width, RL=Rump Length, PW=Pelvic Width, HL=Horn Length, EL=Ear Length, SC=Scrotum Circumference; NS= Non Significant; *$p < 0.05$, ** $p < 0.01$

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

The knowledge of live weight of animals is so important in the livestock production and marketing practices (Birteeb and Ozoje, 2011). Even though the use of conventional weighing scales is the best way of determining live weight of an animal, proper weight measurements are often difficult in villages due to lack of weighing scales. To predict the live weight of animals without weighing scales, mathematical equations can be developed based on actual weight-linear body measurement data (Solomon and Kassahun, 2008).

The regression analysis of live body weight on different body measurements for does and bucks are presented in Tables 30 and 31, respectively. The results of the stepwise multiple regression analysis revealed that chest girth was the single variable of utmost importance in the prediction of live body weight in the three populations in both sexes, with the exception of Short-eared Somali bucks, where chest girth was not significant in the model. This result was supported by highly correlation coefficient found between live body weight and chest girth (Table 29). Even though the magnitude of improvement varied in both sex and population, the inclusion of other linear body measurements with chest girth as well as with body condition improved the accuracy of the prediction model (R^2) in all cases. In agreement with the present finding, several small ruminant researches (Tesfaye, 2008; Grum, 2010; Birteeb and Ozoje, 2011; Halima *et al*., 2012a) have reported comparatively high coefficient of determination (R^2) in body weight prediction equations taking chest girth as independent variable. In addition chest girth was described to be practical comparing to other measurements like wither height and body length.

The proportion of variance explained by body condition (R^2 = 0.48) which accounted the larger variation in body weight than other variables in Short-eared Somali bucks were smaller than the variation explained by chest girth ($R^2 \geq 0.60$) in all does as well as in Bati and Borena bucks. Nsoso *et al*. (2003) stated inconsistencies between the relationship of body condition score and live body weight under extensive management system in dry and wet seasons. Therefore, body condition score appeared to be a more useful trait in assessing nutritional consequences than live weight body condition prediction under extensive management systems.

When chest girth was the first variable explaining more variation, body weight was predicted with better accuracy (R^2) for bucks than does of all populations. The R^2 value was higher for Borena bucks than their counterparts in Bati while higher R^2 values were equally recorded for Bati and Borena does than Short-eared Somali counterparts. As a criterion, the value of R^2 always increased as more independent variables added to the regression model. Therefore, R^2 was not suitable for comparing the equations in a population which included different independent variables. In the present study, inclusion of some independent variables in the model does not produce R^2 value improvement. However, in most cases smaller error mean squares (MSE) were produced indicating better goodness fit of the models.

Even though the extra gain was small for some traits, the coefficient of determination (R^2) improvement obtained by combination of more than one estimates of body measurements clearly indicated that weight can be estimated more accurately by combination of two or more factors than only one. Nevertheless, according to Grum (2010) and Tesfaye (2008), considering more variables under extensive management conditions will be unpractical due to cost and accuracy problems. So, live body weight estimation using chest girth alone would be better under extensive management conditions.

Table 30. Regression of live body weight on different body measurements for does

Population	Equation	Intercept α	Regression coefficients β_1	β_2	β_3	β_4	β_5	β_6	β_7	R^2	R^2 Change	MSE
Bati	CG	-47.34	1.11							0.67	0.00	3.16
	CG+BC	-46.10	1.03	1.65						0.78	0.11	2.63
	CG+BC +CW	-40.92	0.78	1.49	0.78					0.78	0.00	2.61
	CG+BC +CW+BL	-48.66	0.71	1.36	0.71	0.23				0.79	0.01	2.55
	CG+BC+CW+BL+HL	-47.43	0.71	1.46	0.67	0.18	0.16			0.79	0.00	2.53
	CG+BC+CW+BL+HL+RL	-49.60	0.68	1.43	0.59	0.17	0.16	0.45		0.80	0.01	2.52
	CG+BC+CW+BL+HL+RL+HW	-46.57	0.71	1.39	0.58	0.21	0.16	0.52	-0.10	0.80	0.00	2.51
SES	CG	-26.45	0.76							0.61	0.00	2.00
	CG+BC	-20.02	0.62	1.23						0.68	0.08	1.83
	CG+BC+HW	-24.42	0.51	1.53	0.18					0.68	0.00	1.90
	CG+BC+HW+EL	-27.20	0.58	1.23	0.12	0.17				0.70	0.02	1.88
Borena	CG	-51.48	1.13							0.67	0.00	2.97
	CG+BL	-63.68	0.90	0.47						0.73	0.06	2.68
	CG+BL+BC	-60.36	0.86	0.42	0.89					0.76	0.03	2.55
	CG+BL+BC+CW	-55.27	0.73	0.35	0.77	0.55				0.78	0.02	2.47

BC= Body Condition, BL=Body Length, HW=Height at Wither, CG=Chest Girth, CW=Chest Width, PW=Pelvic Width, HL=Horn Length, Ear Length, SES=Short-Eared Somali

Table 31. Regression of live body weight on different body measurements for bucks

Population	Equation	Intercept α	Regression coefficients β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	R^2	R^2 Change	MSE
Bati	CG	-19.20	0.75								0.72	0.00	2.67
	CG+HW	-30.25	0.67	0.23							0.74	0.02	2.58
	CG+HW+PW	-35.41	0.75	0.37	-0.78						0.77	0.03	2.47
	CG+HW+PW+CW	-44.99	0.63	0.52	-1.01	0.64					0.80	0.03	2.34
	CG+HW+PW+CW+BL	-38.97	0.80	0.62	-1.28	0.83	-0.42				0.82	0.02	2.20
SES	BC	15.84	4.59								0.48	0.00	3.40
	BC+HW	-3.60	3.56	0.35							0.58	0.10	3.27
	BC+HW+CW	-6.12	3.09	0.31	0.41						0.60	0.02	3.21
	BC+HW+CW+BL	-7.16	3.00	0.29	0.42	0.04					0.60	0.00	3.24
Borena	CG	-66.68	1.34								0.74	0.00	4.24
	CG+RL	-74.42	1.02	2.07							0.77	0.03	3.99
	CG+RL+HW	-82.85	0.74	1.80	0.46						0.79	0.02	3.83
	CG+BL+CW+HW	-81.19	0.69	0.66	0.72	0.13					0.84	0.00	3.37
	CG+BL+CW+ HW+SC	-77.59	0.84	0.65	0.69	-0.02	-0.11				0.87	0.03	3.14
	CG+BL+CW+ HW+SC+ EL	-93.35	0.73	0.60	0.82	0.14	0.08	0.56			0.88	0.01	3.04
	CG+BL+CW+HW+SC+ EL+HL	-35.53	0.75	0.43	0.55	0.68	0.82	0.81	-0.49		0.95	0.07	2.18
	CG+BL+CW+ HW+SC+ EL+HL+PW	-61.18	0.92	0.51	0.64	0.91	1.06	1.03	-0.71	-1.19	0.96	0.01	2.07

BC= Body Condition, BL=Body Length, HW=Height at Wither, CG=Chest Girth, CW=Chest Width, PW=Pelvic Width, HL=Horn Length, Ear Length, SC=Scrotum Circumference; SES=Short-Eared Somali

4.2.5. Multivariate analysis

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

4.2.5.1. Stepwise discriminant analysis

Result of the stepwise discriminant analysis is presented in Table 32. The stepwise discriminant analysis procedure identified seven (HL, BW, EL, CG, HW, CW and PW) most significant discriminating traits between does while it was five (HW, HL PW, CG and EL) in bucks. The relative importance of the identified morphometric traits in discriminating the three populations of goats was assessed at 5% level of significance. As shown in Table 32, in both sexes all the predictors added some predictive power to the discriminant function between sample populations as all are significant with (p<0.01) associated for each variable against Wilk's Lambda. When the most discriminating traits of both does (HL, BW, EL, CG, HW, CW and PW) and bucks (HW, HL PW, CG and EL) separating the three goat populations were selected chronologically, Wilk's Lambda dropped to 0.18 and 0.19 with a significant difference between the three goat populations (F = 5.42; p <0.05) and (F = 3.86; p <0.05), respectively indicating the proportion of total variability not explained by the discriminator variables between populations. This means that most (82% for female and 81% for male) of the variability in the discriminator variables was due to differences between populations rather than variation within populations. Similar to Wilk's Lambda value, the partial R^2 static dropped down as significant discriminating variables added chronologically, describing the amount of variability in each variable accounted for by the population differences.

As depicted by the respective partial R^2 and F-values; HL was found to have the highest discriminating power in does followed by BW, EL, CG, HW, CW and PW in descending order. In the meantime, HW had the highest discriminating power in male followed by HL, PW, CG and EL from the highest. This implies that bucks required slightly fewer trait measurements to differentiate between the three goat populations than does which asked measurement of seven traits.

Table 32. Quantitative characters selected by stepwise discriminant analysis

Sex	Step	Variable entered	Partial R^2	Wilk's Lambda	F for entry	Pr > F
Does	1	Horn length	0.511	0.489	242.54	< .0001
	2	Body weight	0.419	0.284	167.20	< .0001
	3	Ear length	0.169	0.236	46.96	< .0001
	4	Chest girth	0.119	0.208	31.15	< .0001
	5	Height at wither	0.081	0.192	20.27	.0005
	6	Chest width	0.033	0.185	7.83	.0047
	7	Pelvic width	0.023	0.181	5.42	.0019
Bucks	1	Height at wither	0.567	0.433	85.14	< .0001
	2	Horn length	0.316	0.296	29.86	< .0001
	3	Pelvic width	0.219	0.231	17.90	< .0001
	4	Chest girth	0.124	0.203	8.97	.0002
	5	Ear length	0.059	0.191	3.86	.0235

4.2.5.2. Discriminant analysis

Checking for multivariate normality, the estimated significant ($p<.0001$) multivariate skewness and kurtosis values indicated that multi-attributes do not have a joint multivariate normal distribution for the populations. Thus, non-parametric discriminant analysis (K-Nearest Neighbor method) was used in the discriminant function to determine the percentage of classification of individual animal in to a population. The performance of a discriminant function in the classification of new observations can be evaluated by estimating the probabilities of misclassification or error rates. Among the three Nearest Neighbor

Discriminant Function Analyses (K-2, K-3 and K-4) classification results, K-2 Nearest-Neighbor Discriminant Function Analysis gave the smallest classification error in both sexes.

The overall average error count estimate of does was 10% accrediting 23, 4 and 3% for Bati, Borena and Short-eared Somali goats respectively, while the overall error count estimate for bucks was 14 % assigning 26% for Bati, 13% for Borena and 6% for Short-eared Somali (Table 33). This means 90% of does and 86% of bucks for all populations were correctly classified in their source population. However, the classification rates (hit rate) varied both in sex and population.

In females, most Borena does (96.02%) were classified into their source population followed by Short-eared Somali does (94.24%). The lowest classification rate (hit rate) was 77.34% for Bati does. A total of 22.66% Bati does were misclassified as Borena (17.19%), Short-eared Somali does (3.91%) and out of the three populations (1.56%) while 3.48% of Borena and 2.88% of Short-eared Somali does were wrongly assigned as Bati does but nearly none of Borena does classified as Short-eared Somali does and vice versa. In males, most Short-eared Somali bucks (94.4%) were classified into their source population followed by Borena (86.7%). 11.1% of Borena bucks were wrongly assigned as Bati (8.9%) and Short eared Somali (2.2%). On the other way, 26.5% of Bati bucks were misclassified as Borena. Very few Short-eared Somali bucks (5.6%) were also wrongly classified as Bati and Borena. K-2 Nearest-Neighbor Discriminant Function Analysis method omitted 1.56% Bati does, 2.16% Short-eared Somali does and 2.2% Borena bucks from their source population.

The proportion of individuals correctly reallocated is taken as measurement of the integrity of that population, whereas the number of misclassified individuals (particularly between Bati and Borena goats) suggested that the close/overlapping of measurements between populations since the probability of intermingling between the studied populations is very low due to high geographical distance between their habitats. The reason of relatively lowest classification rate (hit rate) of Bati goats indicates the heterogeneity of the population which might be due to intermixing of the breed with Afar goats as reported by respondents and observed during the course of survey. On the other hand, the lowest misclassification error of Short-eared

Somali and Borena populations could be an indication of more uniformity within the populations.

Table 33. Number of observation and percent of classification in parenthesis for sample population by sex using K-Nearest Neighbour method

Sex	From population	Bati	Borena	Short-eared Somali	Omitted	Total
Does	Bati	99(77.34)	22(17.19)	5(3.91)	2(1.56)	128(100)
	Borena	7(3.48)	193(96.02)	1(0.5)	0(0.0)	201(100)
	Short-eared Somali	4(2.88)	1(0.72)	131(94.24)	3(2.16)	139(100)
	Total	110(23.5)	216(46.15)	137(29.27)	5(1.07)	468(100)
	Error rate	0.23	0.04	0.06	-	0.10
Bucks	Bati	25(73.5)	9(26.5)	0(0.0)	0(0.0)	34(100)
	Borena	4(8.9)	39(86.7)	1(2.2)	1(2.2)	45(100)
	Short-eared Somali	2(3.7)	1(1.9)	51(94.4)	0(0.0)	54(100)
	Total	31(23.31)	49(36.8)	52(39.1)	1(0.8)	133(100)
	Error rate	0.26	0.13	0.06	-	0.14

4.2.5.3. Canonical discriminant analysis

The canonical discriminant analysis was carried out to obtain Mahalanobis distances between sample populations and to observe the spatial distribution of sample populations on canonical variables by means of graph. It was conducted based on the most important discriminant variables for does (HL, BW, EL, CG, HW, CW and PW) and bucks (HW, HL PW, CG and EL) selected using step-wise discriminant analysis procedure. The Mahalanobis distances between the three goat populations of both sexes according to the discriminating variables are presented in Table 34. All pair wise distances of both sexes were significant ($p<0.0001$). However, the higher squared Mahalanobis distance was found between bucks than does. The largest distance (16.18 for bucks and 15.77 for does) was found between Borena and Short-eared Somali goats while the closest distance (3.08 for does and 1.62 for bucks) was recorded between Bati and Borena goats.

Table 34. Squared Mahalanobis distances between sampled populations based on pooled covariance

Does / Bucks	Bati	Borena	Short-eared Somali
Bati	**	3.08	8.60
Borena	1.62	**	15.77
Short-eared Somali	11.50	16.18	**

The canonical analysis allowed extracting three canonical variats (CAN1, CAN2 and CAN3) for both bucks and does. However, the first two canonical variats (CAN1 and CAN2) altogether explained about 100% and 99.96% of the total variation for does and bucks, respectively with the remaining one variat in males accounting only 0.04% of the total variation. Therefore, the last canonical variats was dropped as it is not significant in separating sample populations in both sexes.

Spatial distributions of the three populations for each sex are presented in Figure 10. In both sexes, CAN1 discriminated Borena from Short-eared Somali goat populations effectively, keeping Borena and Bati populations closer on the right side of the X-axis. Though Bati goats put closer to Borena goats, they positioned more or less between Borena and Short-eared Somali goats. CAN2 is not effective in separating the three populations of both sexes except biasing Bati goats to the right side of X-axis.

The similarities between Bati and Borena goats and significance divergence of Short-eared Somali population from the two populations might suggest possible genetic similarities and differences. Even though, the two populations (Bati and Borena) are very similar in quantitative traits measurements, but even they could be genetically quite distant. Hence, further molecular marker information for comparative genetic analysis needed to validate information from morphological characterization.

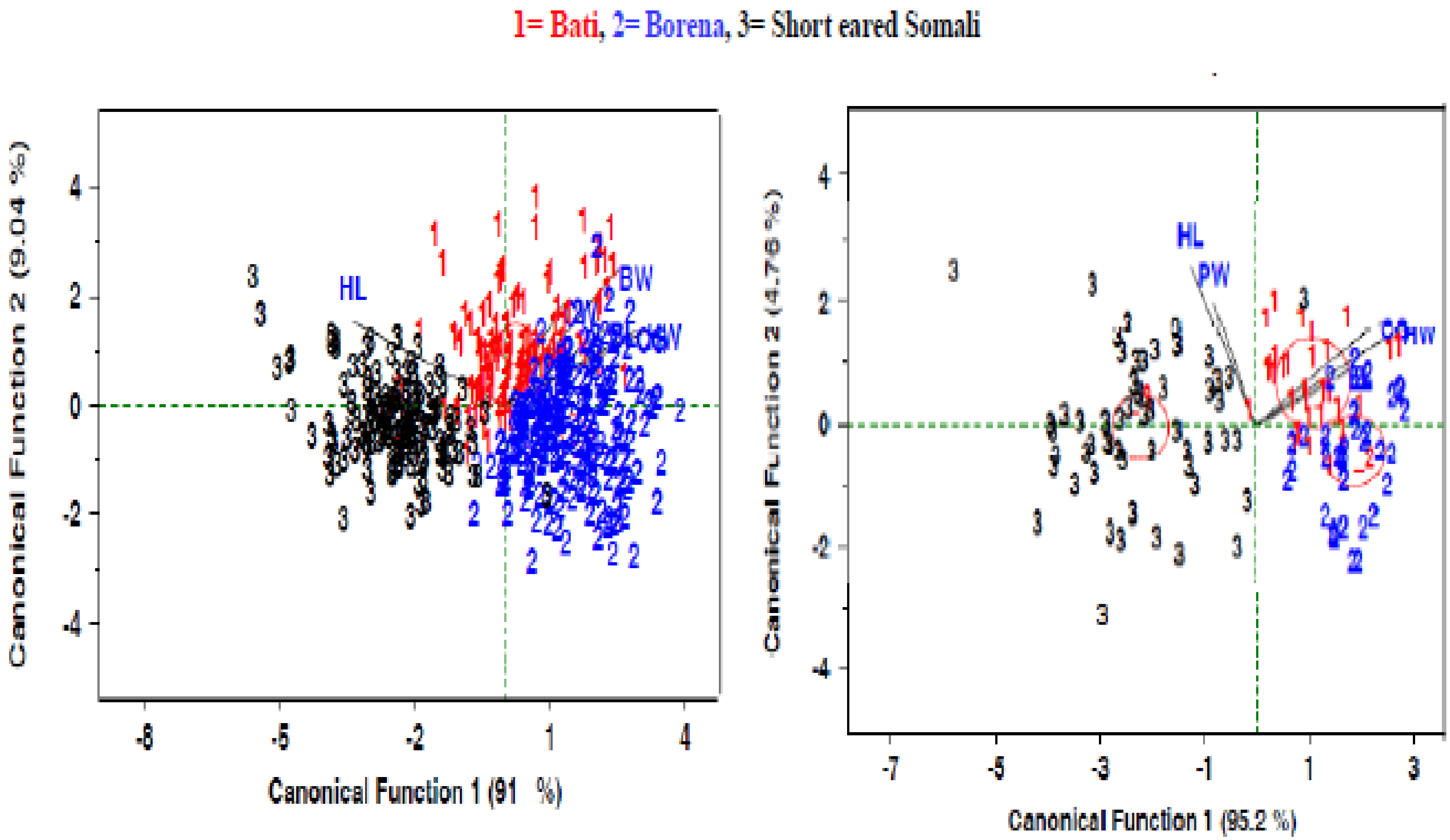


Figure 10. Spatial distributions of does (left) and bucks (right) on the first two canonical variats (CAN1 and CAN2)

4.3. On-farm Goat growth Performance Evaluation and Monitoring

4.3.1. Growth performance

Knowing the growth dynamics of young animals may be used as one of the indicators to evaluate the level of adaptation under conditions of a production system which is different from its origin place (Kume and Hajno, 2010). To see the effect of non-genetic factors (population and/or production environment, sex of kid, parity of dam and type of birth) on the growth performance of kids, weights at different ages (birth, 30, 90 and 180 days) for Bati, Borena and Short-eared Somali goats were recorded.

4.3.2. Average body weight at different ages (birth, 30, 90 and 180 days)

Descriptive statistics (LSM±SE) of body weights (kg) from birth to 180 days of age for studied three goat types are presented in Table 35. Bati goats had the heaviest overall live weight at birth (2.70±0.05kg) followed by Borena (2.42±0.05kg) which were significantly (p<0.0001) higher than that of Short-eared Somali goats (2.19±0.08kg). The birth weight of Bati goats observed in this study was close to the result of Tesfaye *et al*. (2006) for the same goat type but higher than the values reported by Belay (2008) for Abergele and Central highland goats in Ethiopia. Zeleke (2007) also reported higher value of birth weight (3.19kg) for Somali goats in extensive management system at Alemaya (currently Haramaya) university as compared with the result found in the present study for Short-eared Somali goats. The birth weight of Borena goats found in this study was comparable with the birth weight of Arsi-Bale and Abergelle goats in intensive management system reported by Mahlet (2008) and Birhane and Eirk (2006), respectively.

Despite their significant ($p<0.05$) difference in average birth weight, the Bati and Borena goat kids had nearly equal overall average live weight at 90 days of age. However, the overall growth rate of Borena goat kids showed retarding trend after 90 days of age while Bati goat kids maintained their superiority thereafter (Figure 11).

Kume and Hajno (2010) stated that the growth period of young animals until the puberty age can be divided into three phases: (i) maternal phase; from birth to weaning, (ii) phase of development of bio-physiological mechanisms; from weaning to 6 months old and (iii) growth phase; from the age of 6 months to puberty. According to these authors, the second phase tells us more information in relation to the adaptation rate and/or response of breed under the production environment. Therefore, the reason for retarded growth rate seen in Borena kids after 90 days of age might be due to the environmental stress (feed shortage) during short dry season (June-August) and long dry season "*Boona*" (December-February) on the second phase of development.

The results in this study indicated that male kids weighed more than doe kids at birth and were heavier up to 90 days for all studied goat types (Table 35). The result was in consonance with the findings of other authors who observed that male kids were superior to their female counterparts (Banerjee and Jana, 2010; Mabrouk *et al*., 2010; Belay and Mengistie, 2013) but contradicted with the report of Khanal *et al.* (2005) and Bharathidhasan *et.al,* (2009) who reported that the weight of the female kids were higher than their male counterparts. According to Nkungu *et al*. (1995), the heavier body weight obtained for males may be attributed to the effect of the male sex hormone (androgen) which is responsible for the development of male characteristics.

Kids born as single were significantly heavier ($p<0.05$) than twins, up to180 days of age in Bati kids and 30 days in Borena kids (Table 35). The heavier body weight of single born kids attributed to the weight advantage to competition for nutrients (milk) and the less inter-uterine space in cases where does carry two or more fetuses as compared to one (Wilson,1989 cited in Zahraddeen *et al*., 2008). This study also observed that Short-eared Somali kids born single were non-significantly heavier than their twin counterparts. Zahraddeen *et al*., (2008) reported similar findings for local Nigerian goats.

As shown in Table 35, birth weight of kids was significantly affected by parity of doe in all studied goat types. Bati and Borena, kids from the first parity had relatively lower birth weights than kids in other parity.

Table 35. Descriptive statistics (LSM±SE) of body weights (kg) from birth to 180 days of age for Bati, Borena and Short-eared Somali goats

Pop.	Factors	BW		30 DW		90 DW		180DW	
		N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
	Overall	308	***	292	***	270	***	248	***
	Bati	139	2.70±0.05[a]	133	6.14±0.10[a]	119	10.44±0.18[a]	110	15.57±0.19[a]
	Borena	123	2.42±0.05[b]	114	5.51±0.10[b]	108	10.48±0.12[a]	101	13.41±0.20[b]
	SES	46	2.19±0.08[c]	45	4.67±0.16[c]	43	8.76±0.30[b]	37	13.10±0.32[b]
Bati	Sex		*		*		**		NS
	Female	60	2.58±0.07[b]	57	5.81±0.15[b]	50	9.56±0.32[b]	46	15.9±0.38
	Male	79	2.81±0.07[a]	76	6.26±0.14[a]	69	10.58±0.29[a]	64	16.15±0.34
	Parity		**		*		*		NS
	1	26	2.43±0.11[c]	26	5.8±0.22[ab]	22	9.46±0.48[b]	19	16.0±0.58
	2	26	2.62±0.11[bc]	25	5.55±0.22[b]	23	9.81±0.47[b]	23	15.64±0.55
	3	31	2.74±0.1[ab]	29	6.15±0.20[a]	28	10.5±0.42[ab]	26	15.86±0.5
	4	26	3.0±0.11[a]	23	6.31±0.24[a]	21	9.48±0.5[b]	19	16.0±0.61
	≥5	30	2.69±0.1[bc]	30	6.38±0.20[a]	25	11.06±0.44[a]	23	16.6±0.51
	TB		*		*		*		*
	Single	47	2.82±0.08[a]	46	6.28±0.17[a]	43	10.57±0.36[a]	40	16.66±0.42[a]
	Twin	92	2.57±0.06[b]	87	5.79±0.13[b]	76	9.57±0.29[b]	70	15.38±0.33[b]
Borena	Sex		**		**		*		NS
	Female	64	2.21±0.09[b]	59	5.14±0.17[b]	55	10.28±0.34[b]	52	14.35±0.31
	Male	59	2.59±0.11[a]	55	5.77±0.17[a]	53	11.01±0.28[a]	49	14.20±0.29
	Parity		**		NS		NS		NS
	1	13	1.87±0.17[b]	13	5.02±0.31	13	10.68±0.51	13	14.7±0.52
	2	31	2.54±0.1[a]	26	5.39±0.2	26	10.89±0.33	23	14.35±0.35
	3	31	2.44±0.11[a]	31	5.54±0.21	28	9.86±0.35	28	13.80±0.35
	4	19	2.67±0.15[a]	15	5.5±0.30	14	11.22±0.5	13	14.55±0.53
	≥5	29	2.47±0.12[a]	29	5.84±0.23	27	10.57±0.38	24	13.97±0.42
	TB		*		*		NS		NS
	Single	87	2.53±0.07[a]	80	5.71±0.14[a]	76	10.67±0.35	72	14.43±0.24
	Twin	36	2.27±0.11[b]	34	5.2±0.21[b]	32	10.62±0.23	29	14.12±0.37
SES	Sex		**		**		*		NS
	Female	19	1.7±0.17[b]	19	3.61±0.53[b]	17	8.71±.0.7[b]	14	11.73±0.88
	Male	27	2.27±0.16[a]	26	4.74±0.58[a]	26	9.84±0.63[a]	23	13.43±0.86
	Parity		*		NS		NS		NS
	1	11	1.96±0.17[b]	11	4.14±0.68	11	10.38±0.78	8	11.81±1.09
	2	9	1.78±0.2[b]	9	4.77±0.65	9	9.53±0.82	5	12.44±1.16
	3	17	1.63±0.19[b]	17	3.60±0.57	15	8.41±0.78	16	13.17±1.04
	4	3	2.52±0.24[a]	3	4.30±0.70	2	7.38±1.11	3	13.01±1.31
	≥5	6	2.04±0.2[ab]	5	4.08±0.79	6	10.29±0.81	5	12.45±1.13
	TB		NS		NS		NS		NS
	Single	35	2.03±0.14	24	3.92±0.45	32	8.86±0.55	26	12.99±0.73
	Twin	11	1.94±0.2	11	3.85±0.56	11	9.54±0.82	11	12.16±1.05

LSM =least square means, SE= standard errors, N= number of observation, BW=Birth Weight, DW= Day Weight, TB=Type of Birth, NS= Non Significant Pop. = population, SES = Short-eared Somali; Means in the same column with different superscripts are significantly different; *, $p<0.05$, **, $p<0.01$, *** $p<0.0001$

The effect of parity was retained up to 90 days of age for Bati goats with inconsistent increment of live weight in the advancement of parity at different ages. This result was in line with the report of Deribe (2009) and in contrast with the report of Zahraddeen *et al*. (2008) who reported inconsistent and consistent increment of live weight in the advancement of parity at different ages, respectively. The effect of parity on live weight was non-significant after birth in both Borena and Short-eared Somali kids.

Generally, similar to the results reported in elsewhere in Ethiopia (Zeleke, 2007; Deribe, 2009; Belay and Mengistie, 2013); West Bengal (Banerjee and Jana, 2010); Albania (Kume and Hajno, 2010) and Tunisia (Mabrouk *et al*., 2010); non-genetic factors (goat type, sex of kids, parity of dam and type of birth) significantly ($p<0.05$) influenced the weight of young goats at different ages, except type of birth in Short-eared Somali kids.

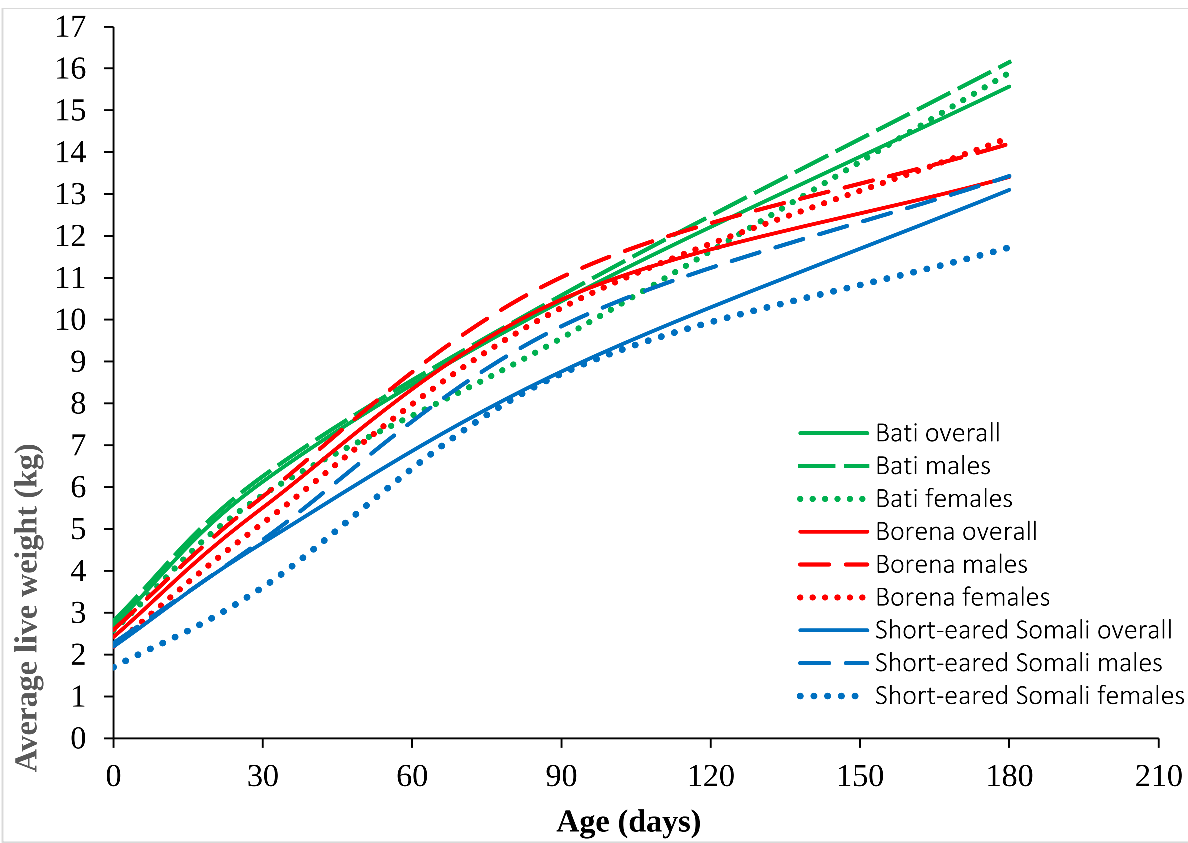


Figure 11. Male, female and overall growth rate trends of three young Ethiopian goats (birth to 180 days)

4.3.3. Average daily weight gain (birth - 90 days)

There was no significant difference in average daily weight gain from birth to 90 days between Bati and Borena kids but Short-eared Somali kids had significantly ($p<0.05$) lighter average daily weight gain at the maternal phase than the two goat types (Table 36). The average daily weight gain found at this phase for Bati and Borena kids in the present study was higher than the report of Deribe (2009) as well as Belay and Mengistie (2013) for indigenous goats in Southern and Northern part of Ethiopia, respectively. The average daily weight gain (birth to 90 days) obtained for Short-eared Somali kids in this study was lower than the previous reports of Zeleke (2007) for Somali goats. According to the later author, such variations in pre-weaning daily weight gain can be attributed to the management difference of both dams and kids at early age.

Sex of kids affected significantly ($p<0.05$) the total daily weight gain (birth to 90 days) of Bati goat kids thus males had the heaviest daily weight gain (86.82±3.05g/day) as compared to their female counterparts (78.17±3.37g/day) while both Borena and Short-eared Somali male goat kids had non-significant ($p>0.05$) heavier daily weight gain than their female counterparts.

Like that of sex, parity was not-significantly ($p>0.05$) affected the average daily weight gain (birth to 90 days) of both Borena and Short-eared Somali kids but it had a significant ($p<0.05$) effect on Bati kids daily weight gain. In the literature, Deribe (2009) and Dadi *et al*. (2008) respectively, reported non-significant and significant effect of parity on the pre weaning daily weight gain of local goats in Ethiopia. As it was reported by different authors, kids from 3rd and 4th parity had relatively higher daily weight gain as compared with kids from 1st and ≥5th party (Dadi *et al*., 2008; Zahraddeen *et al*., 2008); Belay and Mengistie, 2013). However, in this study, Bati goats kids from 5th parity were significantly ($p<0.05$) heavier than kids from the 1st, 2nd, and 4th parities and none-significantly ($p>0.05$) kids from the 3rd parity (Table 36). This result implied that, Bati does even ≥5th parity can be used as breeders in order to obtain an efficient and maximum production.

4.3.4. Average daily weight gain (91-180 days)

The average daily weight gain (91-180 days) for Bati, Borena and Short-eared Somali goat kids are summarized in Table 36. For all cases, daily weight gain after 90 days of age was lighter as compared with before 90 days of age. This study observed significant ($p<0.05$) difference in overall daily weight gain from 91 to 180 days of age between populations.

As expected and documented in literatures (Zeleke, 2007; Zahraddeen *et al*., 2008; Banerjee and Jana, 2010; Mabrouk *et al*., 2010; Belay and Mengistie, 2013) males have heavier daily weight gain before and after weaning. On the other hand, Bazzi and Tahmoorespur (2013) reported heavier average pre-weaning daily gain of females than males. In this study, it was found that non-significant (p<0.05) heavier daily weight gain in male kids before and after 90 days of age, except in Bati kids where sex exerted significant effect on daily weight gain in favor of males (birth to 90 days). Similarly, non-significant effect of sex on daily weight gain of kids from birth to 60 and 100 days of age were reported by Zahradeen (2008) and Nkungu *et al*. (1995), respectively.

Significant (p<0.05) parity effect was also observed in this study with respect to kids daily weight gain in each population from 91 to 180 days of age. Even though, the increment of daily weight gain in the advancement of parity at different ages was inconsistent, in most cases kids at 2^{nd}, 3^{rd} and 4^{th} parity had better daily weight gain (Table 36).

Across all goat types, the influence of type of birth on daily weight gain of kids at different ages (birth, 30, 90 and 180 days) was non-significant ($p>0.05$) only with numerical differences (not statistically significant) in favor of kids born as single. Similarly, irrespective of significantly higher birth and weaning weight of kids born as single, Bazzi and Tahmoorespur (2013) found non-significant difference in average daily weight gain between kids born as single and twin from 6 to 9 months of age. Whereas Busahra *et al*. (2013), Zeleke (2007) and Madibela *et al*. (2002) reported higher pre weaning daily weight gain for single kids compared with multiple births.

Table 36. Descriptive statistics (LSM±SE) of daily weight gain (birth-90 and 91-180 days) for Bati, Borena and Short-eared Somali goats

Factors	Bati				Borena				Short-eared Somali			
	ADWG g/day (birth-90 days)		ADWG g/day (91-180 days)		ADWG g/day (birth -90 days)		ADWG g/day (91-180 days)		ADWG g/day (birth -90 days)		ADWG g/day (91-180 days)	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	119	86.22±2.02	108	56.49±1.70	108	89.88±2.02	101	32.96±1.76	43	73.15±3.20	34	47.20±3.08
Sex		*		NS		NS		NS		NS		NS
Female	50	78.17±3.37^{b}	46	55.83±3.01	55	90.41±3.23	52	30.85±2.66	17	76.65±7.57	12	36.71±6.91
Male	69	86.82±3.05^{a}	62	59.15±20.75	53	94.95±3.22	49	33.67±2.8	26	84.22±7.30	22	43.61±6.91
Parity		*		*		NS		*		NS		*
1	22	77.61 ±5.07^{bc}	19	59.99±4.62^{abc}	13	98.53±5.75	13	31.46±4.71^{ab}	11	93.56±9.05	8	21.61±8.61^{b}
2	23	80.61±4.96^{bc}	23	60.76±4.35^{ab}	26	92.87±5.70	23	36.63±3.22^{a}	9	85.59±9.45	5	34.42±9.35^{b}
3	28	87.08±4.4^{ab}	26	51.87±3.93^{bc}	28	83.26±3.93	28	38.02±3.20^{a}	15	74.05±9.02	14	44.19±8.75^{ab}
4	21	73.51±5.33^{c}	17	65.44±5.02^{a}	14	97.06±5.70	13	20.53±4.86^{b}	2	57.31±12.89	2	68.9±11.9^{a}
≥5	25	93.63±4.69^{a}	23	49.40±4.20^{c}	27	91.67±4.38	24	34.68±3.8^{b}	6	91.69±9.35	5	31.77±9.0^{b}
TB		NS		NS		NS		NS		NS		NS
Single	43	86.5±3.81	40	58.14±3.36	76	91.08 ±2.58	72	34.68±2.14	32	75.88±6.31	23	43.74±5.7
Twin	76	78.48±3.08	68	56.85±2.74	32	94.26±3.99	29	29.85±3.39	11	84.99±9.53	11	36.57±8.96

LSM =least square means, SE= standard errors, ADWG = Average daily weight gain, N= number of observation, TB=Type of Birth, NS= Non Significant Pop. = population, SES = Short-Eared Somali; Means in the same column with different superscripts are significantly different; *, $p<0.05$

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary

Ethiopia has large number of (24.06 million heads) widely distributed multi-functional goat populations. Understanding both the management systems and morphological characteristics of these goat populations simultaneously addressing several constraints will help to craft successful improvement and utilization strategies. Therefore, this study was designed to characterize the production systems, morphological features and productive and reproductive performances of Bati, Borena and Short-eared Somali goats under their home tract that can help for designing community based goat improvement and utilization plan.

In number, goats were the predominant species in Bati, Borena and Siti areas. The mean goat flock size (44.02±3.33) owned per household in Siti was significantly ($p<0.05$) higher followed by Borena (23.08±1.94) and Bati (8.99±0.59). Breeding does made a major share within a flock accounting 3.51±0.91, 9.30±0.78 and 13.30±0.84 in Bati, Borena and Siti areas, respectively. In Borena and Bati areas income generation was the primary reason of goat rearing while in Siti area milk production was a main reason of goat keeping. Traits like body size, fast growth rate, milk yield, reproduction rate, drought tolerance and disease resistance were preferred by the producers with some discrepancies in relation to the primary production objectives across areas. Higher percentage of respondents in Siti (98.26%) and Borena (94.70%), and below half of the respondents (28.57%) around Bati area reported goat milking for household consumption.

Natural pasture (shrubs and bushes) was the primary feed source in all the study areas. Herded free natural browsing was the commonest feeding practice in Borena and Siti areas while in Bati area most of the time movement of goats was limited in small privet and/or communal browsing land. Feed and water shortage, disease incidence and recurrent drought were the major goat production challenges that have been hindering their production and productivity across the study areas. The common goat diseases reported were pneumonia, pasteurellosis, babesiosis, anthrax and goat pox, external parasites, contagious caprinepleuro pneumonia

(CCPP), coenurosis, diarrhea and pest des petit ruminants (PPR) with various degree of economic importance across study areas.

The studied goat populations have a wide range of coat colors. Plain brown (dark and light) (51.85%) was the predominant coat color observed on Bati goats of both sexes, while plain white coat color was most frequently observed on Borena (71.54%) and only 36.27% on Short-eared Somali goat populations. Though most quantitative traits showed slightly higher average values in the Bati goats, differences with Borena goats were not significant ($p>0.05$) whereas the Short-eared Somali goats remained significantly ($p<0.05$) the smallest for most of the qualitative traits. The highest correlation coefficient was found between live body weight and chest girth in does and bucks except in Short-eared Somali bucks where body condition score explained higher variation (R^2=48%). Hence, chest girth was the first variable explaining more variation in body weight of Bati, Borena and Short-eared Somali does (R^2=67, 67 and 61 %, respectively) and Bati and Borena bucks (R^2=72 and 74%, respectively).

Nearest Neighbor Discriminant Function Analysis classified most of Borena does into their source population followed by Short-eared Somali does. The stepwise discriminant analysis procedure identified seven most significant discriminating traits between the three does populations while it was five for bucks. From the identified variables horn length and height at wither had the most discriminating power in does and bucks, respectively. The largest Mahalanobis' distance was found between Borena and Short-eared Somali goats while the least differentiation was observed between Bati and Borena goats.

In the present study, in most cases, the influence of non-genetic factors (sex, parity of dam and type of birth) and genetic factor (goat ecotype) on the average live weight and daily weight gain of young goats at different ages was significant ($p<0.05$). However, type of birth had non-significant effect on daily weight gain of all goat types and live weight of Short-eared Somali kids at different ages. Bati kids had the heaviest overall live weight at birth (2.70±0.05kg) followed by Borena (2.42±0.05kg) which were significantly ($p<0.0001$) higher than that of Short-eared Somali goats (2.19±0.08kg). Despite the significant ($p<0.05$) heavier birth weight of Bati kids (overall), Borena kids had non-significant ($p<0.05$) heavier daily weight gain (89.88±2.02 g/d) from birth to 90 days of age, which do not maintained thereafter.

5.2. Conclusions and Recommendations

The higher proportion of male household heads in Bati (93.88%) Borena (68.18%) and Siti (79.13%) area, respectively, may lead men to have disproportionate benefits from livestock sale. The absence of secular education in most of goat keepers particularly in Borena and Siti areas could have also negative impact for the adoption of technologies. As perceived by the producers the goat populations in the studied areas have developed combinations of adaptable characteristics which enable them to survive and reproduce in those harsh environments. Based on the canonical discriminant analysis result Borena and Short-eared Somali goats were distantly related in morphometric characteristics while the least differentiation was between Bati and Borena goats. Since both Bati and Borena kids had relatively higher growth rate at the maternal phase of development (birth-90 days) than Short-eared Somali kids, they are more promising in terms of growth performance than Short-eared Somali goats. The diversified functions of goats and constraints found in the present study across the study areas speak loud the necessity to formulate holistic research-for-development strategies.

Since the reason of goat keeping, management practices and agro-ecology varied across the study areas, the recommendations presented below need to be revised within the respective local contexts and implemented taking into account producers' interests. Implementation of the recommendations in the absence of producers' participation in the initial phase is unlikely to be successful and leads a total failure. This is, therefore, to suggest the following issues for action by research and /or development institutes:

- Farmers/pastoralists should be encouraged to discuss and take decision together with researchers, development experts and decision makers.

- Implementing community-based animal health management programs and strengthening animal health centers for better animal health care will maximize the productivity of goats in studied areas.

- To overcome feed shortage in Borena and Siti, the productivity of rangelands should be restored by bush clearing and promoting community regulations for the proper utilization of the existing rangelands while in Bati area farmers should be encouraged to grow forage trees in soil conservation structures and stock exclusion areas

- To prevent pregnancy from uncontrolled natural mating and to increase productivity, establishing buck selection and management systems at community level for open mating systems and castrating non-productive bucks is an alternative.

- For adequate water supply Borena and Siti, infrastructures should be developed and strengthen that could help community-based water-point management practices.

- The producers' perception about their goats' adaptability and morphometric trait differences and similarities are suggested to be supported with further genetic analysis studies and steps need to be taken to conserve these animal genetic resources under their production environment.

- Linear measurements could be valuable to estimate live body weight for those farm communities where sensitive weighing scales are not readily available.

- For better age at first kidding of Short eared Somali goats, management practices needed to be improved

- The Bati and Borena goats showed relatively better growth performance at the maternal phase of development (birth-90 days), hence, improvement of these goat types can be made through better husbandry practices including selection.

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7. APPENDICES

Appendix A: Different tables

Appendix Table 1. Ranking farming and non-farming activities by study area

Activities and purpose	Bati area				Borena				Siti			
Food supply	Rank 1	Rank 2	Rank 3	Index	Rank 1	Rank 2	Rank 3	Index	Rank1	Rank 2	Rank3	Index
Livestock and livestock product selling	3	90	1	0.375	65	66	1	0.509	104	11	0	0.797
Crop production	94	2	0	0.565	67	51	0	0.470	11	24	0	0.193
Hand craft	1	2	5	0.024	1	0	1	0.006	0	0	0	0
Trading	0	1	8	0.020	0	2	3	0.011	0	2	0	0.010
Daily laborer	0	1	6	0.016	0	0	3	0.005	0	0	0	0
Income generation											0	
Livestock and livestock product selling	69	22	6	0.549	125	7	0	0.706	115	0	0	0.932
Crop production	16	42	8	0.312	6	61	1	0.256	0	6	0	0.032
Hand craft	1	6	3	0.038	0	1	0	0.004	0	0	0	0
Trading	5	6	6	0.071	0	2	5	0.016	0	3	1	0.019
Daily laborer	5	1	3	0.043	1	2	3	0.018	0	3	0	0.016

Appendix Table 2. Percentages of households castrate their buck and method of castration used by study areas

Do you practice castration?	Bati area (N=98)		Borena (132)		Siti (115)	
	N	%	N	%	N	%
Yes	68	69.39	29	21.97	112	97.39
No	30	30.61	103	78.03	3	2.61
Castration method						
Traditional only	39	57.38	25	89.29	97	86.61
By veterinarians only	18	26.47	3	10.71	2	1.79
Both	11	16.18	0	0	13	11.61

Appendix Table 3. Ranking of category of goats sold first in study areas

	Bati Area				Borena				Siti			
Category	Rank1	Rank2	Rank3	Index	Rank1	Rank2	Rank3	Index	Rank1	Rank2	Rank3	Index
Buck kids	28	23	16	0.236	77	16	25	0.360	30	30	35	0.271
Doe kids	5	21	26	0.135	1	46	19	0.142	0	2	20	0.035
Breeding does	2	9	10	0.055	0	1	6	0.010	0	0	0	0
Breeding bucks	1	7	6	0.037	5	2	1	0.025	0	0	1	0.001
Castrates	37	9	14	0.231	6	-	9	0.034	49	31	20	0.335
Old does	21	19	15	0.188	40	32	39	0.278	29	28	15	0.231
Old bucks	11	15	10	0.118	5	38	30	0.151	13	18	11	0.126

Appendix Table 4. Best models for Bati does regression equation

Model	R^2	Adj. R^2	C (p)	AIC	Root MSE	SBC	Variables in Model
1	0.6668	0.6641	72.2377	292.0983	3.16213	297.77083	CG
1	0.4630	0.4586	191.0254	352.2257	4.01424	357.89824	CW
2	0.7437	0.7396	29.3775	261.0099	2.78429	269.51871	BC CG
2	0.7177	0.7131	44.5589	273.2057	2.92235	281.71452	CG CW
3	0.7777	0.7722	11.5960	245.1110	2.60400	256.45609	BC CG CW
3	0.7602	0.7543	21.7637	254.6279	2.70422	265.97303	BC BL CG
4	0.7881	0.7811	7.5280	241.0688	2.55279	255.25024	BC BL CG CW
4	0.7872	0.7802	8.0465	241.5966	2.55814	255.77801	BC CG CW HL
5	0.7933	0.7847	6.4743	239.9149	2.53152	256.93255	BC BL CG CW HL
5	0.7915	0.7829	7.5099	240.9933	2.54237	258.01100	BC BL CG CW RL
6	0.7968	0.7865	6.4510	239.7808	2.52069	259.63473	BC BL CG CW RL HL
6	0.7959	0.7856	6.9870	240.3496	2.52639	260.20360	BC BL HW CG CW HL
7	0.8004	0.7886	6.3498	239.5256	2.50880	262.21582	BC BL HW CG CW RL HL
7	0.7970	0.7850	8.3095	241.6302	2.52984	264.32044	BC BL CG CW RL PW HL
8	0.8008	0.7871	8.1303	241.2876	2.51712	266.81418	BC BL HW CG CW RL PW HL
8	0.8006	0.7869	8.2382	241.4047	2.51829	266.93119	BC BL HW CG CW RL HL EL
9	0.8010	0.7856	10.0000	243.1462	2.52653	271.50903	BC BL HW CG CW RL PW HL EL

Appendix Table 5. Best models for Bati bucks regression equation

Model	R^2	Adj. R^2	C (p)	AIC	Root MSE	SBC	Variables in Model
1	0.6909	0.6795	11.4217	58.3047	2.64327	61.03933	CG
1	0.3743	0.3512	48.7353	78.7589	3.76097	81.49352	SC
2	0.7187	0.6971	10.1517	57.5767	2.56986	61.67854	BL CG
2	0.7110	0.6888	11.0604	58.3609	2.60485	62.46281	BC CG
3	0.7362	0.7045	10.0921	57.7166	2.53804	63.18578	BC HW CG
3	0.7360	0.7043	10.1130	57.7361	2.53889	63.20527	BL CG PW
4	0.7724	0.7345	7.8190	55.4292	2.40580	62.26563	BL HW CG PW
4	0.7614	0.7217	9.1170	56.7999	2.46333	63.63634	BC HW CG PW
5	0.8185	0.7791	4.3857	50.8640	2.19453	59.06774	BL HW CG CW PW
5	0.7935	0.7486	7.3369	54.6128	2.34106	62.81660	BC BL HW CG PW
6	0.8290	0.7823	5.1554	51.1457	2.17835	60.71674	BC BL HW CG CW PW
6	0.8285	0.7818	5.2085	51.2220	2.18122	60.79310	BL HW CG CW PW SC
7	0.8378	0.7838	6.1135	51.6065	2.17123	62.54486	BL HW CG CW PW HL SC
7	0.8353	0.7804	6.4077	52.0494	2.18787	62.98778	BL HW CG CW RL PW SC
8	0.8422	0.7791	7.5955	52.8097	2.19449	65.11536	BL HW CG CW RL PW HL SC
8	0.8405	0.7767	7.7995	53.1261	2.20649	65.43174	BC BL HW CG CW PW HL SC
9	0.8452	0.7718	9.2464	54.2600	2.23026	67.93296	BL HW CG CW RL PW HL EL SC
9	0.8442	0.7704	9.3613	54.4421	2.23727	68.11506	BC BL HW CG CW RL PW HL SC
10	0.8473	0.7624	11.0000	55.8658	2.27585	70.90601	BC BL HW CG CW RL PW HL EL SC

Appendix Table 6. Best models for Borena does regression equation

Model	R^2	Adj. R^2	C (p)	AIC	Root MSE	SBC	Variables in Model
1	0.6584	0.6565	70.1818	408.6711	3.01957	415.10097	CG
1	0.4999	0.4971	186.2394	478.7934	3.65342	485.22323	CW
2	0.7177	0.7146	28.7252	375.5644	2.75239	385.20919	BL CG
2	0.7081	0.7049	35.7669	381.7276	2.79888	391.37240	CG CW
3	0.7433	0.7391	11.9529	360.0477	2.63173	372.90745	BL CG CW
3	0.7433	0.7390	12.0196	360.1130	2.63220	372.97279	BC BL CG
4	0.7815	0.7562	0.6671	348.5588	2.54409	364.63350	BC BL CG CW
4	0.7463	0.7406	11.8062	359.9341	2.62396	376.00882	BL CG CW EL
5	0.7622	0.7555	2.1741	350.0387	2.54762	369.32829	BC BL CG CW RL
5	0.7617	0.7550	2.4865	350.3684	2.54990	369.65803	BC BL CG CW EL
6	0.7623	0.7543	4.0561	351.9140	2.55394	374.41858	BC BL CG CW RL EL
6	0.7622	0.7542	4.1332	351.9955	2.55451	374.50004	BC BL CG CW RL HL
7	0.7624	0.7529	6.0058	353.8609	2.56082	379.58037	BC BL CG CW RL HL EL
7	0.7623	0.7529	6.0492	353.9067	2.56114	379.62623	BC BL CG CW RL PW EL
8	0.7624	0.7515	8.0009	355.8557	2.56809	384.79013	BC BL CG CW RL PW HL EL
8	0.7624	0.7515	8.0051	355.8601	2.56812	384.79450	BC BL HW CG CW RL HL EL
9	0.7624	0.7501	10.0000	357.8547	2.57545	390.00406	BC BL HW CG CW RL PW HL EL

Appendix Table 7. Best models for Borena bucks regression equation

Model	R^2	Adj. R^2	C (p)	AIC	Root MSE	SBC	Variables in Model
1	0.8175	0.8110	56.1923	79.5698	3.64732	82.37219	CG
1	0.7337	0.7242	93.9401	90.9077	4.40596	93.71011	HW
2	0.8782	0.8691	30.8747	69.4495	3.03488	73.65312	BL CG
2	0.8680	0.8582	35.4600	71.8571	3.15913	76.06065	HW CG
3	0.9111	0.9008	18.0447	61.9978	2.64194	67.60260	BL CG CW
3	0.8934	0.8811	26.0162	67.4441	2.89297	73.04886	HW CG CW
4	0.9167	0.9034	17.5048	62.0320	2.60742	69.03801	BL HW CG CW
4	0.9150	0.9014	18.2963	62.6585	2.63479	69.66452	BL CG CW HL
5	0.9245	0.9087	16.0277	61.1132	2.53483	69.52037	BL HW CG CW SC
5	0.9229	0.9069	16.7205	61.7178	2.56050	70.12502	BL HW CG CW EL
6	0.9357	0.9190	12.9492	58.2642	2.38832	68.07263	BL HW CG CW EL SC
6	0.9347	0.9177	13.4159	58.7440	2.40749	68.55243	HW CG CW HL EL SC
7	0.9488	0.9325	9.0783	53.4648	2.18036	64.67434	BL HW CG CW HL EL SC
7	0.9375	0.9176	14.1679	59.4435	2.40882	70.65305	BC HW CG CW HL EL SC
8	0.9560	0.9393	7.8103	50.8840	2.06763	63.49478	BL HW CG CW PW HL EL SC
8	0.9492	0.9298	10.8875	55.2157	2.22242	67.82645	BL HW CG CW RL HL EL SC
9	0.9578	0.9388	9.0129	51.6514	2.07561	65.66342	BL HW CG CW RL PW HL EL SC
9	0.9562	0.9364	9.7409	52.7787	2.11498	66.79071	BC BL HW CG CW PW HL EL SC
10	0.9578	0.9356	11.0000	53.6311	2.12881	69.04428	BC BL HW CG CW RL PW HL EL SC

Appendix Table 8. Best models for Short-eared Somali does regression equation

Model	R^2	Adj. R^2	C (p)	AIC	Root MSE	SBC	Variables in Model
1	0.6463	0.6435	37.7882	167.5895	1.91936	173.27783	CG
1	0.3565	0.3514	169.526	243.5944	2.58887	249.28281	BC
2	0.6976	0.6927	16.4898	149.7091	1.78200	158.24164	BC CG
2	0.6665	0.6611	30.6007	162.1171	1.87121	170.64962	HW CG
3	0.7209	0.7140	7.8975	141.5275	1.71893	152.90421	BC HW CG
3	0.7072	0.7000	14.1164	147.6037	1.76054	158.98048	BC CG EL
4	0.7274	0.7185	6.9201	140.5122	1.70559	154.73317	BC HW CG EL
4	0.7263	0.7174	7.4090	141.0123	1.70895	155.23319	BC HW CG PW
5	0.7317	0.7206	6.9862	140.5146	1.69921	157.57975	BC HW CG PW EL
5	0.7312	0.7200	7.2175	140.7552	1.70082	157.82027	BC HW CG RL EL
6	0.7359	0.7227	7.0533	140.4861	1.69270	160.39541	BC HW CG RL PW EL
6	0.7354	0.7221	7.2983	140.7450	1.69443	160.65432	BC HW CG CW PW EL
7	0.7403	0.7251	7.0356	140.3336	1.68545	163.08705	BC HW CG CW RL PW EL
7	0.7377	0.7223	8.2448	141.6280	1.69406	164.38145	BC HW CG CW RL PW HL
8	0.7425	0.7250	8.0749	141.2956	1.68568	166.89333	BC HW CG CW RL PW HL EL
8	0.7405	0.7229	8.9521	142.2437	1.69198	167.84138	BC BL HW CG CW RL PW EL
9	0.7426	0.7228	10.0000	143.2144	1.69232	171.65626	BC BL HW CG CW RL PW HL EL

Appendix Table 9. Best models for Short-eared Somali bucks regression equation

Model	R^2	Adj. R^2	C (p)	AIC	Root MSE	SBC	Variables in Model
1	0.6790	0.6650	19.857	55.1721	2.90122	57.60982	BC
1	0.6658	0.6513	21.525	56.1720	2.95983	58.60978	HW
2	0.8091	0.7918	5.2915	44.1728	2.28730	47.82945	BC HW
2	0.7811	0.7612	8.8582	47.5979	2.44948	51.25455	CG HL
3	0.8456	0.8235	2.6521	40.8743	2.10573	45.74976	BC BL HW
3	0.8360	0.8126	3.8722	42.3802	2.17012	47.25569	BC HW CW
4	0.8729	0.8475	1.1768	38.0092	1.95767	44.10360	BC BL HW CW
4	0.8646	0.8375	2.2337	39.5913	2.02061	45.68570	BC BL HW HL
5	0.8837	0.8531	1.8045	37.7930	1.92145	45.10628	BC BL HW CW HL
5	0.8753	0.8425	2.8707	39.5316	1.98943	46.84483	BC BL HW CW EL
6	0.8876	0.8501	3.3078	38.9399	1.94070	47.47201	BC BL HW CG CW HL
6	0.8845	0.8460	3.6963	39.6097	1.96687	48.14179	BC BL HW CW HL EL
7	0.8893	0.8438	5.0843	40.5462	1.98130	50.29716	BC BL HW CG CW PW HL
7	0.8890	0.8433	5.1278	40.6233	1.98436	50.37427	BC BL HW CG CW HL EL
8	0.8896	0.8344	7.0464	42.4789	2.03953	53.44874	BC BL HW CG CW PW HL SC
8	0.8896	0.8344	7.0506	42.4863	2.03984	53.45620	BC BL HW CG CW PW HL EL
9	0.8899	0.8238	9.0126	44.4187	2.10389	56.60744	BC BL HW CG CW RL PW HL SC
9	0.8897	0.8236	9.0328	44.4546	2.10540	56.64336	BC BL HW CG CW RL PW HL EL
10	0.8900	0.8114	11.000	46.3961	2.17675	59.80377	BC BL HW CG CW RL PW HL EL SC

Appendix Table 10. GLM analysis output of quantitative traits of does

Dependent Variable	Source	DF	Type III SS	Mean Square	F Value	Pr > F
BC	Population	2	9.1938626	4.5969313	5.47	0.0045
	Error	465	391.1138297	8411050		
BW	Population	2	6397.612637	3198.806318	139.91	<.0001
	Error	465	10631.26967	22.86295		
BL	Population	2	2294.696848	1147.348424	80.49	<.0001
	Error	465	6628.488515	14.254814		
HW	Population	2	3473.864495	1736.932248	181.42	<.0001
	Error	465	4451.987535	9.574167		
CG	Population	2	3892.400282	1946.200141	141.00	<.0001
	Error	465	6418.31553	13.80283		
CW	Population	2	207.4507228	103.7253614	34.93	<.0001
	Error	465	1380.662525	2.969167		
RL	Population	2	121.7370070	60.8685035	67.34	<.0001
	Error	465	420.2816896	0.9038316		
PW	Population	2	28.07400712	14.03700356	10.37	<.0001
	Error	465	629.6327236	1.3540489		
EL	Population	2	602.7472956	301.3736478	271.33	<.0001
	Error	465	934.267128	2.009177		
HL	Population	2	6238.980174	3119.490087	271.33	<.0001
	Error	435	5001.25473	11.49714		

Appendix Table 11. GLM analysis output of quantitative traits of bucks

Dependent Variable	Source	DF	Type III SS	Mean Square	F Value	Pr > F
BC	Population	2	1.11480662	0.55740331	0.90	0.4076
	Error	130	80.19346405	0.61687280		
BW	Population	2	3214.326027	1607.163013	41.69	<.0001
	Error	130	5011.888410	38.552988		
BL	Population	2	2083.250170	1041.625085	53.28	<.0001
	Error	130	2541.268627	19.548220		
HW	Population	2	3498.056324	1749.028162	85.14	<.0001
	Error	130	2670.627887	20.543291		
CG	Population	2	2661.677478	1330.838739	46.16	<.0001
	Error	130	3747.739815	28.828768		
CW	Population	2	125.7312956	62.8656478	11.84	<.0001
	Error	130	690.3664488	5.3105111		
RL	Population	2	24.38291808	12.19145904	6.10	0.0029
	Error	130	259.8464052	1.9988185		
PW	Population	2	41.98361754	20.99180877	6.65	0.0018
	Error	130	410.2193900	3.1555338		
EL	Population	2	182.8583055	91.4291527	18.22	<.0001
	Error	130	652.3898148	5.0183832		
HL	Population	2	809.4438450	404.7219225	17.47	<.0001
	Error	87	2015.581155	23.167599		
SC	Population	2	48.53722091	24.26861046	4.35	0.0149
	Error	130	725.6921024	5.5822469		

Appendix Table 12. GLM analysis output of growth traits of Bati kids for the effect of sex, parity and type of birth

Dependent Variable	Source	DF	Type III SS	Mean Square	F Value	Pr > F
Birth weight	Parity	4	3.66487187	0.91621797	3.59	0.0082
	Sex	1	1.74312236	1.74312236	6.84	0.0100
	Birth type	1	1.60270690	1.60270690	6.29	0.0134
	Error	129	32.88214839	0.25490038		
30 days live weight	Parity	4	10.92406356	2.73101589	2.63	0.0375
	Sex	1	6.14358719	6.14358719	5.92	0.0164
	Birth type	1	5.62436543	5.62436543	5.42	0.0216
	Error	123	127.7033286	1.0382384		
90 days live weight	Parity	4	43.91982937	10.97995734	2.64	0.0379
	Sex	1	28.90658721	28.90658721	6.94	0.0097
	Birth type	1	19.72173615	19.72173615	4.73	0.0317
	Error	109	454.1798064	4.1667872		
180 days live weight	Parity	4	11.61215631	2.90303908	0.51	0.7253
	Sex	1	1.62948532	1.62948532	0.29	0.5923
	Birth type	1	32.71796530	32.71796530	5.80	0.0179
	Error	100	564.4437968	5.6444380		
Birth-90 day’s daily weight gain	Parity	4	5688.419665	1422.104916	3.05	0.0198
	Sex	1	2090.647230	2090.647230	4.49	0.0363
	Birth type	1	1284.271174	1284.271174	2.76	0.0996
	Error	109	50742.87631	465.53098		
91-180 days daily weight gain	Parity	4	3566.694120	891.673530	2.51	0.0466
	Sex	1	282.162531	282.162531	0.79	0.3750
	Birth type	1	32.770185	32.770185	0.09	0.7620
	Error	98	34807.89031	355.18255		

Appendix Table 13. GLM analysis output of growth traits of Borena kids for the effect of sex, parity and type of birth

Dependent Variable	Source	DF	Type III SS	Mean Square	F Value	Pr > F
Birth weight	Parity	4	4.84859784	1.21214946	4.12	0.0038
	Sex	1	4.11716286	4.11716286	13.98	0.0003
	Birth type	1	1.66216419	1.66216419	5.64	0.0192
	Error	113	33.28568961	0.29456362		
30 days live weight	Parity	4	5.88410183	1.47102546	1.44	0.2272
	Sex	1	10.39588084	10.39588084	10.15	0.0019
	Birth type	1	5.37992190	5.37992190	5.25	0.0239
	Error	104	106.5001708	1.0240401		
90 days live weight	Parity	4	22.62149798	5.65537449	2.13	0.0825
	Sex	1	13.34547518	13.34547518	5.03	0.0271
	Birth type	1	0.03842722	0.03842722	0.01	0.9044
	Error	98	259.9372177	2.6524206		
180 days live weight	Parity	4	8.05571806	2.01392951	0.87	0.4841
	Sex	1	14.96018835	14.96018835	6.48	0.0126
	Birth type	1	2.76801755	2.76801755	1.20	0.2765
	Error	91	210.2023415	2.3099158		
Birth-90 day's daily weight gain	Parity	4	2849.631976	712.407994	2.07	0.0902
	Sex	1	509.926278	509.926278	1.48	0.2261
	Birth type	1	201.037511	201.037511	0.58	0.4462
	Error	98	33683.65356	343.71075		
91-180 days daily weight gain	Parity	4	2775.144564	693.786141	3.07	0.0202
	Sex	1	180.131755	180.131755	0.80	0.3742
	Birth type	1	426.630673	426.630673	1.89	0.1727
	Error	91	20556.02961	225.89044		

Appendix Table 14. GLM analysis output of growth traits of Short-Eared Somali kids for the effect of sex, parity and type of birth

Dependent Variable	Source	DF	Type III SS	Mean Square	F Value	Pr > F
Birth weight	Parity	4	1.31728430	0.32932108	3.05	0.0289
	Sex	1	2.28866899	2.28866899	21.23	<.0001
	Birth type	1	0.03442982	0.03442982	0.32	0.5755
	Error	36	3.88159364	0.10782205		
30 days live weight	Parity	4	5.20793204	1.30198301	1.48	0.2278
	Sex	1	8.25563195	8.25563195	9.41	0.0041
	Birth type	1	1.45747742	1.45747742	1.66	0.2058
	Error	35	30.69139258	0.87689693		
90 days live weight	Parity	4	15.87046078	3.96761519	2.49	0.0620
	Sex	1	10.34736129	10.34736129	6.50	0.0156
	Birth type	1	1.33629019	1.33629019	0.84	0.3663
	Error	33	52.55551435	1.59259134		
180 days live weight	Parity	4	1.64578164	0.41144541	0.14	0.9674
	Sex	1	13.62177598	13.62177598	4.52	0.0428
	Birth type	1	2.34843341	2.34843341	0.78	0.3852
	Error	27	81.3899194	3.0144415		
Birth-90 day's daily weight gain	Parity	4	1979.498940	494.874735	2.32	0.0776
	Sex	1	367.345481	367.345481	1.72	0.1986
	Birth type	1	241.443008	241.443008	1.13	0.2953
	Error	33	7044.15882	213.45936		
91-180 days daily weight gain	Parity	4	2217.084290	554.271072	3.37	0.0253
	Sex	1	197.463395	197.463395	1.20	0.2840
	Birth type	1	115.150973	115.150973	0.70	0.4110
	Error	24	3946.841694	164.451737		

Appendix B: Semi structured questionnaire used for indigenous goat survey

Name of enumerator__________________ Date: ________________________
Questionnaire number: _______________
Zone: _______________________________
District: ______________________ Kebele/Village_____________________

Part 1. General information of households

1.1.Respondent's Sex: 1. Male 2. Female
1.2.Marital status of respondents a. Married b. Single c. Divorced
1.3.Respondent's Age (in years) ______
1.4.Respondent's Educational level 1. Illiterate (unable to read & write) 2. Reading and writing 3. Adult education 4. Religious school, 5. Primary (1-8), 6. Secondary (9-12) 7. Above secondary school
1.5.Household family size (number): Male ______ Female______ Total ______
1.6.What is your major farming activity? 1. Livestock production 2. Crop -livestock production3. Other (Specify)__________________
1.7.Land holding (in ha)

	Own	Rented
a. Cropping land	__________	_________
b. Fallow land	__________	_________
c. Grazing	__________	_________

d. Others (specify) ________________
1.8.Trend in land holding 1. Decreasing 2. Increasing 3. Stable
If decreasing why? ____
1.9. Livestock ownership of households

Species	Number	Trend in the last 10 years			
		Increasing	Decreasing	Constant	Reason
Goat					
Cattle					
Sheep					
Chicken					
Camel					
Donkey					
Mule					
Horse					
Beehives					

1.10. Goat flock profile in number
a. Male kids < 6 months __________
b. Female kids < 6 months __________
c. Male 6 months to 1 year _________
d. Female 6 months to 1 year ______
e. Male > 1 year (Intact) __________

f. Female > 1 year ______________
g. Castrate ______________

1.11. Major crops grown

	Main rain season	Short rain	Irrigated		Main rain season	Short rain	Irrigated
a. barley				e. sorghum			
b. wheat				f. bean			
c. teff				g. pea			
d. maize				others			
				____________			

1.12. Non-farm activities
1. Hand craft 2. Trading 3.Daily labor 4. Others (specify) ________________

1.13. Rank your farming and non-farm activities according to the respective criteria (1 for the most important)

	Household staple diet	Household Cash income
a. Livestock production		
b. Crop production		
c. Hand craft		
d. Trading		
e Daily labor		
f Others (______________)		

Part 2. Production and management systems

2.1. General

2.1.1. Production system

Mixed crop-livestock system	
Agro-pastoralist	
Pastoralist	
Other (Specify)_________________	

2.1.2. Mobility pattern

	Family	Reason for movement	Flock	Reason for movement
Sedentary				
Transhumance		______________________		___________________
Nomadic		______________________		___________________

2.1.3. Purpose of keeping goats (put in order of importance)

Purpose	milk	meat	Wealth status	ceremonies	manure	blood	skin	saving	income	gift
Rank										

Others (specify) ____

2.1.4. If you use goats for milk production,

a. Average estimated milk production of doe per day (litters) during;
   Wet season ____________Dry season____________
b. Lactation length (months) Maximum ___________minimum ________

2.1.5. Frequency of milking

	Wet season	Dry season
Once a day		
Twice a day		
Three times a day		

2.1.6. Milk feeding up to weaning

1. Unrestricted suckling
2. Restricted suckling

2.1.7. Uses of goats milk

a. Market
b. household consumption c. others _________

2.1.8. If the family is making use of it, explain the way of preparation and utilization

____

____

Average weaning age of kids in months: ______________________________

2.1.9.What type of mechanism you use to wean kids? ________________________

2.1.11. Members of household and hired labour responsible for goat activities

Activities	Family			
	female		male	
	≤15years	>15years	≤15years	>15years
Purchasing				
Selling				
Herding				
Breeding				
Caring sick animals				
Feeding				
Milking				
Making dairy products				
Selling dairy products				
Barn cleaning				
Slaughtering				

2.2. Feeding and grazing management

1.2.1. Feed source (*tick under each season and rank them*)

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

Others
(Specify____

1.2.2. Crop residues used for goats' feed (Rank according to priority)

Residues	Wet season	Dry season
Teff		
Wheat		
Barley		
Sorghum		
Maize		
Bean		
Pea		
Lentil		
Chick pea		

Others (Specify) ____

1.2.3. Grazing land ownership : 1. Privet 2. Communal 3. Both

1.2.4. Grazing and /or browsing method

	Wet season	Dry season
Free		
Herded free grazing		
Paddock		
Tethered		
Zero		

Others (Specify____

1.2.5. Length of grazing and/ or browsing time (in hours):

Wet season

a. Morning from_____to ______hours.
b. Afternoon _____to________hours.
c. Goats graze and or brows all the day

Dry season

a. Morning from_______to _____hours.
b. Afternoon _________to________ hours.
c. Goats graze and or brows all the day

1.2.6. Trend in communal grazing areas?
a. Decreasing b. Increasing C. Stable
What do you think the reason? ____

1.2.7. How is goat flock herded during the day time?
a. Male and female are separated
b. Males and female are together
c. kids are separated
d. All classes goats herded together

1.2.8. Goat flock is herded
a. Together with cattle
b. Goats herded separately
c. Together with sheep
d. Together with camel
e. Together with calves
f. Together with equines
g. All herded together

1.2.9. Way of herding
a. Goats of a household run as a flock
b. Goats of more than one household run as a flock, if it is specify the number of households mix their goats________________________________
c. Others (specify) _______________________________________

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

2.2.11. At which month(s) of the year do you experience feed shortage? ____________________

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

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

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

2.2.14. Concentrates used for goats feeds(*rank the most frequent used 1 and so on*)

Type	Rank
Homemade grain	
Oil seed cakes	
Local brewery by-products	
Flour by-products	

Others (Specify____

2.2.15. Do you practice goat fattening ___________ 1= Yes 2=No

2.2.16. If your answer is yes for question no. 2.2.15, which categories of animals do you fatten?

a. Older males
b. Older female
c. Castrates
d. Young males
e. Young female
f. Culled young male
g. Culled Young female

Name 3 categories of goats you use for fattening in order of importance

1.______________ **2.** ____________________ **3.**________________________

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

Season	fattening duration (months)	Reasons
1. ____________	______________	________________________________
2. ____________	______________	________________________________
3. ____________	______________	________________________________

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

a. Naturel Pasture
b. Crop residues
c. Concentrate
d. Others(specify) __________________

2.3. Watering

2.3.1. Source of water

Source	Wet season	Dry season
Water well		
Rain water		
River		

Source	Wet season	Dry season
Spring		
Dam/pond		
Pipe water		

Others (specify) ____________________

2.3.2. Distance to nearest watering point

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

2.3.3. Are kids watered with the adults? _________ 1= Yes 2= No

If no, describe watering distance and frequency of kids________________________

2.3.4. Frequency of watering

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

Others____

2.4. Housing

2.4.1. Housing/enclosure for adult goat (*Tick one or more boxes)*

With roof	a. In family house	
	b. Separate house	
	c. Veranda	
Without roof	a. Kraal	
	b. Yard	
	c. None	
Others (specify)		

2.4.2. Housing materials

Type	Roof	Wall	Floor
a. Iron sheets			
b. Grass/Bushes			
c. Wood			
d. Stone/bricks			
e. Concrete			
f. Earth/mud			
Others _________			

2.4.3. Are kids housed with adults?____________ 1= Yes 2=No

If no, specify____

2.4.4. Are goats housed together with other animals? ________1= Yes 2= No.

2.5. Health management

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

i. ____

Clinical signs____

ii. ____

Clinical signs____

iii. ____

Clinical sign____

iv. ____

Clinical signs____

v. ____

vi. Clinical signs____

2.5.2. Do you have access to veterinary services? 1. Yes 2. No

2.5.3. If yes, which type of veterinary service you accessed?
   a. Government veterinarian
   b. Private veterinarian
   c. NGOs
   d. CAHWs

2.5.4. Distance to nearest veterinary services
   a. 1-5km
   b. 6-10km
   c. >10km
   d. Other
   e. (specify)__________

2.5.5. Most animals are provided with veterinary treatment when they are sick
   a. Never, why? ____
   b. occasionally
   c. regularly

2.5.6. Most animals are subject to traditional treatments
   a. Never, why? ____
   b. Occasionally
   c. Regularly

2.5.7. Adaptability traits of goats

Adaptability	good	moderate	less
Disease			
parasites			
Heat			
Frost			
Drought			
Feed shortage			
Water shortage			

2.6. Breeding practices

2.6.1. Do you have breeding buck?__________ 1= Yes 2= No

If yes,

   a. Number local breeding buck? ____________________
   b. Number of crossbred breeding buck? _____________

2.6.2. If you have crossbred buck, is it a. Exotic b. Local?
   If exotic, how do you have it? _________________________________

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

2.6.4. For how many years on the average is the one buck serving in your flock? __________

2.6.5. Is there any special management for breeding buck? _________ 1= Yes 2= No

2.6.6. If yes, specify type of management___________________________________

2.6.7. Source of breeding buck

a. Born in the flock
b. Purchased
c. Neighbours
d. Communal
e. Others(specify)____________

2.6.8. Purpose of keeping buck

a. Mating
b. Socio-cultural
c. Fattening
d. Other(specify)______________

2.6.9. Do you practice selection for?

a. Breeding male 1= Yes 2= No Breeding female 1= Yes 2= No

2.6.10. Which traits do you consider in selecting breeding buck and doe? Rank the traits in order of importance for selection.

Traits to select **doe**	Rank
Color	
Body size/appearance	
Kid survival doubt	
Paternal history	
Maternal history	
Age at first sexual maturity	
Kidding interval	
Litter size	
Milk yield	
Temperement	
Horn	
Walk ability	
Adaptability	
Others(specify) ___________	

Traits to select **buck**	Rank
Color	
Body size	
Fertility	
Paternal history	
Maternal history	
Libido	
Growth rate	
Adaptability	
Walk ability	
Horn	
Others(specify) _____	

2.6.11. Age of selection (months); Breeding male _______, Breeding female _________

2.6.12. Age of 1stservice (month); Breeding male _________, Breeding female ________

2.6.13. Age at 1st kidding (month) _______________

2.6.14. Average number of kidding per doe life time ___________

2.6.15. Average kidding interval of doe (months) _____________

2.6.16. Type of mating used

a. Controlled
b. Uncontrolled (hand mating)
c. Uncontrolled (natural mating)

2.6.17. If uncontrolled, what is the reason?

a. Goats growth and/or browse together
b. Lack of awareness
c. Insufficient number of bucks
d. Others (specify) _________________

Could you be able to identify the sire of a kid? _______1= Yes 2= No

If yes, specify the criteria used to identify __________________

____

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

Reason

a. Yes ☐ ____

b. No ☐ ____

2.6.20. Do you allow your doe to be served by anyone else buck?

Reason

a. Yes ☐ ____

b. No ☐ ____

2.6.21. Kidding pattern, occurrence of most births*(Tick one or more boxes then rank top three)*

Month		Month		Top 3 months most births occur
January		July		
February		August		1. ____________________
March		September		2. ____________________
April		October		3. ____________________
May		November		
June		December		

2.6.22. Do you castrate your buck? 1= Yes 2= No

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

a. Control breeding
b. Improve fattening
c. Better price
d. Others ___________________

2.6.24. Specify Castration method you used.

a. By your own (traditional)
b. Veterinarians(modern)

2.6.25. If you castrate traditionally, explain the technique of castration? _____________

2.6.26. At what age do you castrate bucks? ____________________

2.7. Marketing

2.7.1.Which class of goat do you sell first in case of cash needed?

Class	Rank
Buck kids less than one year	
Doe kids less than one year	
Breeding does	
Breeding bucks	
Castrated	
Old does	
Old bucks	

2.7.2. Average market age in month male_________ female__________

2.7.3. Average culling age due to old age male__________ female___________

2.8. Goat production constraints

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

	If yes mark(✓)	Rank
a. Drought		
b. Feed shortage		
c.Water shortage		
d.Disease		
e. Predator		
f. Market		
g. Labor shortage		
h. Lack of superior genotypes		
I. Others (specify) __________		

Appendix C: Goats physical description recording format and respective codes

Name of enumerator_______________________ Date: ______________

Zone: ___________________________________

District: _________________________Kebele/Village_______________

Goat type/breed: ________________________

No.	Sex	Body condition	Coat color pattern	Coat color	Head (facial) profile	Horn presence	Horn shape	Horn orientation	Ear orientation	Back profile	Wattles	Ruff	Beard
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													

Sex: F= Female M= Male, **Coat color pattern**: 1= plain 2= Patchy/pied 3= Spotted, **Coat color**: 1 = White, 2=dark red, 3 = Black, 4= Grey, 5 = light red, **Head (facial) profile**: 1 = Straight, 2 = concave, 3= convex, **Horn presence**: 1= Present 2= Absent 3= Rudimentary, **Horn shape**:1= straight, 2= curved, 3= spiral, 4= corkscrew, **Horn orientation**: 1= lateral(sideways), 2= obliquely upward, 3= back ward, **Ear orientation**: 1= erect, 2= pendulous, 3= semi-pendulous, 4= carried horizontally, **Back profile**: 1= straight, 2= slopes up towards the rump, 3= slopes down from withers, 4=curved(dipped), **Wattles**: 1= Present 2= Absent, **Ruff**: 1= Present 2= Absent, **Beard:**1= Present 2= Absent

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

Measurements	Description
Body weight (BW)	The live body weight taken using spring balance (in kilograms)
Body length (BL)	The horizontal distance from the point of shoulder to the pin bone to the nearest centimeter
Height at wither (WH)	the (vertical) height (in centimeters) from the bottom of the front foot to the highest point of the shoulder between the withers
Chest girth (CG)	the circumference of the body (in centimeters) immediately behind the shoulder blades in a vertical plane, perpendicular to the long axis of the body
Chest width (CW)	The width of the chest between the briskets to the nearest centimeter
Rump length (RL)	Distance from the most cranial and most dorsal point of the hip to the most caudal point of the pin bone
Pelvic width (PW)	The distance between the pelvic bones, across dorsum to the nearest centimeter
Horn length (HL)	From the base of the horn at the skull along the dorsal surface to the tip of the horn using tape meters to the nearest centimeter
Ear length (EL)	The length of the ear on its exterior side from its root at the poll to the tip to the nearest centimeter
Scrotal Circumference (SC)	Pushing the testicles to the bottom of the scrotum and the widest Circumference measured to the nearest centimeter

Appendix E: Quantitative traits measurement recording format

No.	BW	BL	HW	CG	CW	RL	PL	HL	EL	SC
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										

BW=Body weight, **BL**= Body Length, **HW**= Height at Withers, **CG**= Chest Girth, **CW**= Chest width, **RL**= Rump Length, **PW**= Pelvic Width, **HL**= Horn Length, **EL**= Ear Length, **LH**= Length of Head and **SC**= Scrotum Circumference

Appendix F: Descriptions of body condition score

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

Appendix G: Growth performance recording format

Owner's name ____________________________________Name of enumerator: ____________________
Zone: __________________ District: ________________ Kebele/Village ___________________

Dam's							Kid												Remarks
ID. No.	Color	Body cond.	Dentition	Parity	Postpartum wt.	Origin (market /born)	Id.	Color	Sex	Type of birth	Birth date	Birth wt.	30 days wt. (kg)		90 days wt. (kg)		180 days wt. (kg)		
													Date	Wt.	Date	Wt.	Date	Wt.	