

**ON-FARM PHENOTYPIC CHARACTERIZATION AND CONSUMER
PREFERENCE TRAITS OF INDIGENOUS SHEEP TYPE AS AN INPUT
FOR DESIGNING COMMUNITY BASED BREEDING PROGRAM IN
BENSA DISTRICT, SOUTHERN ETHIOPIA**

MSc THESIS

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**On-Farm Phenotypic Characterization and Consumer Preference Traits of
Indigenous Sheep Type as an Input for Designing Community Based
Breeding Program in Bensa District, Southern Ethiopia**

**A Thesis Submitted to the School of Animal and Range Sciences,
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**In Partial Fulfilment of the Requirements for the Degree of
MASTER OF SCIENCE IN ANIMAL GENETICS AND BREEDING**

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**February 2017
Haramaya University, Haramaya**

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DEDICATION

This work is dedicated to my family for their endless love.

STATEMENT OF THE AUTHOR

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BIOGRAPHICAL SKETCH

The author, Hizkel Kenfo Dando, was born in November 1987 at Damot Sore district, Wolayita Zone of the Southern Nations, Nationalities and Peoples' Regional State (SNNPRS). He attended his elementary education at Denba Zamine Elementary School from 1993 to 1998. He pursued his junior secondary education at Anchucho from 1999 to 2000. He attained his secondary high school study at Boditi Secondary and preparatory School from 2001 to 2005. He then joined the then Ambo University in 2006 and awarded a B.Sc. degree in Animal production in July, 2009. After his graduation, he was employed by Office of Agriculture and Rural Development of Humbo Woreda, Wolaiyta Zone, and served as Animal product and quality control expert for two years and five month. He again employed by the Southern Agricultural Research Institute (SARI), Worabe Agricultural Research Center, as junior Animal breeder in Animal Science Research Department until he joined the Postgraduate Programmes Directorate of the Haramaya University to pursue his Master of Science degree in Animal Genetics and Breeding in November, 2014.

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ACRONYMS AND ABBREVIATIONS

AFL	Age at First Lambing
AnGR	Animal Genetic Resources
Cm	Centimeter
CSA	Central Statistical Agency
DAGRIS	Domestic Animal Genetic Resources Information System
DNA	Deoxyribose Nucleic Acid
EARO	Ethiopia Agricultural Research Organization
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GLM	General Linear Model
IBC	Institute of Biodiversity Conservation
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
Kg	Kilogram
m.a.s.l	Meters above sea level
Mm	Millimeter
MoA	Ministry of Agriculture
PPI	Permanent Pair of Incisor
SAS	Statistical Analysis System
SPSS	Software Package for Social Sciences

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On-Farm Phenotypic Characterization and Consumer Preference Traits of Indigenous Sheep Type as an Input for Designing Community Based Breeding Program in Bensa District, Southern Ethiopia

ABSTRACT

The study was carried out in Bensa district of Sidama Zone, southern Ethiopia. Agro-ecologically the study sites were classified into highland and mid-altitude. The objective of the study was to phenotypically characterize indigenous sheep type with respect to physical linear traits and consumer preference. A total of 128 households from four kebeles were selected purposively based on sheep population and production potential, and accessibility for characterization of production system. A total of 574 sheep were sampled for phenotypic characterization. The Sampled sheep were classified by sex in to two (female, male) and by dentition in to four (0PPI, 1PPI, 2PPI, 3PPI) groups. Both qualitative and quantitative data were analyzed using SAS versions 9.1.3 (2008). The result showed that most of the household heads were male (92.75%) and mixed crop-livestock system was the dominant production system. Among the livestock species, sheep accounted for the largest proportion across the two agro ecologies and the average sheep flock size was 4.6 ± 33 in highland and 4.3 ± 213 in mid-altitude. The primary reason of keeping sheep was for cash income and saving across the two agro ecologies. The major feed resources for sheep during the wet and dry seasons were natural pasture and crop residues across the two agro-ecologies. Rivers and spring water were the main water source for sheep in the study area. Castration was not common practice by the keepers in the study area. Docking the fat tail of ewe lambs is a common practice in the highland. Farmers in the study area mainly practice natural and uncontrolled mating systems. Selection was practiced both for male and female. Growth rate, appearance and color were the most frequently reported traits in selecting breeding rams across the two agro ecologies. Twinning ability, appearance, color and lamb growth were reported as traits given due emphasis in choosing future breeding ewes across the two agro ecologies. Feed shortages, disease, parasite prevalence and market were the major sheep production constraints in Bensa district. There are four towns where sheep was marketed in addition to many villages that were used as primary market outlets for sheep. Farmers, collectors, traders, brokers, restaurant/hotel owners and individual consumers were the major actors in

the sheep market. There are five main market channels and three market outflow route of sheep in the study area. The most preferred traits by consumer in the study area were younger age, uncastrated, large frame size, good body condition and non-black color. The demand of sheep was high during the time of crop harvesting and Christian holidays. The main frequently observed coat color pattern of sampled male and female populations of indigenous sheep were patchy (51.9%) and while the most observed coat colour type was red followed by mixture of red and brown. Majority of female and male sheep in the study areas had medium and smooth coat cover, and most of female had no horn. In the study area overall mean of ear length, body weight, body length, chest depth, chest girth, height at withers, pelvic width, tail length, tail circumference and scrotum circumference were 10.3 ± 0.07 cm, 27.6 ± 0.5 kg, 60.2 ± 0.34 cm, 23.2 ± 0.08 cm, 68.5 ± 0.6 cm, 60.2 ± 0.5 cm, 17.23 ± 0.54 cm, 32.73 ± 0.54 cm, 20.17 ± 0.3 cm and 24.93 ± 1.06 cm, respectively. Sex of the sheep had significant ($P > 0.05$) effect on the body weight and linear body measurements except ear length, pelvic width and tail length and rump length. Dentition classes of sheep contributed significant differences to body weight and the linear body measurements except ear length. The correlation coefficient between body weight and other linear body measurements were positive and significant both for male and female sheep. The result of the multiple regression analysis showed that chest girth alone could accurately predict body weight both in female and male of sampled population of indigenous sheep with the equation $y = -20 + 0.67x$ for females and $y = -29 + 0.8x$ for males, where y and x are body weight and chest girth, respectively. It was concluded that understanding the production system, consumer preferences and breeding practices of indigenous sheep can be used as first step in designing a sustainable breeding programme in the study area.

Key words: *Consumer preferences, Indigenous sheep, Linear body measurements, Production system*

1. INTRODUCTION

Ethiopia is home for most populous and diversified indigenous sheep breeds/populations in Africa. There are about 14 traditionally recognized sheep populations in Ethiopia, which are classified into nine genetically distinct breeds and 6 breed groups (Solomon, 2008). The country has about 26 million heads of sheep, of which about 75% is found in the highlands where mixed crop-livestock production systems dominate, while the remaining 25% is found in the lowlands (DAGRIS, 2006; CSA, 2013). In Ethiopia sheep are widely distributed across the diverse agro-climate prevalent in the country. Sheep production in Ethiopia is based on indigenous breeds which account for about 99.78% of the total national sheep population (CSA, 2014).

Sheep production is a major component of livestock farming in Ethiopia. It contributes close to 30% of the total ruminant livestock meat output and 14% of the total domestic meat production (Workneh *et al.*, 2004). The sheep enterprise in the Ethiopian highland, where crop and livestock production are integrated, it is the most important form of investment and cash income and provides social security in bad crop years. The livestock sector contributes 30 to 35% of the Ethiopian agriculture GDP, 19% of the total GDP and more than 85% of farm cash income (Benin *et al.*, 2002). Small ruminants account for about 40% of the cash income earned by farm households, 19% of the total value of subsistence food derived from all livestock production, and 25% of total domestic meat consumption (Adane and Girma, 2008).

The level of production and productivity of sheep in the country is generally extremely low, due to several technical (genotype, feeding and animal health), institutional, environmental and infrastructural constraints (Markos, 2006). For instance, the average annual off-take rate and carcass weight per slaughtered animal for the years 2000 to 2007 were about 32.5% and 10kg, respectively, the lowest even among Sub-Saharan African countries (FAO,2009). But indigenous sheep breed has a great potential to contribute more to the livelihood of people in low input, smallholder and pastoral production system.

The dominant sheep production system in Ethiopia is traditional and subsistence. So far, only very limited efforts have been exerted to promote market-oriented sheep production in the country and hence the current income generating capacity of the sector is not at all justifiable. Production system approach, which involves designing an effective and informed breeding programme, is a necessity to bring about improvements sheep production system of the sector. This approach entails proper valuation of both traded and non-traded products and services generated from the system. Information on the economic value of populations, traits and processes would ease the management of animal genetic resources that requires many decisions (Scarpa *et al.*, 2003). Proper identification and valuation of the different characteristics of the production systems and animals would make resource allocation decisions among the different livestock improvement interventions for commercialization of the system quite fast and smooth (Kassie, 2007). This will also enable identification of sheep market opportunities by identifying preferred traits of sheep by the market in general and local consumers in particular.

Sheep genetic improvement programs in developing countries have not been very successful may be due to failure to perceive the multidirectional aspect of the problem such as implementing genetic improvement programs without taking into consideration other vital needs of the farmers (Sölkner *et al.*, 1998; Kosgey *et al.*, 2006). In addition, poor performance of imported breeds from the temperate regions to tropical region with sub optimal management conditions has created a negative image for genetic improvement programs (Workneh *et al.*, 2003). Further, crossbreeds such as Blue du Maine X Menz, Rambouillet X Menz, Romney X Menz, Corriedale X Menz and Hampshire X Menz produced at different research stations and ranches in Ethiopia were rejected by smallholders upon distribution because of phenotypic unlikeness and other characters to the indigenous ones (Markos, 2006). Other authors (Workneh *et al.*, 2003; Kosgey *et al.*, 2006) explained the failure of crossbreeding in the tropics due to incompatibility of the genotypes with the breeding objectives and management approaches in low-input and low-output production systems. Community-based breeding programs that adopt to take into account the farmers' needs, views, decisions, and active participation, from inception through implementation, and their

success is based upon proper consideration of farmers' breeding objectives, infrastructure and ownership (Sölkner *et al.*, 1998).

Characterization of animal genetic resources 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 adapted on. The aim is to obtain better knowledge of Animal Genetic Resources (AnGR), to their present and potential future uses for food and agriculture in defined environments, and their current state as distinct breed populations (FAO, 2007). Genetic and phenotypic characterization of locally available farm animal populations provides essential information to make rational decisions for the improvement and the development of effective breeding programmes. In developing regions, there exist types of farm animal species which owe their distinct identity to a combination of traditional 'breeding objectives' and geographical and/or cultural separation by communities which own them (Mwachero and Rege, 2002). But extensive characterization activity was not undertaken in some part of the country.

Bensa district is one of the PLDs (Pilot Learning District) of Livestock and Irrigation Value chains of Ethiopian Smallholders (LIVES) project of ILRI in Sidama highlands of Southern Ethiopia. It is one of the leading district's in terms of sheep population from Sidama zone. However, no or little effort has been made to characterize the indigenous sheep population of the district. Therefore, the present study was conducted with the following objectives:

General Objective:

- On farm phenotypic characterization and to assess consumer trait preference of indigenous sheep in the study area

The specific objectives:

- To identify and characterize sheep production systems and their production environments for designing community based breeding program in the study area.
- To assess consumer preference of indigenous sheep as an input for designing community based sheep breeding.
- To phenotypically characterize indigenous sheep population in the study area.

2. LITERATURE REVIEW

2.1. Socio Economic Importance of Sheep Production in Ethiopia

The importance of small ruminants to the socioeconomic well being of people in developing countries in the tropics in terms of nutrition, income and intangible benefits (i.e., savings, an insurance against emergencies, cultural and ceremonial purposes) cannot be overemphasized. Small ruminants also play a complementary role to other livestock in the utilization of available feed resources and provide one of the practical means of using vast areas of natural grassland in regions where crop production is impractical (Markos *et al.*, 2006). Small ruminants are not only advantageous for human being during periods of cyclical and unpredictable food shortages but they are also useful for balancing the energy and protein supply during normal variations occurring over the years as well as between different seasons.

Indigenous sheep in Ethiopia have a multipurpose role for smallholder farmers as sources of income, meat, skin, manure and coarse wool or long hairy fleece. They are also a means of risk avoidance during crop failure. Thus, increasing the current level of productivity of sheep is essential to meet the demands of the ever-increasing human population. On the other hand, by improving the productivity of sheep, export earnings as well as the income of the household will be improved. There are however, a number of constraints that affect the productivity of sheep such as mortality, feed scarcity and inadequate indigenous breed utilizations to production. Various scholars from different corners of the world have been advising that the performance of indigenous sheep could be improved through management and there is also potential for genetic improvement through selection.

In all regions, small ruminant contribute significantly to food production and economic output. About 31-38% and 21-33% of the Ethiopian smallholder farmers own sheep and goat (Asfaw and Jabbar, 2008), The livestock sector contributes 30% to 35% of the Ethiopian agriculture GDP, 19% of the total GDP and more than 85% of farm cash income (Benin *et al.*,2002). Small ruminants account for about 40% of the cash income earned by farm households, 19% of the total value of subsistence food derived from all livestock production,

and 25% of total domestic meat consumption (Adane and Girma, 2008). The demand and prices for sheep are also increasing locally due to increased urbanization and increased income in the cities. The demand is especially pressing given that the current population of the country is expected to rise to about 129 million by the year 2030 (IBC, 2004).

2.2. Origin and Domestication of Sheep

The domestic sheep is one member of the genus *Ovis*, and is thought to be descended from the wild mouflon of South-West Asia. Sheep (*Ovis aries*) are quadruped ruminant mammals typically kept as livestock. Like all ruminants, sheep are members of the order Artiodactyla, the even-toed ungulates. Although the name "sheep" applies to many species in the genus *Ovis*, in everyday usage it almost always refers to *Ovis aries*. Sheep, *Ovis aries*, (Mammalia, Artiodactyla, Bovidae, Caprinae) are a highly versatile and adaptable species. From their domestication in the Fertile Crescent, approximately 11,000 years ago, sheep now span the diverse terrains of each inhabited continent where they are exploited for a variety of uses including the production of food (milk, fat, meat) and clothing (skin, wool) (Dwyer,2008).

African sheep are thought to be of Near-Eastern origin (Epstein 1954, 1971; Ryder, 1984). The earliest sheep in Africa were thin-tailed and hairy and introduced to East Africa through North Africa. The second wave of sheep introduction to Africa included fat-tailed sheep entering North Africa via the Isthmus of Suez straits and East Africa via straits of Bab-el-Mandeb (Ryder 1984). Fat-rumped sheep entered East Africa much later (Epstein 1954, 1971; Ryder, 1984).Accordingly, African sheep have been traditionally described and classified based on their tail type (Epstein, 1971; Ryder, 1984). However, the relationship between the traditional classification and genetic variation across currently recognized breeds are unknown. Recently, the study by Solomon (2008) indicated that Ethiopian sheep are classified in to 6 major breed groups and breeds.

2.3. Ethiopia Sheep Breeds/Populations

Ethiopia is believed to be one of the major gateways for domestic sheep migration from Asia to Africa (Devendra and McLeroy, 1982). Ethiopia is a home of most populous and diversified indigenous sheep breeds. Ethiopian sheep breeds have been traditionally classified into four broad categories based on tail type and fiber type: the hairy thin tailed, woolen thin tailed, fat tailed and fat rumped (MoA, 1975). Accordingly, attempts have been made to group some of the indigenous sheep types in to these different categories. Previous studies on Ethiopian sheep limited only on few specific sheep types in the country such as such as Horro, Menz, Afar and Bonga and/or are based on few animals (Galal,1983;Kassahun, 2000;Solomon,2002;Sisay,2002;Zewdu *et al.*, 2010; Getachew *et al.*,2010;). Morphologically characterized sheep types in Gamogofa, Sidama-Gedeo, Gurage -Silte, Kembata Tembaro – Hadya and Wolaita zones and very few woredas of SNNPR were undertaken(Abera *et al.*, 2013). Molecular characterization of 14 sheep types was also studied by Solomon (2008). However, information on sheep types in some pocket areas of Southern Nation Nationalities and Peoples Region is lacking.

Table 1. Indigenous sheep types of Ethiopia

Breed group	Breed type	Population	Tail type/shape	Fiber type
Short-fat-tailed	Simien	Simien	Fatty and short	Fleece
		Sekota,Farta, Tikur,Wollo, Menz	Fatty and short	Fleece
Washera	Washera	Washera	Fatty and short	Hair
Thin-tailed	Gumuz	Gumuz	Thin and long	Hair
Long-fat-tailed	Horro	Horro	Fatty and long	Hair
	Arsi	Arsi-Bale, Adilo	Fatty and long	Hair
Bonga	Bonga	Bonga	Fatty and long	Hair

“Continued...”

Fat-rumped sheep	Afar	Afar	Fat rump/fat tail	Hair
	BHS	BHS	Fat rump/tiny tail	Hair

Source: Solomon (2008) BHS = Blackhead Somali;

2.4. Sheep Production System in Ethiopia

The choice of farmers/pastoralists of agricultural enterprises in Ethiopia depends on the production environment (availability of resources, particularly land, water and climate), long-standing tradition of agricultural production in the community, socio-economic circumstances (awareness and skill, access to inputs and markets), and government support (inputs and services) which stems from agricultural policies. In subsistence-oriented traditional production system, goats and sheep are important because they require low initial capital and maintenance costs, are able to use marginal land and crop residues, produce milk and meat in readily usable quantities, and are easily cared for by most family members. Furthermore, they are important in feeding the rapidly expanding population of the developing world under typical harsh environmental conditions (Markos *et al.*, 2006).

Ethiopia is one of the countries that have predominantly traditional sheep production system. The major sheep production systems in Ethiopia include the traditional sheep production system, which consists mixed crop- livestock systems, and pastoral and agro-pastoral system and the government ranches for breeding and multiplication centers, characterized by different production goals and priorities, management strategies and practices, and constraints (Markos, 2006).

The sheep production systems of Ethiopia are classified into five based on 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).

2.4.1. Highland Sheep-barley system

This production system prevails in the high altitude areas (above 3000 m.a.s.l.) where the major crops grown are barley and pulses such as faba beans, lentils, etc. Sheep are the dominant livestock species. The main feed resource-base includes wasteland grazing, stubble and sometimes straw. Sheep flock sizes range from 30 to several hundred head. Although sheep are reared mainly for meat but skins and coarse wool production for the cottage industry of the central highlands are subsidiary products (Solomon *et al.*, 2008).

2.4.2. Mixed crop-livestock production system

This system is predominantly found in highland agro-ecological zones where the climatic factors are conducive for farming of crops and raising livestock. This system is generally found in areas where the altitude ranges between 1500 and 3000 m.a.s.l. The area has adequate rainfall and moderate temperature and is thus suitable for grain production. In this production system, livestock and crops are maintained as complementary enterprises. The average land size per household is often less than two hectares (Solomon *et al.*, 2008). Within the mixed crop-livestock system, small ruminant production systems are found associated with the different agricultural production systems which vary in potentials, intensity of the mixed farming operation, natural resources base including grazing and livestock resources. Furthermore, in highland agro-ecology, as in central Ethiopia, increased human population has led to decreased farm size and a gradual shift from keeping large to small ruminants, mainly goat and sheep (Peacock, 2005).

2.4.3. Pastoral and agro-pastoral systems

Pastoral and agro-pastoral systems are found in the lowlands are characterized by extensive production based largely on the rangeland (Tembely, 1998; EARO, 2000). Small ruminant production is associated with the purely livestock based nomadic and transhumance pastoral production systems based largely on range, primarily using natural vegetation. In the lowlands of Ethiopia, livestock is comprised of large flocks and herds of sheep and goats, cattle and camels mainly transhumant's, where only surplus are sold at local markets or trekked to major

consumption centers. Extensive livestock keeping is the backbone of the economies of the lowlands (Tembely, 1998; EARO, 2000).

2.4.4. Ranching system

Ranching system is a range-based system of livestock production similar to the pastoral systems but with different production parameters, livestock functions and management. The system can be considered as a modern land use system. The main function of this system is to generate cash income. Both highland and arid/semi-arid ranching can be undertaken in Ethiopia (Solomon *et al.*, 2008).

2.4.5. Urban and peri-urban production systems

Urban and peri-urban production systems involve the production of sheep and goats within and at the periphery of cities. In this system the feed resource of livestock are usually household wastes, market area wastes, mill leftovers, by-products and roadside grazing. Currently, small-scale sheep and goat fattening is emerging as an economic activity in many growing cities (Solomon *et al.*, 2008).

2.5. Flock Demography, Size and Ownership Pattern

Flock structure or flock composition is the proportion of the flock which is formed by different age and sex classes. This is determined by flock owner on the basis of economic and management considerations. The composition is also influenced by reproductive and mortality rates. Determination of the best flock structure is strongly influenced by the owner's management objectives, whether the main interest is in the production of milk or meat, the prevailing constraints in the system and it can further provide the basis for calculating or forecasting flock productivity (ILCA, 1990). For example, in Konta special Woreda of SNNPR sheep flock consisted of breeding ewes, castrates, ram lambs, rams, ewe lambs, ewes, breeding rams account for about 20.2, 18.6, 16 13.1, 12.1,10.4 and 9.3% respectively (Amelmal, 2011) of the flock while On the other hand, average flock sizes of 24 animals were reported in the central highlands of Ethiopia (Abebe, 1999). Lower flock sizes of 6.3 for

Horro sheep (Solomon *et al.*, 2005) and 6.97 for sheep breed found around Dire Dawa (Aden, 2003) were reported.

Under farmers management condition both breeding ram and ewe graze together throughout the year with all age class of sheep and in most cases with other species of livestock (Abebe, 1999; Aden, 2003). Report on male to female ratio of different studies range from 1:5.21 to 1:29 (Niftalem, 1990; Abebe, 1999; Aden, 2003; Solomon, 2007; Tesfaye, 2008; Dejen, 2010).

2.6. Characterization of Animal Genetic Resources

Animal genetic resources for food and agriculture are an essential component of the biological basis for world food security. Characterization of animal genetic resources refers to the process by which populations or ecotypes are identified or differentiated. Characterization means the distillation of all available knowledge, both published and unpublished, which contributes to the reliable prediction of genetic performance in a defined environment. It does not imply mere accumulation of existing reports or individual findings on genetic performance (Rege and Lipner, 1992). The exercise includes a clear definition of the genetic attributes of an animal species or breed, which has a unique genetic identity, and the environments to which species or breed populations are adapted or known to be partially or not adapted.

Characterization activities should contribute to objective and reliable prediction of animal performance in defined environments, so as to allow a comparison of potential performance within the various major production systems found in a country or region. It is, therefore, more than the mere accumulation of existing reports. The information provided through the characterization process enables a range of interest groups, including farmers, national governments and regional as well as global bodies to make informed decisions on priorities for the management of AnGR

Characterization of a livestock breed or population should be done both at the phenotypic (phenotypic characterization) as well as molecular level (genetic characterization). Both are

complementary to each other. Phenotypic and molecular genetic characterizations of AnGR are used to measure and describe genetic diversity in these resources as a basis for understanding them and utilizing them sustainably.

The term “phenotypic characterization of AnGR” generally refers to the process of identifying distinct breed/ population and describing their external and production characteristics within a given production environment. 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”.

2.7. Reproductive Performance

Reproduction is the process by which animals produce offspring for the purpose of continuing the species. It is a series of events comprising of gamete production, fertilization, and gestation, reproductive behavior, calving, lambing and kidding. Reproduction is one of the most important considerations determining the profitability of livestock production, whether one is talking about dairy or beef animals. Good reproductive performance is a prerequisite for any successful livestock production programme. In any livestock production system, high reproductive performance is a very important attribute and a major component of the overall production efficiency. Reproductive performances like age at first lambing, lambing interval, litter size and annual reproduction rate of the breed are the most important traits of sheep production.

2.7.1. Age at first lambing

Age at first lambing is the age at which a breeding ewe-lamb could give her first birth. It is a function of puberty, age at first breeding and conception and successful completeness of pregnancy. The age affected by genotype or breed, nutrition, season and other environmental factors (e.g., climate) affects the age at first lambing (Habib, 1998), which in turn affects the

total number of lambs a ewe produces in her lifetime. Age at first lambing of some of Ethiopian sheep breeds are summarized in Table 2. The type of birth of the ewe significantly affects the age at which the ewe first lambed. Lambs in multiple litter attained age at first lambing later than single born contemporaries (Wilson and Murayi, 1988). Maternal parity also significantly affects the age at first parturition. Offspring of young and old ewes mature later than those from dams in the intermediate age groups.

Table 2. Age at first lambing (AFL) for some Ethiopia sheep breeds/types

Breed/type	AFL (months)	Management system	Source
Gumuz	13.67	On-farm	Solomon (2007)
Menz	15-22	On-farm	Abebe (1999)
Washera	15.46	On-farm	Mengiste (2008)
Blackhead Ogaden	19.36±3.75	On-farm	Abraham (2013)
Bonga	15±3.1	On-farm	Zewdu(2008)
Horro	13.3 ± 1.7	On-farm	Zewdu(2008)
Afar	13.5	On-farm	Tesfaye (2008)
Dawuro sheep	13.8	On-farm	Amelmal (2011)
Adilo	14.6	On-farm	Getahun(2008)
Arsi-bale	12.7	Traditional	Tsedeke(2007)

2.7.2. Lambing interval

Lambing interval (LI) refers to the number of days between successive parturitions. It is one of the major components of reproductive performance that has an important influence on a sheep production enterprise. LI affected by the breed, season and year of parturition, the parity of the ewes, and post partum weight of the dam (Devandra and McLeroy, 1982). Shorter lambing interval is desirable if the fertility (regular production of viable offspring) and productivity of the flock is to be maintained. Wilson and Durkin (1984) reported a longer lambing interval on the station flocks of African long fat-tailed sheep in Rwanda than most of the intervals from African traditional systems where no practices to control breeding were employed. Mukasa-Mugerwa and Lahlou-Kassi (1995) reported that lambing interval of local

sheep from field studies are highly variable and ranged from 223 to 336 and the variability is attributed due to the effect of season, parity, management and genotype.

2.7.3. Litter size

The combination of ovulation rate and embryo survival, number of lambs or kids born per parturition is the litter size. It is largely influenced by ovulation rate and is a major determinant of ewe reproductive efficiency. Ovulation rate varies between breeds of sheep; increase with age of ewe up to six years, and is greater for seasonally breeding ewes in the first half of the breeding season(Hafez, 1974) It is also affected by age (parity), season and to a large extent ewe body weight at mating which itself modulated by nutrition. Parity had a significant effect on litter size. Litter size increases with increase age of the dam up to about five years or fourth parity, and decreases slightly thereafter (Wilson and Durkin, 1984).

Table 3. Average litter sizes of some Ethiopian sheep

Breed	Litter size	Management	
		system	Source
Gumuz	1.17	On-farm	Solomon (2007)
Bonga	1.4	On-farm	Belete(2009)
Adilo	1.42	On-farm	Getahun(2008)
Menz	1.03	On-farm	Abebe (1999)
Washera	1.11	On-farm	Mengistie (2008)
Arsi-bale((Alaba)	1.7	Traditional	Tsedeke (2007)
Arsi-bale((Alaba)	1.52	On-farm	Deribe(2009)

2.7.4. Annual reproductive rate

Annual reproductive rate is defined as litter size times 365 days divided by lambing interval in days. It is used to measure flock fertility and reflects the total number of lambs weaned per ewe reproductive age per year (Mukasa-Mugerwa and Lahlou-Kassi, 1995). The annual reproduction rate is also a convenient measure for direct comparison of reproductive output in the different African systems, especially in the traditional ones where breeding is completely uncontrolled and where the number of females “ joined “ or mated is not exactly known. ARR

influenced by litter size, lamb mortality and lambing interval in years. According (Niftalem, 1990) annual reproductive rate of Menz sheep was highest when the ewes lambed during the small rainy season and lowest when lambing occurred during the dry season. This was due to the fact that ewes that lambed during dry season had longer subsequent lambing interval than those born during rainy season.

2.8. Growth Performance

The growth performance of sheep is also influenced by age of the dam/parity, pre-mating weight of the dam, type of birth, sex, the season and month of birth. Birth weight is an indicator of the size and vigor of the lamb at the beginning of postnatal development and an important factor influencing later growth. Birth weight which itself is affected by dam size, dam body condition and litter size influences the survival rate and pre-weaning growth performance of the off springs. Birth type and sex are sources of variation in lamb pre-weaning growth rate .Lambs which are heavier at birth are usually singles or are those produced by ewes with larger body sizes and good feeding conditions. The indication is that lambs heavier at birth have larger adult weight and higher growth capacity (Kassahun, 2000).

Weaning weight is a trait of great economic importance in meat sheep production since it has influence on growth rate and survival. Weaning weight and post-weaning growth rate of lambs is as important as the pre-weaning growth performances, mainly when the objective is producing meat through lamb production. Weaning weight influenced by season of birth, sex of lamb and type of birth (Kassahun, 2000; Gbangboche *et al.*, 2006); ram lambs and single-born ones were heavier than their counterparts. Parity and postpartum ewe body weight had significantly influenced weaning weight; dams with higher parity and heavier postpartum weight produced heavier lambs at weaning (Gbangboche *et al.*, 2006).

2.9. Community Based Breeding Strategies

Communities are defined as groups of people bound together by social, cultural and economic relations based on shared interests and living in a well defined area. Communities are not homogeneous; there may be differences between sub-groups (e.g. families) and individuals in a community. However, shared interests in cooperation outweigh competing interests that serve as the glue linking members together. A community-based breeding program refers to village-based breeding activities planned, designed, and implemented by smallholder farmers, individually or cooperatively, to effect genetic improvement in their flocks and conserve indigenous genetic resources. The community-based breeding strategies also consider the production system holistically and involve the local community at every stage, from planning to operation of the breeding program (Sölkner-Rollefson, 2003).

Community-based breeding programs are most appropriate to implement in situations where livestock keepers already run their animals together, such as in communal grazing areas (Solomon *et al.*, 2010; Solomon *et al.*, 2011). These situations also have potential for other community-level collective actions, such as joint procurement of services (veterinary, feeding and marketing). Programs that adopt community-based strategies need to take into account farmers' needs, views, decisions, and active participation, from inception through to implementation, and their success is based upon proper consideration of farmers' breeding objectives, infrastructure, participation, and ownership (Sölkner *et al.*, 1998). Thus, a full understanding of local knowledge and practices of communities in animal management is of paramount importance for the design and implementation of such programs. Indigenous knowledge is closely related to survival and subsistence and provides a basis for local-level decision making in natural resource management, food security, human and animal health, education, and various other community-based activities.

In the Ethiopia past failures in sheep genetic improvement have led to research on design of breeding programs. Small flock sizes, communal grazing/herding and uncontrolled mating did not favour the implementation of selective breeding/recurrent selection programs within village flocks. The approach adopted initially and implemented for Afar, BHS, Horro and

Menz sheep was to generate improved rams in closed, nucleus flocks and to disseminate them to village flocks. The projects generally ended in failure, as most lacked long-term vision and did not involve farmers in the planning (Solomon *et al.*, 2011). These failures led to the argument that such breeding schemes may not be appropriate for smallholder systems in developing sheep industries. A new village- or community-based breeding scheme, which does not involve central nucleus flocks, has thus been adopted recently to improve village flocks through recurrent selection (Solomon *et al.*, 2009; Gemed, 2011; Tadele, 2011). Solomon *et al.* (2011) also suggested a breeding scheme that integrates the merits of central nucleus-based and village-based breeding schemes.

Since 2009, the International Center for Agricultural Research in the Dry Areas (ICARDA), International Livestock Research Institute (ILRI) and University of Natural Resource and Life Sciences (BOKU) in partnership with the national agricultural research systems in Ethiopia designed and implemented community-based sheep breeding programs for four sheep breeds (Afar, Bonga, Horro and Menz) representing different production systems in Ethiopia. Appreciable genetic improvement has been achieved in the Menz program. Body weights at birth, 3 and 6 months of age increased by 0.42, 2.29 and 2.46 kg, respectively, in the third generation over those in the base generation. (Gemed, 2011; Solomon *et al.*, 2011; Tadele, 2011).

2.10. Role of Indigenous Knowledge in Animal Genetic Improvement Strategies

Indigenous knowledge is the body of knowledge acquired by a community in any given area and relating to agriculture, livestock rearing, food preparation, education, institutional management, natural resource management, health care and other pertinent subjects. It is regarded as a valuable resource for development activities that may be equal or even superior to the knowledge introduced by outsiders and should therefore be considered and applied in development projects wherever suitable” (Mathias, 1995). It is variously referred to as “traditional knowledge” or “local knowledge”. Much indigenous knowledge is based on practical experience and is not easily expressed verbally – it represents “tacit knowledge”, to

distinguish it from “explicit knowledge”. This knowledge is not evenly distributed. One culture or community has different knowledge from another.

Indigenous knowledge of animal breeding is made up of various concepts and practices used by livestock breeders to influence the genetic composition of their herds. It includes:

- Cultural concepts on the uses of animals (general breeding objectives)
- Local preferences for certain characteristics, such as colour, size, behavioral patterns and disease or drought resistance (specific breeding objectives)
- Selection practices for certain qualities (castration, culling, offspring testing)
- Pedigree-keeping
- Social restrictions on the sale of genetically valuable breeding animals that lead to closed gene-pools.

2.11. Linear Body Measurement

Nowadays, small ruminant improvement programmes are being promoted under the smallholder farmers to enhance meat supply. However, there is difficulty in animal marketing in relation to price setting. The market price is usually set by subjective measurements (*i.e.* visual judgment and loin-eye-area palpation). Estimating the market price based on live weight is quite important in reducing the bargaining practices. Due to lack of weighing scale in the remote rural areas of the region, it is almost impossible to obtain any accurate measurement of this very important trait. Estimating the live weight of small ruminants is quite important for good animal management, including understanding medication doses, adjusting feed supply, monitoring growth and choosing replacement males and females (Mathieu *et al.*, 2011).

Body measurements are considered as qualitative growth indicators which reflect the conformational changes occurring during the life span of animals. Studies indicated that variation exists indigenous sheep breeds for body weight traits (Kassahun, 2000; Sisay; 2002; Markos, 2006; Solomon; 2007). According to Attach and Elkhidir (2004) body measurements are indices of skeletal development and indirectly help to determine carcass composition. Determination of relationships between measurements could be by regressing ear length, heart

girth, body length and wither height on the age of the animal (Afolayan *et al.*, 2006) to estimate age and on body weight (Kassahun, 2000) to predict weight of the animal. Many research works have been reported on body weight and linear body measurements among them recently, Mengistie *et al.* (2010) reported 32.3 kg, 67.1cm, 56.9cm and 73.0 cm for body weight, wither height, body length and chest girth, respectively for Washera male sheep. Similarly the same authors reported 28.3 kg, 70.7 cm, 58.3cm and 75.6cm for body weight wither height, body length and chest girth, respectively for Washera female sheep.

2.12. Sheep Marketing System

Sheep marketing operations are generally small-scale family businesses. The sheep producers supply to the market is not based on market demand, rather buyers must choose from whatever is available in the market. The live animals are either transported in trucks or herded over long distances to feedlot operators, export abattoirs, or major markets. These final market destinations are far away from supply sources, and the transportation costs associated with getting live animals to markets can result in significant weight loss and even death; stock routes are characterized by lack of adequate feed, water, and resting places. Price is determined through bargaining at the market; sheep producers are usually less informed about price, supply, and demand situations. Producers are highly fragmented, while there is a concentration of major sheep buyers, a situation which might lead to noncompetitive pricing and marketing behavior (CSA, 2005).

There is a need for a well performing marketing system which satisfies consumer demands with the minimum margin between consumer and producer prices. Higher prices for producers can encourage farmers to adopt new technologies which, though potentially more profitable, may pose greater risk than traditional production system (Belay, 2013).

The marketing channels flow to final consumers in both the domestic and export markets are lengthy, without significant value-added activities. The sheep marketing channels, which start with the smallholder livestock producers from the mixed crop-livestock farming system, mainly cater to the domestic market. The marketing channel starting with the pastoralists is

for both domestic and export markets. The market actors may be involved in cattle only, sheep and goats only, or cattle, sheep, and goat transactions (Fekadu, 2006).

2.13. Consumer Preferences

Economic valuation of phenotypic traits starts from elicitation of the preferences of consumers of the livestock raised or bought from the market. Reorientation of livestock production systems towards consumer preferences and demands through timely and comprehensive transformation is currently the main agenda among the stakeholders of livestock improvement. Market orientation of livestock production system requires proper valuation of both traded and non-traded products and services generated from the system. This is why eliciting farmers' preferences of the phenotypic characteristics of livestock and estimating the economic values of these characteristics become crucially important. Proper identification and valuation of the different characteristics would make resource allocation decisions among the different livestock improvement interventions for commercialization of the system quite fast and easy. The research was justified for the basic reason that prices of animals are determined mainly based on phenotypic and qualitative traits than quantitative traits such as live weight or carcass weight as commonly practiced in developed markets (Girma *et al.*, 2007).

However, information on the different types of criteria used for marketing sheep, and whether these market criteria have significant association with the buying price and purpose for which they are assessed is lacking. Such information provides first hand idea for sheep breeders so as to improve production according to market demand.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

This study was conducted in Bensa district of Sidama Zone in Southern Nations Nationalities and Peoples' Region (SNNPR) of Ethiopia. Bensa district is one of the 19 districts in Sidama zone that extends into the Oromia region of Bale Zone or Borana like Peninsula. Bensa district is bordered on the South and North by the Oromia Region, with Bona Zuria on the west, Arbegona district on the North West, Chere district on the East, and Aroresa district on the South east. Daye, the capital of Bensa district, is located at 420 kms South east of Addis Ababa and 135kms north east of Hawassa city, the SNNPR capital city.

Bensa district is located at altitude which ranges from 1452 to 3129 meters above sea level (m.a.s.l.). The two rainy seasons are the *belg* (short rainy season), which covers from late February to May, and the *kremt* (main rainy season), which extends from late June to early October. The annual average rainfall of the area is 1208.5mm. The average temperature of the district is 19°C. The district has 3 major agro-ecologies where about 50% is moist weyna dega (mid-altitude), 36% moist dega (highland) and 14% moist kola (lowland (LIVES, 2012)

According to the district Office of Livestock and Fishery Bureau the population size district of 342,545, of which 147,471 are men and 195,074 women. The information obtained from Bensa district Livestock and Fishery Bureau(2015) indicated that the district has an estimated cattle, sheep, goat, chicken, horse, donkey and mule of 377867, 124,021, 25852, 231081 , 12377, 2474 and 870 respectively . Geographical location of the study area indicated in Figure 1.

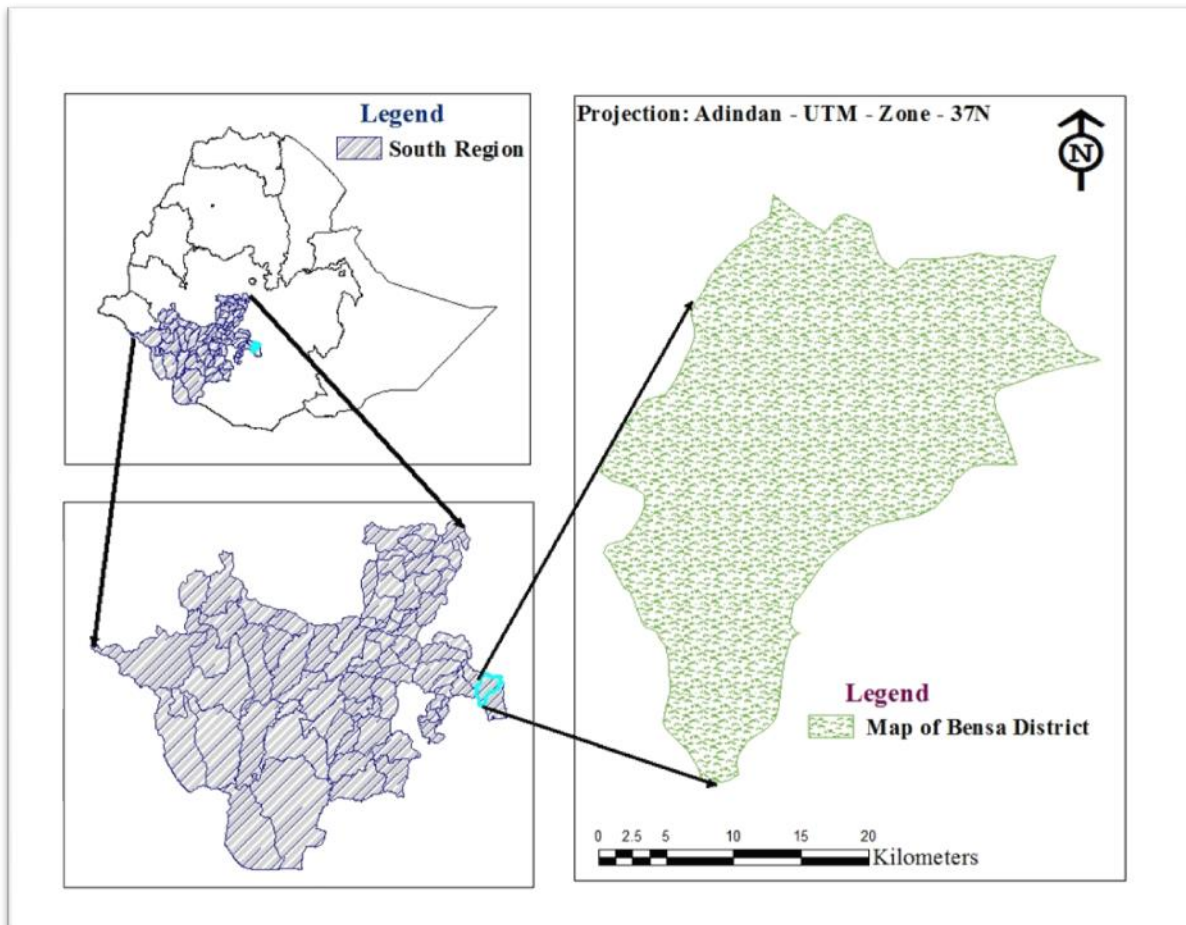


Figure 1. Location of the Study Area

3.2. Farming Systems of the Study Area

The agricultural production system of Bensa district is mainly characterized by mixed crop livestock system. The most important staple food crops grown by the farmers in the area are enset (*Enset ventricosum*), maize and haricot bean. *Enset* is the major stable food source for human and its by products serve as an important source of animal feed in the study area. The main crops grown during the long rainy season are barely, wheat, vegetables and pulses which are grown exclusively in highland and mid-altitude areas. Perennials crops are cash crops which include coffee and fruit trees (Avocado). Among cash crops coffee is the most important source of income. Livestock production is one of the major economic bases of the

study area. Sheep production has always been an integral part of the traditional subsistence mixed crop-livestock production system in this area.

3.3. Sampling Techniques

Bensa district was selected purposively based on the high value livestock and irrigation commodities including sheep by the Livestock and Irrigation Value Chain for Ethiopian Smallholders (LIVES) Project (www.lives-ethiopia.org). Before deciding on the target kebeles, discussions were held with the district experts, development agents and the farmers' representatives about the local sheep types and the current production systems of the study area. The district was stratified into two based on sheep dominant agro-ecology (highland and mid-altitude). From each agro ecology; two rural kebeles were selected based on the size of sheep population, and accessibility for transportation. Then after, the list of households with minimum number of two sheep and had prior experience in sheep production was collected from secondary sources. This was followed by identification of 32 households from each rural kebele randomly. The total numbers of randomly sampled households 128 were selected from the study area.

For consumer preference study, discussion was held with district marketing and cooperative promotion office of study area. Accordingly, all possible markets and primary, secondary and tertiary market of the study district were identified. Accordingly, *Gonjobe*, *Bura*, *Chebe* and *Daye* markets were identified as the major markets in the study area. After identification of potential markets, producers and traders (small and large) and consumers (butchers, hotels, and restaurants) were selected and discussion was held on consumer's preference of indigenous sheep of the study area.

For morphological characterization study both qualitative and quantitative traits of indigenous sheep were measured. Measurements were made on individual animals from 446 randomly selected females and 128 randomly selected males in the study area. Every Animal to be measured was identified by sex and dentition. Morphological measurements were taken from each individual animal (0PPI to 3PPI) that were available in sampled sheep population

in study area. All sampled sheep were individually handled and dentition characters were used to determine the age correlated in each case by owner's information.

3.4. Data Collection

Data were collected by administering a semi-structured questionnaire, individual interview employing field measurement and observations, through organized group discussion and from secondary sources.

3.4.1. Questionnaire and focus group discussion

A modified questionnaire was prepared by adopting a questionnaire prepared by ILRI (International Livestock Research Institute) for survey of livestock population. It is used to collect information on the following variables: General socio-economic household characteristics, reproductive performances (age at first lambing, lambing interval, litter size and lambing pattern), flock structure, breeding practices, breeding objectives, feeds and feeding management, diseases prevalence and production constraints.

The questionnaire was pre-tested before administration and some re-arrangement, reframing and correction in accordance with respondent perception was done. To substantiate the information obtained from the formal interview local agricultural development agents; local leaders and sheep owners were interviewed informally to gather information on local knowledge on sheep population. Sets of open-ended questions were used to guide focus group discussions.

Key informant discussions were held with representatives of farmer groups and extension staffs. The main points for discussion included indigenous knowledge about history of origin and introduction of existing sheep type, distinctive features of the sheep type as well as their desirable and undesirable characteristics, utility and status of the existing sheep population and other information related to indigenous sheep in the study area. Semi-structured questionnaires were also administered to randomly selected farmers in district who was interviewed for the household survey.

Rapid market appraisal (RMA) as outlined by Holtzman (2002) was employed to study the consumer preferences and marketing systems of sheep in the district. Local traders, terminal traders, hotel/ restaurant owners and consumers were interviewed using respective checklists. The checklists included meat consumption level and pattern of consumers, phenotypic trait they prefer to buy sheep from market, limitation of meat consumption trends of consumers, factors influencing consumers' choice of meat. All possible to and from sheep market chains in Bensa district were identified.

3.4.2. Morphological and linear body measurements

Quantitative (body measurements) and qualitative (morphological characters) data were collected based on age groups and recorded on the format adopted from the standard description list developed by FAO (2012) and ILRI (International Livestock Research Institute)-OADB (Oromiya Agricultural Development Bureau) for survey of livestock breeds in Oromiya (Workneh and Rowlands, 2004). The standard breed descriptor list for the sheep developed by FAO (2012) was closely followed in selecting morphological variables (Appendix Table 1 and Appendix Table 2).

Qualitative traits like coat color pattern, coat color type, hair type, head profile, ears, wattle, horn, ruff and tail were observed and recorded. Quantitative traits like body measurements viz., Chest Girth (CG), Body Length (BL), Wither Height (WH), Ear Length (EL), Tail Length (TL), Tail circumference (TC), Chest Depth (CD), Pelvic width (PW) and Scrotum circumference (SC) were measured using flexible measuring tape while body weight (BW) was measured using suspended spring balance having 50kg capacity with 0.2kg precision. Each morphologically measured animal was identified by sex and age group. Sheep was classified into four age groups; no pair of permanent incisor (0 PPI), 1 PPI, 2 PPI and 3 PPI to represent age of less than 15 months, 15.5 to 22.0 months, 22.5 to 27.0 months and 28.0 to 38 months, respectively based on the finding of Wilson and Durkin (1984) for African sheep breed. Body condition score (BCS) was assessed subjectively and scored using the 5 point scale (1= very thin, 2 = thin, 3= average, 4 = fat and 5 = Very fat/ obese) for both of the sexes

according to Hassamo *et al.* (1986). Linear body measurements were taken by restraining and holding the animals in a stable condition.

3.5. Data Managements and Analysis

The data collected was checked for any inconsistency and corrected, and then coded and entered into computer. The collected data that is morphological and qualitative data were entered into Microsoft EXCEL software's. Survey data was described and analyzed using SPSS (2009). Indices were calculated to provide ranking of the reasons of keeping sheep, importance of major farming activities to the family food source and income, selection criteria, and major constraints of sheep production according to the following formula: Index = Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] given for particular qualitative variables divided by Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all qualitative variables considered.

Effective population size for randomly mated population was calculated according to Falconer and Mackay (1996) as: $N_e = (4N_m N_f) / (N_m + N_f)$ Where, N_e = effective population size, N_m = number of breeding males and N_f = number of breeding females. The rate of inbreeding coefficient (ΔF) was calculated from N_e as $\Delta F = 1/2N_e$. The mean of these parameters was also computed.

Qualitative data from individual observation was analyzed following the frequency procedures of SAS version 9.1.3(2008). The General Linear Model (GLM) procedure of SAS was employed to analyze quantitative variables to determine effects of class variables (sex and dentition). Sex and age group were fitted as fixed independent variables and body weight and a linear body measurement except scrotum circumference was fitted as dependent variables. Tukey's test was used to separate means when significant difference was detected.

The models for analyzing quantitative data except scrotal circumference were:

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

Where: Y_{ijk} = the observed k (body weight or linear body measurements except scrotum circumference) in the i^{th} age group and j^{th} sex

μ = overall mean

A_i = the effect of i^{th} age group (0-3 pair permanent incisor)

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

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

e_{ijk} = random residual error

Model to analyze the scrotum circumference was:

$$Y_{ij} = \mu + A_i + e_{ij}$$

Where: Y_{ij} = the observed j (scrotum circumference) in the i^{th} age group

μ = overall mean

A_i = the effect of i^{th} age group (0-3 pair permanent incisor)

e_{ij} = random residual error

Multiple linear regressions were used to estimate the body weights of sheep from various body measurements. The association between body weight and linear measurements were assessed using Pearson's correlation coefficient in SAS version 9.1.3 (2008). The following models were used for estimation of body weight from linear measurements:-

For male:

$$Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e_j$$

Where:

Y_j = the response variable; body weight

α = the intercept

$X_1, X_2, X_3, X_4, X_5, X_6$ and X_7 are the explanatory variables chest girth, body length, height at withers, pelvic width tail length, tail circumference and scrotal circumference, respectively.

$\beta_1, \beta_2, \dots, \beta_7$ are partial regression coefficients of the variables X_1, X_2, \dots, X_7

e_j = the residual random error

For female:

$$Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + e_j$$

Where:

Y_j = the dependent variable body weight

α = the intercept

X_1, X_2, X_3, X_4, X_5 and X_6 are the independent variables; chest girth, body length, height at wither, pelvic width, tail length and tail circumference, respectively

$\beta_1, \beta_2, \dots, \beta_6$ are partial regression coefficient of the variable X_1, X_2, \dots, X_6

e_j = the residual random error

4. RESULTS AND DISCUSSIONS

4.1. Household Characteristics and Socio Economic Aspects

Household characteristics of the sampled households are presented in Table 4. The majority (92.95%) of the interviewed households in the study area were male headed. The age of the majority (84.3%) of the respondents fall under 50 year, which is the active age group and are the main source of farm labor. Moreover, about 94.5% of the interviewed households were married.

The educational status of the respondents in the present study was 33.6, 25.75, and 22.7, and 18.2% for primary attendants, illiterate, read and write and secondary attendants, respectively. In contrast to this report, higher proportions of illiterate and primary attendants (33.55% and 54.75%) lower level of read and write and secondary attendants (8.35% and 3.35) were reported in southern Ethiopia (Dejene, 2010). This survey result indicates that the higher proportion of farmers having primary educational background would be an opportunity to utilize them in keeping simple records which are of paramount importance in decision making and easy to implement community based breeding program in the study area .

The average family size of the households was 7.8 ± 0.39 (ranging from 2-14), which is closer to 8.5 reported for the same district previously (Yoseph *et al.*, 2015). However, the present family size was higher than Benchi Maji and Keffa Zone of southern Ethiopia (6.7 ± 3) (Dejen, 2010). The higher family size in the current study indicates the existence of polygamous marriages and lack of awareness on family planning in the area.

Table 4. Household characteristics of the sampled households in the study area

Variables	Agro ecology					
	Highland(n=64)		Mid-altitude (n=64)		Overall Total (n=128)	
	N	%	N	%	N	%
Sex structure						
Male	64	100	55	85.9	119	92.95
Female	-	-	9	14.1	9	7.05

Age structure

	<i>"Continued..."</i>					
<31	10	15.63	8	12.5	18	14.05
31-40	32	50	23	35.9	55	43.0
41-50	15	23.44	20	31.2	35	27.3
51-60	4	6.25	12	18.8	16	12.5
61-70	2	3.1	1	1.6	3	2.35
>70	1	1.6	-	-	1	0.8
<hr/>						
Marital status						
Married	63	98.4	58	90.6	121	94.5
Un married	-	-	1	1.6	1	0.8
Windowed	-	-	4	6.2	4	3.1
Divorced	1	1.6	1	1.6	2	1.6
<hr/>						
Educational status						
Illiterate	15	23.4	18	28.1	33	25.75
Read and write	12	18.75	17	26.56	29	22.7
Primary	24	37.5	19	29.7	43	33.6
Secondary	13	20.8	10	15.6	23	18.2
<hr/>						
Religion						
Protestant	63	98.4	58	90.6	127	94.5
Orthodox	1	1.6	6	9.4	1	5.5
Average family size	7.89±0.4		7.70±0.38		7.8±0.39	
(Mean±SE)						

N=Number of households SE=Standard error

4.2. Land Holding and its Allocation

The average land holding per household in the study area was 2.13 ha. The result was consistent with 2.15 ha reported for the same district previously (Yoseph et al., 2015). The average land holding per household showed a significant difference ($p < 0.05$) between the two agro-ecologies of the study area. Accordingly, landholding was significantly higher ($P < 0.05$) for highland ($2.38 \text{ ha} \pm 0.06$) compared to mid-altitude (1.88 ± 0.05) agro-ecology. The reason for small land size in mid-altitude agro ecology was mainly due to conduciveness of the area for cash crop production especially for coffee production. Land holdings range from 1.01 to 2.00 ha for about 30.8% of farmers in the SNNPR and for 33.3% of farmers at the national level (CACC, 2003). The average landholding per household in Bensa is greater than the

value reported for Gomma district of Jima zone (1.93 ha) (Belete,2009), Debarak district of Gondar (1.66ha) (Sisay, 2006); and Yerer district of east shoa zone (1 to 1.5ha) (Samuel, 2005). However, it is smaller than the average land holding reported for Metama (6.17ha) (Sisay, 2006) and Bale high lands of Oromia region (Teshome, 2006). The size of land holding is an important factor that determines availability of feed for livestock. Thus, feed resources are more available in highland compared to mid-altitude agro-ecology in the study area.

Table 5. Mean (\pm SE) land holding per household in Bensa district of Sidama zone

Descriptor	Agro ecology of the study district		
	Highland (n=64)	Mid-altitude (n=64)	Overall Mean (n=128)
	Mean \pm SE	Mean \pm SE	Mean \pm SE
Cereal crops	0.5 \pm .07 ^b	0.84 \pm 0.07 ^a	0.67 \pm 0.07
Pulse crop	0.2 \pm 0.03 ^a	0.06 \pm 0.01 ^b	0.13 \pm 0.02
Sugar cane	0	0.12 \pm 0.01	0.06 \pm 0.005
Coffee	0	0.3 \pm 0.02	0.15 \pm 0.023
Enset	0.75 \pm .07 ^a	0.25 \pm 0.04 ^b	0.5 \pm 0.055
Grazing land	0.52. \pm 0.05 ^a	0.26 \pm .04 ^b	0.39 \pm 0.045
Forestland	0.245 \pm 0.02 ^a	0.05 \pm 0.01 ^b	0.15 \pm 0.015
Vegetables	0.165 \pm 0.008	0	0.083 \pm 0.004
Average total land holding (ha)	2.38 \pm 0.06 ^a	1.88 \pm 0.05 ^b	2.13 \pm 0.04

Different superscripts denote significant differences at $P < 0.05$ between means of the agro ecologies
n =number HH; SE = standard error;

4.3. Farming Activities

The major farming activities and their contribution as food and income source to the family in the study area are presented in Table 6. Thus, the major source of food as ranked by the sampled households was cattle production followed by crop and sheep farming, while the major source of cash income was both crop and cattle production followed by sheep. Among the crop type *enset*, maize, coffee, wheat, barley, teff, haricot bean, pea and beans are the

major crops used as a source of cash income and household consumption. Among these crops, enset is used as the main source of food for household consumption, source of income and for livestock feed across both agro ecology of the study area. On the other hand, maize and haricot bean were the major crops used for income and household consumption in mid-altitude agro ecology while barley and wheat were the major crops used for income and household consumption in highland agro ecology. Coffee is an important source of cash particularly in the mid-altitude agro ecology while bean, peas, cabbage and onion were used as additional source of income in highland agro ecology.

Table 6. Major farming activities for the supply of food and income in the study area

Importance	Species	Rank			Index
		1 st	2 nd	3 rd	
Food	Cattle	17.2	62.5	7	0.40
	Crop	61.7	21.9	16.4	0.30
	Sheep	13.3	7	63.3	0.20
	Chicken	7.8	8.6	21.9	0.10
Income	Crop	49.2	13.3	29.7	0.35
	Cattle	34.4	49.2	7.8	0.34
	Sheep	16.4	21.1	62.5	0.26
	Chicken	0	7.8	8.6	0.04

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 variable 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 variables.

4.4. Livestock Species Composition

The average livestock holding/household of the study district is presented in Table 7. Respondents in highland had significantly higher number of cattle, sheep and horse holding

($p < 0.05$) than respondents in the mid-altitude. However, they had significantly lower ($p < 0.05$) number of chicken, goat and donkey compared to mid-altitude agro ecology. All the households considered had sheep across the entire study district. This is due to the fact that this study considered only those farmers who had sheep.

Sheep was the largest livestock species possessed by the two agro ecology of the study area. The possible reasons that sheep is easy to manage and conducive environment for sheep production in the study area. The average sheep flock size (4.45) per household was by far lower than 31.6 reported for Menz sheep (Getachew *et al.*, 2010), 12.5 reported for north Wollo zone (Tassaw, 2012); but higher than 3.6 reported for Goma sheep (Belete, 2009).

Table 7. Species composition and livestock holdings in the study area

Descriptor	Highland (n=64)	Mid-altitude (n=64)	Overall Mean (n=128)
	Mean \pm SE	Mean \pm SE	Mean \pm SE
Cattle	4.5 \pm 0.57 ^a	3.0 \pm 0.17 ^b	3.75 \pm 0.37
Sheep	4.6 \pm .33 ^a	4.3 \pm 0.213 ^a	4.45 \pm 0.27
Goat	0.03 \pm 0.2 ^b	0.2 \pm 0.06 ^a	0.1 \pm 0.13
Chicken	1.78 \pm 0.30 ^b	2.9 \pm 0.312 ^a	2.34 \pm .30
Donkey	0.04 \pm 0.26 ^b	1.8 \pm 0.49 ^a	0.92 \pm 0.37
Horse	0.2 \pm 0.55 ^a	0.06 \pm 0.30 ^b	0.13 \pm 0.42
Total herd size	11.15 \pm 2.2	12.26 \pm 1.5	11.7 \pm 1.85

Different superscripts denote significant differences at $P < 0.05$ between means of the agro ecologies
n = number HH; SE = standard error;

4.5. Current Status of Livestock Species

The population trends of major livestock species for the last ten years in the study area is summarized in Table 8. According to the respondents, the decline in the number of livestock species was the highest for chicken (50%) followed by cattle (39.85%) and sheep (20.7%).

The possible reasons reported by the respondents for this trend were frequent occurrence of disease, presence of predators, shortage of feed both in quality and quantity, cultivation of grazing land. According to the information generated during group discussions in the study area, feed shortage and disease are the major causes for the decline in the number of livestock. Similar reasons were reported by Solomon (2007). The possible reasons for an increasing trend of sheep population comparing to other livestock species in the study area might be due to the use of sheep as immediate source of cash income. The present finding was similar to Wossenie (2012) who indicated that the population of livestock was increasing in west Hararghe zone of Oromia region. It was related to the availability of grazing land, high demand (increased human population) and attractive price for livestock.

Table 8. Population trend of major livestock species for the last ten years in the study area
Agro ecology of the study area

Species	Highland		Mid-altitude		Over all Total	
	N	%	N	%	N	%
Sheep						
Increasing	44	68	43	82.5	87	75.25
Decreasing	19	29.7	14	11.7	33	20.7
Stable	1	1.6	7	5.8	8	3.7
χ^2 value	43.7		50		93.7	
Cattle						
Increasing	35	54.7	26	40.6	61	47.65
Decreasing	27	42.2	24	37.5	51	39.85
Stable	2	3.1	14	21.9	16	12.5
χ^2 value	27.78		3.87		31.65	
Chicken						
Increasing	22	34.4	27	42.2	49	38.3
Decreasing	34	53.2	30	46.9	64	50
Stable	3	4.7	2	3.1	5	3.9
χ^2 value	9.5		20.37		29.87	

4.6. Sheep Flock size and Structures

Sheep flock size of the sampled households in the study area is presented in Table 9. The flock owner determines the flock composition on the basis of economic and management considerations. The average sheep flock size in the study area was 4.6 ± 0.33 in highland and 4.3 ± 0.21 in mid-altitude. The higher proportion of females in the flock in the present findings is consistent with sheep flock structure reported for Menz sheep where breeding ewes (49.2%) were dominant (Getachew *et al.*, 2010). Breeding ewes formed the largest proportion (33.7%) of the flock followed by ewes (19.2%), ewe lambs (17.9%), ram lambs (17.5%), ram (6.7%), breeding ram (5.43%) and castrates (0.64%) for highland whereas the proportions of breeding ewes, ewe lambs, ewes, ram lambs, ram, breeding ram and castrates were 32.57%, 25.9%, 15.6%, 11%, 9.17%, 4.65% and 1.16, respectively, for mid-altitude.

According to the current study, sheep flock size was higher significant ($p < 0.05$) for highland agro-ecology compared to mid-altitude. The proportion of breeding ewes (33.7% for highland and 32.57.0% for mid-altitude) obtained in the current study was above 30% reported for Keffa and Bench-Maji ewes (Dejen, 2010) and 15.3-20.7% reported for Dawro zone and Konta special Woreda sheep (Amelmal, 2011). However, the result is lower compared to 46.8% reported for Menz and 49.2% reported for Afar ewes (Tesfaye, 2008). Flock size is an indicator of breeding objective of the owner. Keeping of high proportion of female sheep, imply the production of larger number of lambs which has direct impact on selection intensity.

Table 9. Average sheep flock structure of the surveyed households in the study area

Age category	Agro ecology of the study district					
	Highland (n=64)		Mid-altitude(n=64)		Overall Mean (n=128)	
	Mean \pm SE	%	Mean \pm SE	%	Mean \pm SE	%
Ram lambs < 6 month	0.81 ^a \pm 0.12	17.5	0.48 ^b \pm .07	11	0.64 \pm 0.09	14.25
Ram lambs(6-12 month)	0.31 \pm .07 ^b	6.7	0.40 ^a \pm 0.06	9.17	0.35 \pm 0.07	7.93
Breeding rams>12 months	0.25 \pm 0.06 ^a	5.43	0.20 \pm 0.06 ^a	4.65	0.22 \pm 0.06	5.04

"Continued..."

Castrates(> 1 year)	0.03± 0.02 ^a	0.64	0.05±0.03 ^a	1.16	0.01± 0.03	0.59
Ewe lambs (<6 months)	0.83± 0.11 ^b	17.9	1.13± 0.08 ^a	25.9	0.98± 0.1	22
Ewes (6-12 months old)	0.89± 0.08 ^a	19.2	0.68± .08 ^b	15.6	0.78± 0.08	17.4
Breeding ewes (>12 months old)	1.56± 0.09 ^a	33.7	1.42± 0.09 ^b	32.6	1.49± 0.09	33.12
Total flock size	4.6±0.08 ^a				4.3±0.07 ^b	

Different superscripts denote significant differences at $P < 0.05$ between means of the agro ecologies
n =number HH; SE = standard error;

The ratio of breeding ram to ewe in the study area was 1:6.24 and 1:7.1 for highland and mid-altitude sheep flocks, respectively. This ratio is closer to 1:7.5 reported for Menz sheep (Abebe, 1999) while it is lower than 1:1.98 reported for Dawuro and Konta sheep (Amelmal, 2011) and 1:5.21 reported for Kaffa and Benchmaji sheep (Dejene, 2010). The male to female ratio of the two agro ecologies of the study area is higher than 1:8.7 for Menz sheep and 1:17.4 for Afar sheep (Tesfaye, 2008). Maintaining the correct ratio of breeding rams and ewes (one ram to 20-25 ewes or 3:100 in year round mating) is important as it can affect the overall reproductive efficiency (Girma, 2009).

4.7. The Origin and Typical Features of Indigenous Sheep

Most of the farmers did not have any idea about the origin of indigenous Sheep in the study area. However, some sheep producers suggested that indigenous sheep was spread from Arbegona, Bura and Hagereselam of Sidama highlands to Bensa and others surrounding districts. Focus group discussion (FGD) with elders indicated that indigenous sheep was kept for the past centuries by their ancestors and transferred to the current generation. The smallholder preferred this sheep population because it has fast growth, short lambing interval and resistance to disease, adaptability to cold climatic condition, acceptable meat quality, fat tail and coat color.



Figure 2. Indigenous male sheep (left) and female sheep (right)

4.8. Purpose of Keeping Sheep

The purposes of sheep keeping in the study area are presented in Table 10. Knowledge of reasons for keeping animals is a prerequisite for deriving operational breeding objectives (Jaitner *et al.*, 2001). The results of this survey revealed that sheep play multi-functional roles in both agro ecologies with similar production goals. The results indicated the relative importance of tangible benefits of sheep keeping (such as regular source of income, saving, and meat). Most farmers in both agro ecologies keep sheep primarily as source of income.

Table 10. Ranked purpose of keeping sheep as indicated by respondents

Purpose of keeping	Highland				Mid-altitude			
	Rank 1	Rank 2	Rank 3	Index	Rank1	Rank2	Rank 3	Index
Meat	4.7	0	56.2	0.11	12.5	4.7	46.9	0.15
Milk	0	0	21.9	0.04	0	0	0	0.00
Ceremony	0	0	7.8	0.01	0	0	10.9	0.02
Wealth status	0	0	6.2	0.01	0	0	12.5	0.02
Manure	0	0	26.6	0.04	0	0	23.4	0.04
Saving	35.9	62.5	0	0.37	20.3	73.4	0	0.33
Income	62.5	34.4	3.1	0.42	78.1	21.9	0	0.44

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 variable 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 variables.

Functions like ceremony, wealth status and manure received relatively low ranking among the reasons for keeping sheep in both agro ecologies. Highland farmers keep sheep for milk purpose rather than mid-altitude farmers. Similar multipurpose functions of sheep rearing were reported for sheep keepers in the southern highlands of Ethiopia (Dejene, 2010). Diverse functions are particularly important under subsistence production system. The importance of diverse values of indigenous livestock breeds under low input system was well documented (Tesfaye, 2008 and Zewdu, 2008).

4.9. Labor Allocation in Sheep Managements

In the study area both male and female involved in sheep management interchangeably, except milking which is dominantly undertaken by the female in highland agro ecology (Table11). All activities of sheep management across the study area were done by family labor. The responsibility of purchasing (85.9%), selling (84.4%) and breeding (80.5%) of sheep was dominantly undertaken by head of the household. However, children and women were heavily involved in caring and herding of sheep. The same members of the household feed and protect sheep from bad weathers, predators and theft and assisted during lambing. Therefore, in designing breeding strategies, the role of women and children in sheep production should not be undermined. Similar result was reported from north western lowlands of Amhara region (Solomon, 2007).

Table 11. Division of labor in sheep management in the study area

Responsible bodies	Activity						
	Purchasing	Selling	Herding	Breeding	Caring for Sick animas	Feeding	Milking
Males \geq 15 years	96.6	85.7	30.27	77.48	25.46	1.93	-
Female \geq 15 years	3.4	14.3	23.24	16.55	62.18	13.16	81.97
Male <15 years	-	-	34.50	5.97	9.55	43.36	-
Female <15 years	-	-	11.98	-	2.82	41.55	18.03

4.10. Feeds and Feeding Systems

The quality and quantity of feed resources available for animals primarily depends upon the climatic and seasonal factors (Zewdu, 2008). Feed resources commonly used by farmers in the study area across the different seasons are presented in Table 12. The major feed resources for sheep during the wet season were natural pasture followed by crop residues across in the two agro ecologies. The findings of the current study (wet season feed availability) in Bensa district of Sidama zone was similar with Tesfaye (2009), Grum (2010) and Amelmal (2011) who reported for Metema district of Amhara region, around Dire Dawa, Dawuro Zone and Konta Special Woreda of SNNPR, respectively. However, the major feed resources during the dry season across the two agro-ecologies were crop residues followed by natural pasture. Enset leaf and stem, and bamboo leaf are also important feed resources used to complement feed supply particularly during the dry season when the availability of forage is low. In study area, during wet season the important feed recourses were natural pasture, crop residues and fallow land.

The major crop residues in highland agro ecology include barely, wheat, bean and peas straws while in mid-altitude it includes maize stover, wheat, haricot bean, and teff straws. The difference in type of crop residues availability between the two agro-climates is due to difference in agro-climatic requirements of the different crops.

Table 12. Major feed resources of sheep during the dry and wet seasons in the study area

Feed Resources	Wet season								Dry season							
	Highland				Mid-altitude				Highland				Mid-altitude			
	1 st	2 nd	3 rd	Index	1 st	2 nd	3 rd	Index	1 st	2 nd	3 rd	Index	1 st	2 nd	3 rd	Index
Natural pasture	100	-	-	0.54	100	-	-	0.62	15.2	50	23.4	0.28	37.5	43.8	10.9	0.36
Hay	-	-	-	0	-	-	-	0	-	6.2	14.1	0.04	-	-	-	0
Crop residues	-	95.3	-	0.34	-	92.2	-	0.37	45.42	27.8	6.5	0.33	50	40.6	-	0.40
Fallow Land	-	-	42.2	0.08	-	1.6	-	0.01	1.6	-	25	0.05	3.1	14.1	1.6	0.07
Concentrates	-	-	3.1	0.01	-	-	-	0	-	-	-	0	-	-	21.9	0.04
Enset leaf and stem	-	-	18.8	0.03	-	-	-	0	23.4	6.2	25	0.18	-	1.6	26.9	0.05
Bamboo leaf	-	-	-	-	-	-	-	-	14.5	9.7	6	0.12	--	-	-	0
Sugar cane tops	-	-	-	-	-	-	-	-	-	-	-	-	9.4	-	20	0.08

Index= sum of (3 X number of household ranked first +2X number of household ranked second +1 X number of household ranked third) given for each variable divided by sum of (3 X number of household ranked first +2X number of household ranked second +1X number of household ranked third) for all variables

4.11. Husbandry Practices

4.11.1. Grazing Practices

There are different methods of grazing practiced by sheep producers in the study area (Table 13). In fact, the different types of grazing methods depend on season. Thus, during the wet season, majority (about 71.9%) of the respondents use tethering grazing in order to prevent sheep from grazing cultivated annual food crops. According to focus group discussants, the main reasons for tethering apart from preventing crop damage, was for optimal usage of family labor, protect from predators and unwanted breeding. During the dry season, majority of the respondents (59.5%) practice free grazing, followed by rotational grazing (23.4%) and tethered grazing (10.9%) and herded (6.2%) in highland agro-climate.

Table 13. Major grazing methods of sheep as reported by respondents in the study area.

Grazing management	Highland		Mid-altitude	
	Rainy season (%)	Dry season (%)	Rainy season (%)	Dry season (%)
Free grazing	3.1	59.5	21	93.8
Tethered grazing	71.9	10.9	79	6.2
Herded	17.2	6.2	-	-
Rotational grazing	7.8	23.4	-	-

4.11.2. Herding Practices

A good understanding of the community's herding practices is crucial to bring sustainable improvement in the smallholders flock through community-based strategies (Sölkner-Rollefson, 2003). The percentage of households mixing their sheep flock during day time, with other species and way of herding within a village in study are presented in Table 14. The results indicated that all classes of the sheep are herded together during the day time though new born lambs were managed separately for some days near the house. In highland and mid-altitude 100 and 75% of the households respectively keep their own sheep as a flock. Because

of their feed habit, farmers prefer to manage sheep separately but shortage of labor forced them to keep them with other livestock.

Table 14. Sheep herding practices in the study area

Sheep herding practices	Agro-climate			
	Highland		Mid-altitude	
	N	%	N	%
Sheep flock is herded				
Together with cattle and equine	50	78.13	52	81.2
Sheep herded separately	14	22.87	12	18.8
Way of herding				
Sheep of a household run as a flock	64	100	48	75
Sheep of more than one household run as flock	-	-	16	25

4.11.3. Fattening

The majority of farmers in highland (71.9%) and mid-altitude (78.1%) do not fatten sheep (Table 15). The finding of the current study is less than 89.5% reported for Adiya kaka but higher than 53.3% reported for Horro sheep (Zewdu, 2008). The difference might be due to lack of awareness on value addition through fattening and seasonality of markets for fattened sheep. Although fattening is less common, the major classes of sheep used for fattening by those who practice fattening in study area were castrate followed by young males and older females. Crop residues, enset leaves, salt, grain and home left over were commonly supplemented for fattening sheep in the study area. According to the respondents, most of the producers didn't consider consumer preferences while fattening sheep in the study area.

Table 15. Sheep fattening practices in the study area

Fattening practices	Agro-climate					
	Highland		Mid-altitude		Overall Total	
	N	%	N	%	N	%
Do you practice fattening of sheep?						
Yes	18	28.1	14	21.9	32	25
No	46	71.9	50	78.1	96	75
Classes of fattening sheep						
Young males	12	66.67	10	71.4	22	69.0
Older males	2	11.11	1	7.1	3	9.1
Older females	4	22.22	3	21.5	7	22.0

4.12. Watering Resource and Utilization

Table 16 showed that river water was the major water source of sheep in wet and dry seasons in both agro ecologies. The proportion of sheep watered by river water were 78.12 % and 75 % during the dry and wet seasons, respectively, in highland agro-climate while it was 65.62%, and 60.9 % during the wet and dry seasons, respectively, in mid-altitude agro-climate. The distances to watering points varied during the dry and wet seasons.

Table 16. Water sources and utilization during dry and wet seasons

Descriptors	Dry Season				Wet Season			
	Highland		Mid-altitude		Highland		Mid-altitude	
	N	%	N	%	N	%	N	%
Source of water								
River	50	78.12	42	65.62	48	75.0	39	60.9
Spring	14	21.88	22	34.38	15	23.4	25	39.1
River and spring	-	-			1	1.6	-	-
Distance of water								
Water at home	5	7.8	7	10.9	8	12.5	14	21.9

"Continued..."

Less than 1km	49	76.56	40	62.5	51	79.68	38	59.4
1-5km	10	15.6	14	21.87	5	7.8	11	17.2
6-10km			3	4.68			1	1.6
Greater than 10km								
Frequency of water								
Free available	8	12.5	9	14.1	4	6.25	10	15.6
Once a day	52	81.25	55	85.9	54	84.37	53	82.8
Once a two days	4	6.25	-	-	6	9.37	1	1.6

The majority (76.5% for dry and 79.6% for wet seasons) of the respondents water their animals within less than one km distance in highland agro-climate. Similarly majority of the households (62.5% for dry and 59.4% for wet seasons) water their animals at less than 1 km in mid-altitude agro-climate. Similar to this study Workneh and Rowlands (2004) reported that the majority of households (three-fourth) water their animals with less than 1 km in wet season Oromia region. The majority of the respondents water their animals once a day during both the dry and wet seasons both in highland and mid-altitude agro ecologies. In general, water was not a limiting factor for sheep production in the study area.

4.13. Housing of Sheep

House protects animals from extreme temperature, rain, wind, predators and theft. In the study area different types of houses, housing materials and the common housing systems were identified (Table 17). The majority of the respondent in both agro ecologies house their sheep in the main house together with the family. Separate sheep house with roof was also reported by some farmers across two agro ecologies. The majority of the farmers across the study district house their sheep during the night. About 26.6% and 21.88% of the respondents house their sheep in separate house constructed purposively for sheep in highland and mid-altitude agro ecologies, respectively. The results indicated that 85.9 and 90.6 % of the households used grasses or bushes for construction of roof while the remaining 14.1% and 9.4% used corrugated iron sheet. Similar to this study, Workneh and Rowlands (2004) indicated that

60% of the households used family house for housing their sheep in crop livestock system of Oromia region. The majority of respondents house their sheep together with cattle while 3.1% of house separately.

Table 17. Reported housing of sheep in the study area

Type of housing	Agro ecology					
	Highland		Mid-altitude		Overall Total	
	N	%	N	%	N	%
Family house with roof	47	73.4	50	78.12	97	75.76
Separate house with Roof	17	26.6	14	21.88	31	24.24
<hr/>						
Type of housing material						
Grasses or bushes	55	85.9	58	90.6	113	88.25
Grass/bushes	9	14.1	6	9.4	15	11.75
<hr/>						
Sheep is housed						
Separately	2	3.1	-	-	2	1.55
Together with cattle	62	96.9	64	100		98.45

4.14. Major Diseases and parasites of sheep

Diseases have numerous negative impacts on productivity of herds i.e. death of animals, loss of weight, slow down growth, poor fertility performance, decrease in physical power etc. (CSA, 2012). Gatenby (1986) also stated that maximum productivity in a given system of production is obtained when disease control is optimal. Healthy sheep with normal physiological function and structure that enable the sheep to attain highest production is vital. Farmers in the study area do not exactly know the type of disease which causes mortality but they were able to describe the symptoms. According to the livestock and fishery office of Bensa district, the major types of diseases and parasites of sheep which frequently occurred in the study area are presented in Table 18. Accordingly, *Ovine Pasteurellosis* (Sonbe), Contagious Caprine Pleuropneumonia (Shonbe) and sheep pox were the major diseases, while liver fluke and external parasites were the major parasites prevalent in the area. The cold

environmental temperature prevailing in the survey district might have predisposed the animals to respiratory diseases such as Pasteurellosis. Similar diseases were reported across different part of the country by different authors (Abebe, 1999; Zewdu 2008; Tesfaye 2008). According to focus group discussants, most of the respondents in the study area use modern veterinary drugs to treat sick animals and it were entirely from government since there was no private veterinary service provider. In general, for effective breeding strategy sheep producers should be encouraged to adopt proper and cost effective disease control measures, and the limited animal health services need to be strengthened.

Table 18. Major sheep diseases and parasites in the study area.

Common name	Local name (Sidamgna)	Season of occurrence	Susceptible age group	Rank
Diseases and parasites				
Ovine pasturiolosis	Shonbe	Any time of the year	All age group	1
CCPP	Sonbe	Any time of the year	All age group	2
Sheep pox	Fexelle	Any time of the year	All age group	5
Liver fluke	Gognogne	Any time of the year	All age group	3
External parasite	Mejabinno	During dry season	All age group	4

CCPP: Contagious Caprine Pleuropneumonia

The majority (96.1%) of sheep producers in the study area had access to veterinary services of which about 35.15% walk less than 1kms to reach the nearest government veterinary service centre while 32.8 % walk 1-5km. (Table 19).

Table 19. Access to veterinary services in the study area

Veterinary service	Agro ecology					
	Highland		Mid-altitude		Over all Total	
	N	%	N	%	N	%
Access veterinary service						
Yes	60	93.8	63	98.4	123	96.1
No	4	6.2	1	1.6	5	3.9
Distance to nearest veterinary service						
Less than 1km	35	54.7	10	15.6	45	35.15
1-5km	23	35.9	19	29.7	42	32.8
6-10 km	2	3.2	15	23.4	17	13.3
Greater than 10 km	-	-	19	29.7	19	7.425

4.15. Milk Production and Weaning

Sheep milk consumption was common in highland agro ecology of the study area. Producers in the study area milk their sheep for different purposes where priority was given to the lambs. Lambs were allowed to suck their ewes freely for about a week to ensure survival of the lamb after birth. When the Lambs were in a good growth (after about a month) and supplemented with feed, farmers start to take out some amount of milk for consumption, mainly for coffee whitening, children and old people (mixed with coffee). According to FG discussants some farmers prefer sheep milk for butter making due to the perceived higher fat content. Sheep milk contains higher fat (6.8 to 8.5%) compared to goat (3.4 to 4.5), cattle (3.4 to 5.5) and camel (5.0 to 5.5) (Degen, 2007). According to the FG discussants sheep milk was not marketed in the area mainly because of cultural reasons. Thus the producers were reluctant to disclose that they milk sheep though they consume the milk at home. Frequency of milking and milk yield per day per ewe were different in the rainy and dry seasons due to feed scarcity in the dry season (Tesfaye, 2008). Sheep milking was not practiced in mid-altitude agro ecology of the study area.

Table 20. Sheep milk production and lamb weaning practices in the study area.

Parameter	Highland		Mid-altitude	
	N	Mean \pm SE	N	Mean \pm SE
Average daily milk yield of sheep (ml)	55	476 \pm 0.15	-	-
Frequency of milking	55	1.1 \pm 0.14	-	-
Lactation length of sheep (month)	55	3.5 \pm 1.2	-	-
Lamb weaning age (month)	64	4.2 \pm 0.16	64	4.6 \pm 0.17

Note: Though the lactation continues up to the period of suckling by the lamb but the lactation length was recorded as the number of days up to which sheep were hand milked.

Weaning is a crucial period which influence both dam and lamb productivity. In the study area, lambs wean naturally without shepherd intervention. The overall reported average weaning ages for both sexes was 4.4 months. It was a little bit longer than 3-4 months reported for indigenous sheep breeds of Ethiopia (Tembely *et al.*, 1994). Moreover, the present finding was higher than what had been reported for the thin tailed Gumuz sheep (3.95 \pm 0.9 months) (Solomon, 2007).

4.16. Reproductive Performance of indigenous sheep

Good reproductive performance is a prerequisite for any successful sheep production program. Reproductive performances of sheep in the study area are presented in Table 21. There was significant ($P < 0.05$) difference was observed between the agro ecologies with respect to reproductive performance of indigenous sheep because of better sheep management practices in the highland than the mid-altitude. The average age at sexual maturity of male sheep in highland was 7 \pm 0.12 months while it was 7.15 \pm 0.2 months in mid-altitude agro-climate. Similarly, an average age of 7.1 months was reported for Afar sheep earlier (Tesfaye, 2008). The average age at sexual maturity of females in highland was 7.68 \pm 0.23 months while it was 7.8 \pm 0.12 months in mid-altitude.

According to the respondents, early mating and lambing of very young females could result in stunted growth in addition to occurrence of difficult birth that might be associated with lambs and/or ewes mortality. In a similar fashion, male sheep that started service at very early age or exposed to a number of breeding females might not be grown to their full potential and could also produce weak lambs and such rams do not fetch good price if sold. They suggested that, the beginning of reproduction very early is not desirable because of the possibility of harm to their body development and future production. Despite these facts, all respondents did not fix age at first mating because of the traditional uncontrolled breeding practices conducted in their situations.

Average age at first lambing of 12.15 ± 0.27 months and 13.53 ± 0.21 months were reported for highland and mid-altitude local sheep type, respectively. The average age at first lambing observed in both agro ecologies was smaller than 14.77 ± 1.8 months reported for Dawuro and Konta special woreda sheep (Amelmal, 2011) In Ethiopia, sheep breeds like Menz, have wide range of age at first lambing from 15-22 months (Gautsch, 1987; Neftalem, 1990; Abebe, 1999). This could be attributed to breed or environmental difference. This is due to the availability of grazing land and good husbandry practices in the study area.

Table 21. Reproductive performances of indigenous sheep population in the study area.

Reproductive Parameters	Agro ecology of the study district					
	Highland		Mid-altitude		Over all Mean	
	N	Mean \pm SE	N	Mean \pm SE	N	Mean \pm SE
Average age at sexual maturity of (male; month)	64	7 ± 0.12^b	64	$7.15 \pm 0.2a$	128	7.07 ± 0.16
Average age at sexual maturity (female; month)	64	7.68 ± 0.23^b	64	7.8 ± 0.12^a	128	7.74 ± 0.175
Age at first lambing	64	12.15 ± 0.27^b	64	13.53 ± 0.21^a	128	12.84 ± 0.24
Lambing interval	64	9.38 ± 0.07^b	64	9.8 ± 0.14^a	128	9.59 ± 0.1

“Continued...”

Reproductive life time of Ewes (years)	64		64	7.86 ± 0.06^b	128	8.1 ± 0.11
Average number of lambs per ewes life time	64	9.1 ± 0.23^a	64	8.28 ± 0.14^b	128	8.69 ± 0.185
Average number of lambs per lambing	64	1.3 ± 0.34^a	64	1.2 ± 0.15^b	128	1.25 ± 0.24

Different superscripts denote significant differences at $P < 0.05$ between means of the agro ecologies
n =number HH; SE = standard error;

Lambing interval of 9.38 ± 0.07 months and 9.8 ± 0.14 months were reported for highland and mid-altitude local sheep type, respectively. The lambing interval observed in both agro ecologies was more or less fall within the range of 7.1 to 14.6 months reported for tropical sheep breeds (Wilson, 1982; Wilson *et al*, 1989; Abebe, 1999; Gbangboche *et al.*, 2006). Under village conditions, estimates obtained are mostly in the range of 8.5 to 12.2 months in semi-arid zone, and 7.1 to 10.7 months in the humid Zone (Wilson, 1982). However, the result of the present study was in agreement with the reported result of 10.33 ± 4 for Marka (Amelmel, 2011) and 8.9 for Bonga sheep (Zewdu, 2008). The results indicated that the reproductive life of ewes in highland was 8.34 ± 0.16 years while it was 7.86 ± 0.06 years in mid-altitude. The present finding was higher than 7.9 ± 3.1 reported for Horro sheep as (Zewdu, 2008).

According to the respondents on average a ewe could produce 9.1 ± 0.23 in highland and 8.28 ± 0.14 in mid-altitude lambs in her life time. The finding of the present study on life time lamb crop is slightly lower than 9.42 reported by Amelmal (2011) for Dowuro zone and Konta special woreda sheep. Productions of large number of progeny in ewe's life span provide ample scope for selection and genetic improvement other than large numbers of animals for sale. According to the respondents the average number of lambs per lambing was 1.3 ± 0.34 in highland and 1.2 ± 0.15 in mid-altitude. The observed value was higher than the litter size of East African sheep under pastoral management systems were reported in the range of 1.03, 1.05 and 1.14 in Ethiopia, Kenya and Sudan, respectively (Wilson, 1982) but lower than sheep breed (50.1%) in Bench-Maji Zone (Dejene, 2010).

4.17. Sheep Breeding Practices

The breeding practices of sheep in the study area presented in Appendix Table 3. The dominant sheep breeding practices in the study area was uncontrolled mating system. Similarly, Workneh and Rowlands (2004) reported that 77.3% of the farmers in Oromia region practice uncontrolled mating system. With regard to ram possession of the study area, about 39.1% of the respondents have no breeding ram to breed their breeding ewes. They use rams from neighborhood or borrow males from other areas for mating. Most of the respondent had one ram running with the flock throughout the year. Majorities of the respondents do not give additional feeds for breeding rams. The purpose of keeping rams was for mating purpose (64.1%), for socio cultural (7.7%) and for saving purpose (28.21%). The majority of the males used for breeding purpose were born or originated within the flock (82.05%) and the remaining was purchased and managed privately. This implies that the animals within the flock are very closely related and have narrow relationship which leads to inbreeding (Jaitner *et al.*, 2001). Similar scenario was observed among Menz and Afar sheep breeders (Tesfaye 2008). The majority of the respondents (65.62%) could identify the sire of the new born lamb by relating the color of the lamb with the color of its sire and knowing the sire of a lamb. Although the disadvantage of inbreeding was not clear for farmers in the study area, some of them reported that they heard the negative effect of inbreeding.

4.17.1. Castration

According to the respondents castration of sheep was not a common practice in the study areas. Some farmers with better wealth status, however, castrate and fatten one to two rams for one year period for home consumption as well as for market. The method of castration is traditional through repeatedly crushing the spermatic cord using a smooth river-stone and wood. Although the age of the animals at time of castration is not fixed, farmers suggested that it should be after eruption of one pair of permanent teeth. This is because farmers believe that the rams will mature and finishes growth at this age. The scheme should introduce and emphasize on awareness creation of castration of the inferior rams/unselected/ for fattening purpose and select superior rams with better management to be parents/sires of the next generation.

4.17.2. Docking

Docking of female sheep was a common practice undertaken by sheep producers in highland agro ecology of the study area. Accordingly, about 60.94% of the respondents practice docking in the highland while in mid-altitude docking was not common (Appendix Table 3). The major reason for docking female sheep was that it facilitates mating easily. Moreover, the focus group discussants reported that docking females improves body weight and condition, appearance, ease hygiene during delivery and widening the tail. Unlike females, males were not docked since docked males are not preferred at the market. Even though there is no standardized specific age and site of tail cutting in female sheep, most producers during the focus group discussion estimated that it is about 5cm from the tip of the tail based on the body condition of the ewe lambs.

4.18. Effective Population Size and Level of Inbreeding

The effective population size (N_e) and the rate of inbreeding (ΔF) calculated for sheep flocks in the study area are presented in Table 22. High level of inbreeding and decreased genetic diversity may be the result of the utilization of breeding rams born within the flock, uncontrolled mating, and lack of awareness about inbreeding and small flock's size (Falconer and Mackay, 1996; Kosgey, 2004). Effective population size is a measure of genetic variability within a population with large values of N_e indicates more variability and small values indicate less genetic variability (Maiwashe *et al.*, 2006). In this study, the estimate of N_e was 97.68 when a household flock is herded alone. Under random mating when the sheep flock of a household was not mixing, the rate of inbreeding was 0.005. This value is lower than the report of Amelmal (2011) for Tocha (0.17), Mareka (0.2) and Konta sheep (0.18). Tesfaye (2008) also reported 0.079 and 0.2 for Menz and Afar sheep respectively, when sheep flocks were not mixed, which is higher than the present study. Rate of inbreeding in the study area is maximum acceptable level (0.063) (Armstrong, 2006) which is due to small effective population size, lower proportion of breeding ram and uncontrolled mating practiced in the study area. The small effective population size and lower proportion of breeding ram in the study area is due to absence of mixing various flocks from different households. Study

(Tesfaye, 2008) indicated that mixing of flocks was reported to reduce ΔF by a range of 86% to 78%.

Table 22. Effective population size and level of inbreeding in the study area

Nm	Nf	Ne	ΔF
28	191	97.68	0.005

N_e = effective population size; ΔF = coefficient of inbreeding; N_m = Number of breeding male; N_f = Number of breeding female

4.19. Trait Preferences of local Sheep in the Study Area

Knowing the potential of local sheep population and trait preferences are useful to make better informed decisions in developing interventions to improve the contribution of sheep to livelihoods of their keepers (Tassaw, 2010). In the study area appearance/size, coat color, character, meat quality, growth rate, fertility, disease tolerance and tail type were among the reported preferred traits in both agro ecologies. In highland appearance/size (index= 0.29), coat color (index= 0.19), fast growth rate (index= 0.18) and meat quality (index=0.12) were among the reported preferred traits in their order of importance by the respondents (Table 23) while in mid-altitude fast growth rate (index= 0.25), appearance/size (index= 0.21), coat color (index= 0.17) ,tail type (index= 0.12) and fertility (index= 0.12) were among the traits considered for improvement intervention. The most preferred color was red, light red and white with white patch and white respectively, while unwanted color was black because of lower market value. Similarly Zewdu (2008) indicted that traits like body appearance and coat color were the most considered characters in Adiyu Kaka and Horro rams.

Table 23. Ranking of trait preference of farmers in the study area

Trait	Agro ecology							
	Highland				Mid-altitude			
	1 st	2 nd	3 rd	Index	1 st	2 nd	3 rd	Index
Size	45.3	23.4	12.5	0.29	23.4	20.3	20.6	0.21
Color	17.2	26.6	23.4	0.19	17.2	17.2	17.2	0.17
Character	3.1	10.5	4.7	0.05	0	0	3.1	0.005
Meat quality	9.4	12.5	37.5	0.13	7.8	3.1	17	0.07
Growth rate	15.6	32.8	7.8	0.18	23.4	39.1	7.8	0.25
Fertility	4.7	0	3.1	0.02	15.6	7.8	10.9	0.12
Disease tolerance	12.5	3.1	3.1	0.07	1.6	3.1	12.5	0.03
Tail type	3.1	4.7	7.8	0.04	15.6	3.2	20.3	0.12

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 variable 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 variables.

In both agro ecologies, FG discussants and key informants reported that the tendencies of farmers to rear their local sheep has become high. According to them, they liked these local sheep type for their large body size, attractive coat color, fast growths, and nice posture. They also mentioned that such type of sheep can fetch high premium price when it has been sold. Due to this reason, it was observed that some farmers practice selective breeding of ram and ewe. The proportions of red /light red and white sheep are increasing and that of black sheep is decreasing over time. This is strongly supported by the preference of farmers to white and red/light red colors against the black color for which the farmers are exercising some kind of selection for the preferred ones. The results indicated that, any sheep breed improvement interventions should take into account the need of the producer trait preferences and the demand markets in the study area.

4.20. Selection Criteria

Selection criteria are the characteristics that allow the farmers to achieve the breeding objectives and select replacement animals (Holst, 1999). It is expected that farmers select replacement stocks by considering its own morphological and production characteristics. In general as stated by Tabbaa and Al-Atiyat (2009) livestock producers place more weight on morphological selection criteria (subjective selection) than production selection criteria (objective selection). In the study area selection of breeding rams and ewes were practiced by the farmers, although they don't have specific age of selection. Farmers in the study area select rams/ewes when they need to cull some for market and save the others. Ranking of selection criteria of breeding ram and ewe are presented in Tables 24 and 25. In selecting a breeding ram, fast growth was ranked first in highland while appearance/size conformation was ranked first in mid-altitude agro-climate with an index of 0.32 and 0.35, respectively. In highland, appearance/size and coat color were ranked second, and third high with indices of 0.32 and 0.24 respectively. In mid-altitude fast growth rate, color and tail length were ranked second, third and fourth high with indices 0.25, 0.19 and 0.14 respectively.

Table 24. Selection criteria for selecting breeding ram in the study area

Characters	High land				Mid-altitude			
	<i>Rank1</i>	<i>Rank2</i>	<i>Rank3</i>	<i>Index</i>	<i>Rank1</i>	<i>Rank2</i>	<i>Rank3</i>	<i>Index</i>
Appearance/size	37.5	31.2	15.6	0.32	39.1	25	10.9	0.32
Color	10.9	35.9	37.5	0.24	7.8	7.8	65.6	0.19
Behavior	0	9.4	0	0.03	0	0	1.6	0.002
Adaptability	0	0	12.5	0.02	0	1.6	0	0.005
Growth rate	51.6	17.2	21.9	0.35	29.7	21.9	7.8	0.25
Age	0	6.2	0	0.02	0	15.6	12.5	0.08
Tail length	0	0	4.7	0.007	23.4	4.7	1.6	0.14

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 variable 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 variables.

In selecting a breeding ewe, twinning ability was ranked first both in the highland and mid-altitude agro-climate with indexes of 0.35 and 0.37, respectively. In highland,

appearance/size, coat color and lamb growth were ranked as second, third and fourth with indices of 0.27,0.23 and 0.11, respectively/ while in mid-altitude appearance/size, coat color and lamb growth were ranked second, third and fourth with indices of 0.25,0.16 and 0.13, respectively. Mothering ability of ewes embraces maternal behavior that allows proper bonding to take place between mother and offspring, as well as nursing behavior, responsiveness and attentiveness towards the lambs, and protection of the lambs from predators (Gemed, 2011).

Table 25. Selection criteria for selecting breeding ewe in the study area

Characters	High land				Mid-altitude			
	<i>Rank1</i>	<i>Rank2</i>	<i>Rank3</i>	<i>Index</i>	<i>Rank1</i>	<i>Rank2</i>	<i>Rank3</i>	<i>Index</i>
Appearance/size	31.2	26.6	42.2	0.27	29.7	6.2	51.6	0.25
Color	15.6	39.1	34.4	0.23	0	40.6	15.6	0.16
Lamb survival	0	0	0	0	3.2	0	7.8	0.02
Lamb growth	3.1	29.7	12.5	0.11	7.8	25	9.4	0.13
Age at first sexual maturity	0	0	0	0	0	7.8	14.1	0.04
Lambing interval	6.2	0	0	0.02	0	1.6	0	0.005
Twining ability	59.4	28.1	6.2	0.35	60.9	18.8	1.6	0.37

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 variable 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 variables.

4.21. Flock Dynamics

Knowledge about ways of acquisition of breeding stock and mode of disposal is important in assessing the breeding practices of sheep owners (Helen *et al.*, 2015). Major modes of flock entry and exit are summarized in Table 26. In the study area, sheep were added on farm through birth, purchase and exchange, of which the contribution of the former (87.55%) was the highest followed by purchase (8.55%). The contribution of exchange as source of animals was very minimal (3.9%). Similarly, birth was reported as the main mode of indigenous sheep flock entry in Horro, Adiya Kaka, and Alaba districts (Tsedek, 2007; Zewdu, 2008). The highest share of the total exit (70.85%) was accounted for sale, followed by mortality (11.9%) and exchange (10%) while only 7.25 % was reportedly slaughtered.

Table 26. Mode of sheep flock entry and exit (in percent) during the last 12 months

Means	Agro ecology		
	Highland	Mid-altitude	Overall Total
Entry			
Birth	89.1	86	87.55
Purchase	6.2	10.9	8.55
Exchange	4.7	3.1	3.9
Exit			
Sale (Off take)	70.2	71.5	70.85
Death	11.4	12.4	11.9
Exchange	10.4	9.6	10
Slaughter	8	6.5	7.25

4.22. Constraints for Sheep Production

Participatory identification and prioritization of the major constraints of livestock production is the first step to design and implement need based interventions development options. Constraints impending sheep productivity in the study area are presented in Table 27. Although the major constraints limiting sheep breeding were mostly similar, their importance, however, varied across the study areas. This study observed that feed shortage, disease, genotype and market were the major constraints challenging sheep production across both agro ecologies. Feed shortage have been reported by the majority of respondents as common constraint and ranked first. Similar results were reported for Menz and Afar areas (Tesfaye, 2008). The major causes of feed scarcity were shortage of grazing land and expansion of arable farming at the expense of grazing land.

Table 27. Ranking of sheep production constraints by smallholder farmers (%)

Constraints	Agro ecology							
	Highland				Mid-altitude			
	1 st rank	2 nd rank	3 rd rank	Index	1 st rank	2 nd rank	3 rd rank	Index
Genotype	7.8	18.8	35.9	0.16	26.6	14.1	26.6	0.23
Feed shortage	45.3	10.9	6.2	0.28	53.1	18.8	10.9	0.35
Disease	9.4	42.2	18.8	0.22	6.2	43.8	25	0.21
Market	17.2	12.5	21.9	0.17	14.1	14.1	29.7	0.165
Predator	4.7	1.6	-	0.03	-	1.6	-	0.005
Labour	15.6	14.1	3.1	0.13	1.6	4.7	3.1	0.03

Predator and labor problem were among the minor reported problems limiting sheep farming across the study areas. However, labor shortage received a little bit higher proportion around highland area as compared with mid-altitude. Therefore, since producers across all the study areas practice traditional sheep farming, awareness should be created on the merits of sheep improvement before implementations of breed improvement programs. In the present study, ranking of sheep rearing constraints (indices) by the producer's reflect their priority needs for intervention. Hence, governmental and nongovernmental organizations should give diligent attention to address the problems according to its importance.

4.23. Marketing and Consumer Preferences of Indigenous Sheep

4.23.1. Market place

In the study area, there are four permanent market places, namely *Daye* market located at district town, *Gonjobe* located at *Gonjebe* kebele, *Bura* located at *Bura* kebele and *Chebe* located at *Dinsa* kebele. *Daye*, the capital town of the district, has two different sheep marketing places that operate on Tuesday and Saturday. The consumers in the district town and restaurant owners can buy sheep throughout the week days since there are temporary marketing places that cater small number of sheep to consumers in addition to two days of marketing. *Daye* market place was fenced but there was no other facilities. *Gonjebe* sheep

market is a small market located at about 30 km north of Daye town and is operational on Wednesday and Friday. The market place is not fenced (open) and contains no other facilities. *Bura* sheep market is located at the north eastern tip of the district some 28 km far from Daye. The market is operational on Monday and Thursday. Although this market was fenced, it has poor access for road and transportation. *Chebe* sheep market is located at about 25km east of the Daye town. The market days are Monday and Thursdays. Similar to *Gonjebe*, this market place was not fenced and there was no other facility. Generally, the district has poor market infrastructure, which hinders the movement of livestock inputs and outputs.

4.23.2. Purposes of Selling Sheep

The major reasons of selling sheep as reported by the respondents in the study area are shown in Table 28. Most of the sampled households sell their sheep to purchase farm inputs for crop production (28%) and cover school fee for children (20%). Sheep is often at immediate disposal for several income requirements in the rural households. Producers do not sale large animals and other farm resources for urgent needs because acquiring back them is not easy. Among the household members, husbands are usually responsible for selling sheep.

Consistent with other parts of the country, the sheep to be sold were usually trekked from home to the markets. The most important months in which farmers sell their sheep included June (for farm input purchase), July and August (to purchase grain), September (for festival and covering children school fee), December (for Christmas holiday) and April (for Easter holiday).

Table 28. Purposes of selling sheep by the sampled household in the study area

Purposes	N	%
Purchase grain	15	11.7
Festivals	20	15.6
School fee	26	20
Reduce flock size	13	10
Saving	18	14
Purchase farm inputs	36	28

4.23.3. Sheep marketing and major traits considered by traders

The major actors involved in sheep marketing in the study area included traders, sheep producers, brokers, hotels/restaurants and individual consumers. The number and type of sheep buyers and sellers vary according to the level/stage of markets. Thus, the major buyers at primary market (Bura, Gonjobe and Chebe) were small traders and sheep producers, while at secondary and terminal markets (Daye, Hawassa) the major buyers were trader's, butcheries, restaurants/hotels, individual consumers and institutional users. The major suppliers/sellers of sheep in the primary, secondary and tertiary market were producers, small traders and large traders, respectively. Producers buy sheep mainly for rearing and to a less extent for slaughtering. Thus, they buy young ewes for rearing. The type of sheep purchased for slaughtering depends on the economic status of farmers.

The major parameters considered by traders during buying sheep are presented in Table 29. Body conditions and age were ranked as the most important parameters considered by traders for buying sheep. Accordingly, traders opt for sheep with better body condition, intact male and young. On the other hand, restaurants prefer to buy old ewes due to their lower price. Castrated male sheep were required during festivals such as New Year, Easter (Fasika) and Christmas (Gena).

Table 29. Major parameters considered by traders during buying sheep in the study area.

Parameters	Rank 1	Rank 2	Rank 3	Index
Color	25	-	41.7	0.120
Body Size	41.5	24	-	0.177
Sex	33.5	-	46	0.150
Age	47	33	-	0.212
Price	-	30.5	54	0.118
Body condition	46	24.5	29.5	0.222

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 variable 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 variables.

4.23.4. Market Participants

Producers

Producers raise sheep and sale any time when cash is needed. According to buyers they purchase sheep for breeding, slaughtering and fattening purposes. They sell the animals after value addition (breeding/fattening) during the holidays or during the period of coffee harvesting times. In addition, collectors buy sheep at primary markets (Gonjobe, Bura, Chebe) and trek to Daye (secondary) and other surrounding markets to sell in a better price.

Collectors

Collectors are found in rural areas and they purchase sheep from primary markets. They were market actors in the study area who buy sheep from the rural markets and supply them to small traders and large traders. There are more collectors than traders (large and small) in the study area. Collectors use either their own capital or large-scale and small-scale trader's money to buy sheep. They may also sell to farmers and individual consumers. Collectors who use traders' money deliver the animals to the same traders on commission basis.

Small traders

Small traders who buy sheep from producers and collectors. They are those who buy sheep from primary markets like *Gonjobe*, *Bura* and *Chebe* and sell them in district town such as Daye or to bigger traders who transport the animals to central markets. Usually they buy and sell small number of animals, not more than 20 in the study area. These traders also use other non-regular market days (*gulit*) in district town (Daye) to sell their animals.

Big traders

In the context of this study area, big trades are those market agents that can supply about 40 sheep to tertiary and terminal markets which are located in major cities such as Hawassa, Shashemene and Dilla. Big traders also supply sheep to individual consumers, hotels/restaurants and butchers. They share the premium obtained as a result of collecting

large numbers of animals with their suppliers. In addition, they provide working capital to their agents (small traders) in order to ensure the supply of adequate number of animals that fetch them premium prices. Traders have quality parameters to be considered when buying sheep. They consider the age of animals, so mostly look for yearlings. Similar market participation was also reported from pastoral areas of Borena (Solomon, 2004).

Brokers

Brokers, locally called Delalas, are also major participants in marketing of sheep in the study area. According to key informants, without the involvement of broker's, they don't sell the animals. The role of brokers in marketing sheep in the area was perceived in different ways. Some people describe them favorably as they facilitate transaction between buyers and sellers while others see them as problem in marketing as they are the ones who mainly decide on the price. The fee they collect is also described by some as exorbitant and unnecessary as they negotiate the price his/her animal with the buyers/sellers. In agreement with this report, the role of brokers was also described previously (Endeshaw, 2007; Tsedeke, 2007; Daniel, 2008)

Consumers

There are two groups of consumers in the study area. These are hotels/restaurants and individual consumers. Hotels/restaurant buy sheep either directly from the producers, small traders and/or larger traders, and make local delicacies like *Misto*, *Tibis*, *Dullet*, , *Key wot* and *Kikil*. Public servants, traders and farmers are also an important part of actors in the sheep value chain in the study area. They buy sheep directly from traders and from farmers. Preferences for size and type of animals are influenced by individuals' purchasing power and the type of festivity/holiday to be celebrated.

4.23.5. Seasonality in Marketing of Sheep

In the study area, season was the most important factor influencing the price, supply and demand of sheep. The variability in sales is associated with holiday markets, crop planting and harvesting seasons and drought seasons and years. During major crop harvesting time,

cultural and religious holidays the demand for sheep increases and so does the supply by the producers as well as the price of sheep. According to the traders, most of the households in the study area prefer to sell their sheep during the major holiday season. There was also a time where sheep price was high, which was mainly associated with coffee and other crops harvesting time (October to December). Money is available at hands for most people during the coffee producing season in the study area. During this period, producers purchase sheep using the money obtained from the sale of coffee and keep the animals (breed/fatten) to be used at the time of deficit, and for harvesting farm inputs in mid-altitude and highland areas. The supply of sheep increases during the time when farmers need additional farm and household inputs and religious festivals. Such as during the months of June, July and August (Figure 3). During this time, most farmers forced to sell their sheep to fulfill different household needs such as fertilizer, improved seeds, clothing and stationery for schoolchildren, household consumable items etc. Therefore, in most cases sheep are sold for lower prices during this period.

According to the producers', traders' and consumer response, demand for sheep varies depending on the season. The demand of sheep was high during times of crop harvesting time, religious and other holidays as well as those times when there is a priority to buy household and consumer goods. Compared to other months, farmers sell their sheep at higher price during the months of April, September, and December and November farmers sold their sheep) at higher prices.

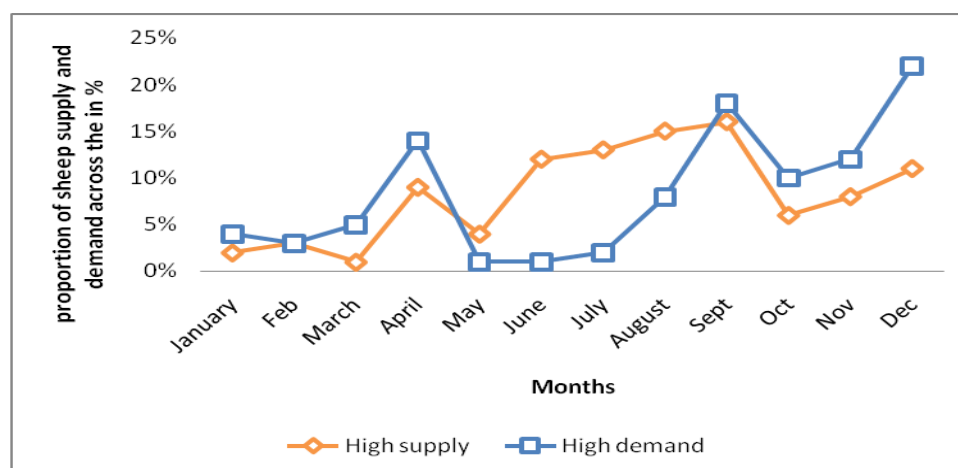


Figure 3. Seasonality of sheep supply and demand in the study area

4.23.6. Marketing channel and routes

Market channels are the alternative routes of product flow from producer to consumer. In study area, sheep marketing channel starts with the smallholder sheep producers from the mixed crop-livestock farming system, and supply the animal to domestic market. According to the market participants described in the market place (Figure 4), sheep trading routes in the study area are categorized into five main channels based on their destination and purpose of sales as listed below.

Channel 1: Producers =>other producers for rearing/breeding purpose

Channel 2: Producers =>Collectors => Small traders => Big traders =>Consumers (Restaurants/Hotels, individuals)

Channel 3: Producers =>Small traders => Big traders => Consumers (Restaurants/Hotels, individuals)

Channel 4: Producers =>Consumers (Hotels and butcheries)

Channel 5: Producers =>individual consumers

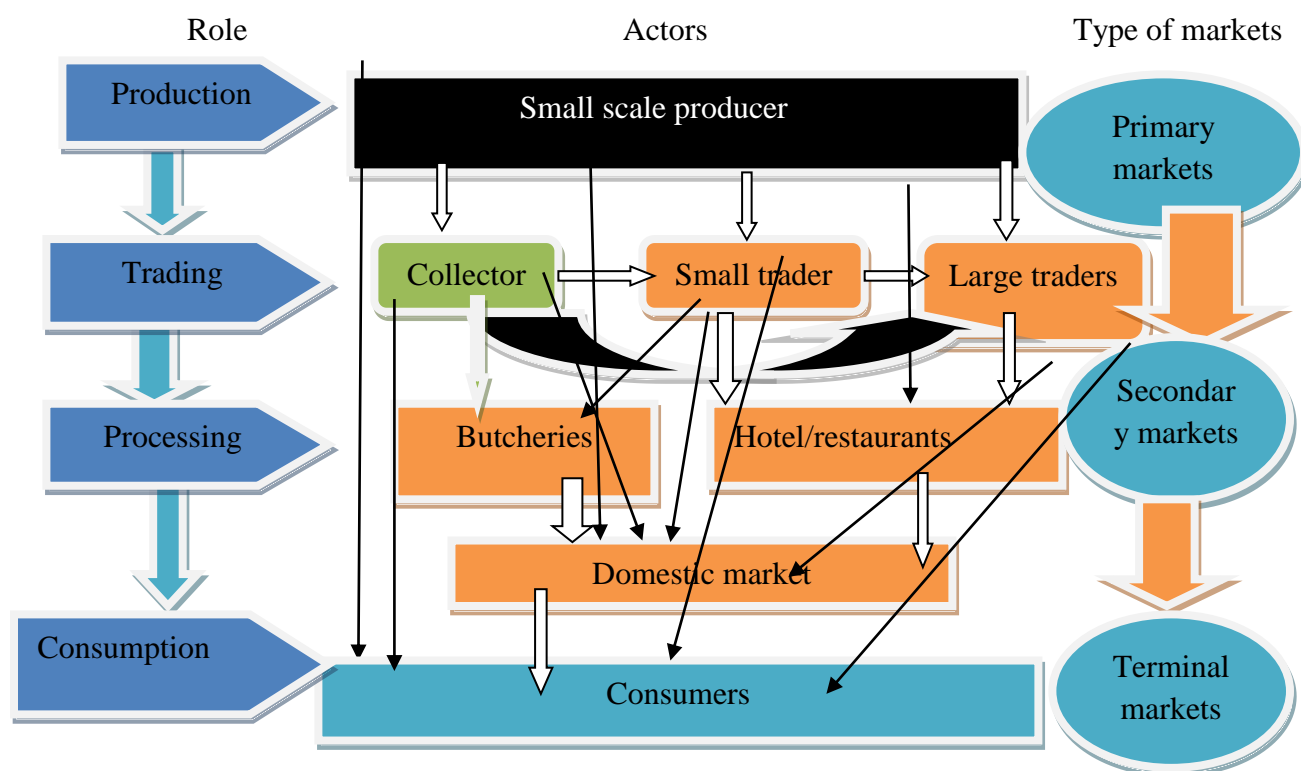


Figure 4. Sheep marketing channels in the study area

A market route is a path through which a product flows into different market destinations. Daye is the main market in the study area for inflow of sheep (figure 5). Sheep were trekked and supplied to Daye town from different surrounding towns in the district and other districts of Sidama highland zone. The main source of sheep to Daye market are the primary markets of the study area which include Gonjobe Bura and Chebe from district and Aroressa, Chire and Daella from other districts. Supply of sheep to the primary and secondary markets is mostly done through trekking. Producers, collectors and small traders use traditional stock routes to trek their sheep to the markets in the study area.

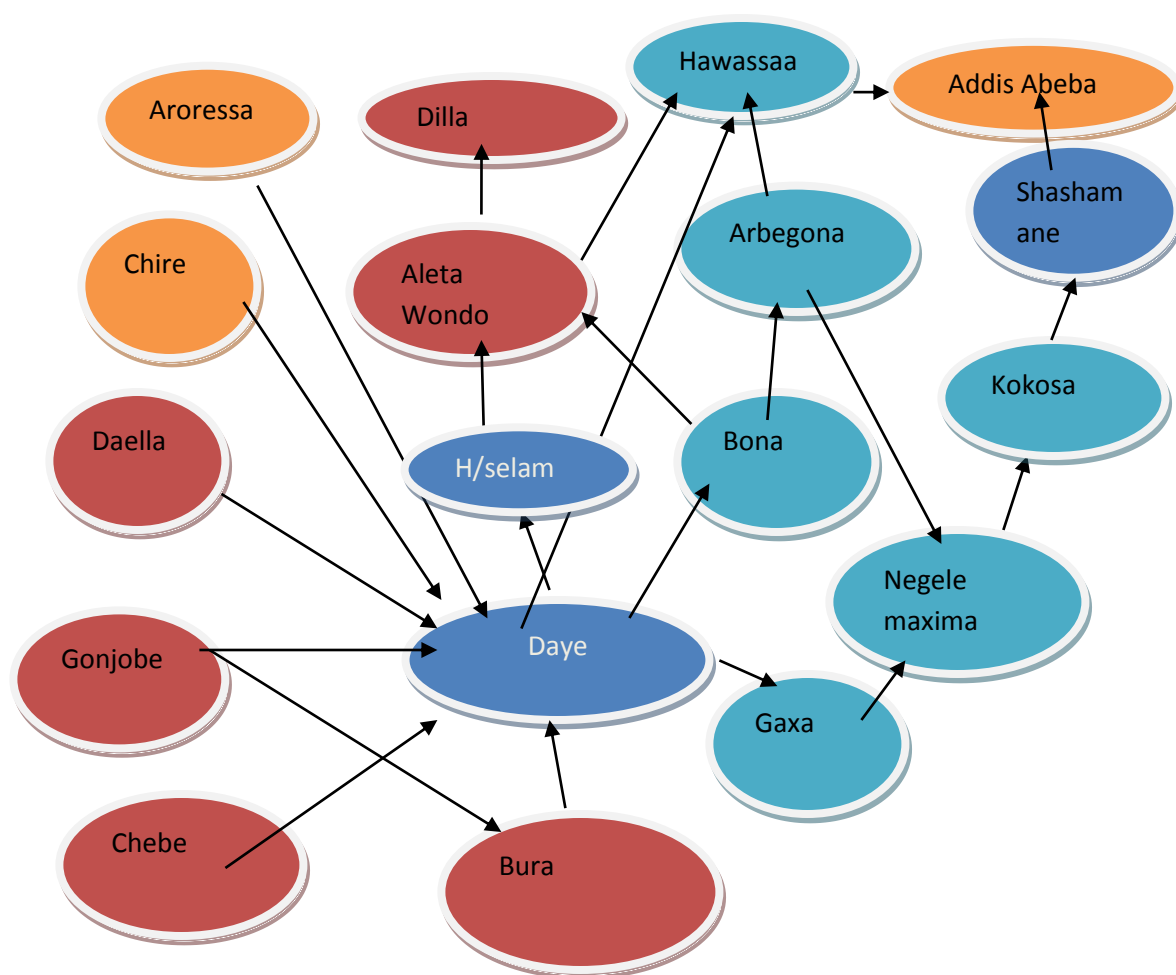


Figure 5. Sheep marketing routes in the study area

The diagram above (Figure 5) indicated that various outflow routes have been identified for sheep marketing. These were: Daye through Hager selam to Aleta Wondo to Dilla Daye to

Bona to Arbegona to Hawassa to Addis Abeba and Daye to Gaxa to Negele Maxima to Kokosa to Shashamene to Addis Abeba.

4.23.7. Mode of setting price and market Information

In the study area the price of sheep marketing is set by eye ball estimation. It is also accompanied by traditional methods of body condition scoring. There was no weighing or grading of animals for sale in the market. Consequently, it is difficult to estimate the quantity of carcass produced from the animal. This is expected to influence the production and productivity of the animals negatively. The finding was similar with previous works (Ayele *et al.*, 2003; Endeshaw, 2007; Tsedeke, 2007).

4.23.8. Consumption pattern of sheep meat in the study area

This study demonstrated that sheep meat is consumed without any taboo in the study area. However, majority (83%) of the sampled households consume sheep meat during the major holidays. Sheep meat is also consumed during occasions such as wedding, birth of child, funerals and during the time of coffee harvest (Figure 6). In the study area sheep is slaughtered in group and divided among group members or slaughtered individually depending upon wealth status and type of occasion. It is not common to purchase sheep meat from butchereries by the households in the study area. According to group discussants, slaughtering sheep at the time of crop harvest, particularly for coffee grown areas, is a common practice in the study area.

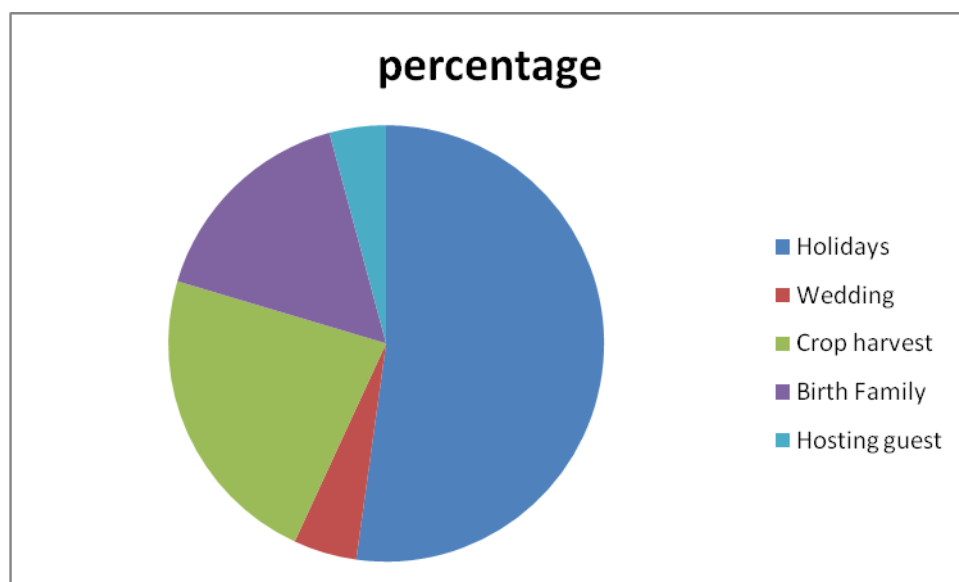


Figure 6. Consumption pattern of sheep meat in the study area

According to the respondents', the major parameters which consumer prefer to buy sheep included age of the animal, sex, body condition, body size and color type. Younger age, uncastrated, large frame size, good body condition, non-black color were highly demanded by the consumer. Thus, those types of animals are usually costly. On the other hand, animals such as females, old age, thin animals and those with black colors are less preferred and cheaper. According to Beneberu (2003) young sheep fetch higher prices. This is true not only for economic purpose but also for its tenderness, softness and the like. This study demonstrated that, respondents preferred meat from male than female animals. The difference could be attributed to variation in mass and sensory test of meat produced from different sexes of livestock (Tsegay, 2012). According to this study, about 35% of the respondents prefer meat from young animals, while 20% preferred from middle aged animals, 14% from old animals and 31% consume meat irrespective of the age of the animal. The high number of people associated with the consumption of meats from young animal probably could be as a result of preference for lean meat which characterizes younger animals.

4.23.9. Marketing Constraints

The major constraints related to sheep marketing in the study area are shown on Table 30. Seasonality of market price, lack of market information, and over exploitation by brokers were the major constraints identified by the households.

Table 30. Major constraints related to sheep marketing as reported by the sampled households in the study area

Constraints	N	Percentages
Tax burden	14	11.27
Brokers	20	15.50
Seasonality	43	33.80
Market and price information	39	30.42
Infrastructures /road/	12	9.01

4.24. Phenotypic Characterization

4.24.1. Qualitative traits of the sample population

Qualitative traits of indigenous sheep population of the study area are summarized in Table 31. Out of the total sampled sheep population in the study area about 19.70% had thin (scored 2 in scale of 5) body condition while about 71.14% had average (scored 3) and 9.16% had fat (> 3 score) during the study period. The coat color pattern of indigenous sheep population in the study area was 47.43% plain, 51.90% patchy and 0.68% spotted coat color. The main dominant coat color types were red (22.46%), red and brown (19.58%), light red (13.85%) and white with red color (12.65%). Besides, white (7.98%), brown (1%), black (4.90%), grey (1.56%), dark brown (8.06%) and black and white (7.97%) coat color were observed in plain, spotted and patchy pattern. The indigenous sheep had dominant patchy color pattern. The result is consistent with Arsi Bale sheep (Solomon, 2008). The higher proportion of animals with red coat colour could be a reflection of strong selection for animals manifesting red colour to meet the preference of market demand. The majorities (81.96%) of sampled population of study area had medium and smooth hair type followed by short and smooth

(14.63 %) and long and smooth (3.41%). The observed hair type was similar with Dawuro and Konta sheep types reported previously (Amelmal, 2011).

The face profile of most of the sample population was flat (73.4%) followed by convex (13.57%) and concave (13.03%). Moreover, majority of the sheep population do not have wattle (94.4%), and all of them had no ruff. The majority of the sampled sheep population had straight tip (95.58%) tail sheep while the others (4.42%) had tail shape twisted end curved at tip. Almost 99.89% of the sampled population had long fat tail. Similarly, Solomon (2008) reported that Arsi-Bale sheep had long fat tailed with some of them having tail shape which is twisted at the end and all had hair fiber type.

The most dominant ear orientation or form of sampled sheep population of female was carried horizontal (73.54%) followed by semi pendulous(21.30%) and erect(5.15%) whereas the male was carried horizontal (46%) followed by semi pendulous(38.30%) and erect(15.62%) . The majority (74.89%) of the females' sheep were polled whereas 87.5% of the male sheep were horned. Out of the horned male sheep, 56.25% had spiral horn shape followed by straight (31.25%) and (12.6%) rudimentary horn shape. These findings are contrary to the results of Solomon. (2008), who reported that above 50% Arsi Bale female sheep were horned (52%).

Table 31. Descriptions of qualitative traits of indigenous sheep in study area

Characters	Attributes	Sex					
		Female		Male		Overall Total	
		N	%	N	%	N	%
Body condition	Thin	99	22.20	22	17.20	121	19.70
	Average	342	76.68	84	65.60	426	71.14
	Fat	5	1.12	22	17.20	27	9.16
Coat color pattern	Plain	206	46.24	62	48.62	268	47.43
	Patchy	238	53.33	65	50.46	303	51.90
	Pied/spotted	2	0.43	1	0.92	3	0.68
Coat color type	Red	110	24.73	26	20.18	136	22.46
	White	22	4.95	14	11.01	36	7.98
	Brown	5	1.08	1	0.92	6	1
	Black	35	7.96	2	1.83	37	4.90
	Grey	6	1.29	2	1.83	8	1.56
	Light red	50	11.18	21	16.51	71	13.85
	Dark brown	27	6.02	13	10.09	40	8.06
	Red and brown with red dominant	81	18.06	27	21.10	108	19.58
	White and red with white dominant	72	16.13	12	9.17	84	12.65
	Black and white with black dominant	38	8.60	9	7.34	47	7.97
Hair type	Short and smooth	65	14.57	19	14.68	84	14.63
	Medium and smooth	371	83.19	103	80.73	474	81.96
	Long and smooth	10	2.24	6	4.59	16	3.41
Face profile	Flat	362	81.17	84	65.63	446	73.4
	Concave	50	11.21	19	14.84	69	13.03
	Convex	34	7.62	25	19.53	59	13.57
Wattle	Present	43	9.64	2	1.56	45	5.6

"Continued..."

	Absent	403	90.36	126	98.44	529	94.4
Ruff	Absent	446	100	128	100	574	100
Tail shape	Straight tip	431	96.64	121	94.53	552	95.58
	Twisted end(curved at tip)	15	3.36	7	5.47	22	4.42
Tail type	Long fat	445	99.78	128	100	573	99.89
	Short fat	1	0.22	-	-	1	0.11
Ear orientation	Erect	23	5.15	20	15.62	43	10.4
	Semi pendulous	95	21.30	49	38.28	144	29.8
	Carried horizontally	328	73.54	59	46.0	387	59.8
Horn	Present	112	25.11	112	87.5	224	56.30
	Absent	334	74.89	16	12.5	350	43.7
Horn shape	Straight	36	32.15	35	31.25	71	31.7
	Spiral	51	45.53	63	56.25	114	50.89
	Rudimentary	25	22.32	14	12.5	39	17.41

4.24.2. Body Weight and Linear body measurements

Body weight: Information on body weight and physical linear measurements of specific sheep population at constant age has paramount importance in the selection of genetically superior animals for production and reproduction purpose (Yoseph, 2007). In general, body weight of indigenous sheep increases with an increase in age of the animal. Thus, body weight of indigenous female sheep population increased by 8.97kg, 1.55kg and 2.67kg as animal grows from milk tooth stage (0PPI) to 1PPI dentition class, from 1PPI to 2PPI dentition class and from 2PPI to 3PPI dentition class whereas the male sheep were 8.39kg, 3.98kg and 4.12kg, respectively (Table 32). The change in body weight was higher in both sexes between the age class 0 PPI and 1PPI, which was approximately 8.68kg. This might be due to the wide age range of the sample populations. From this study, it can be shown that the sample sheep populations attain their mature weight when they had ≥ 1 PPI. Similar trend was reported for Black head Somali (Fikrte, 2008), Bonga (Zewdu, 2008), and Horro, sheep breeds (Sisay, 2009).

The body weight of indigenous sheep recorded in this study was less than 34.14 kg reported for Gumuz sheep (Solomon, 2007), 30.7 kg reported for the North western low land sheep (Sisay, 2009), and 29.0 kg reported for Bonga and Benchmaj sheep (Dejen, 2010). On the other hand, the value was higher than those noted for Central highland (24.6kg) and Rift valley sheep (24.7kg).

Sex effects: In this study, sex of animals had significant ($p < 0.05$) effect on body weight and most of linear body measurements (LBMs) except EL, PW and TL (Table 32). Differences in live weight and most of the LBMs between sexes observed in this study showed that these parameters are sex dependent. Male sheep were consistently heavier than females across all the significantly affected variables except some that were not significant ($p < 0.05$). Ewes have slower rate of growth and reach maturity at smaller size compared to males due to the effect of estrogen which restricts the growth of the long bones of the body (Sowande and Sobola, 2007).

Age effects: The variation between the different age classes were found to be significant ($p < 0.05$) as detected by pair-wise comparisons for both sexes (Table 32). The trend showed that all linear body measurements increased with increase in dentition class. The present study was similar with Yoseph (2007) who reported that the size and shape of the animal increases until the animal reaches its optimum growth point or until maturity. Similar finding was reported by Fasae et al. (2006) who noted that body weight and body measurements increased with age of ewes for the first three years.

Sex by age group: The interaction of sex and age group were only significant ($p < 0.05$) for PW and EL. Body length of males in the youngest, intermediate and oldest age group of sampled sheep population were 56.4, 62.1, 62.3 and 62.5, respectively and the corresponding value for females were 54.7, 60.2, 60.7 and 61.5, respectively. In the youngest, intermediate and oldest age groups, body lengths of males were higher than females (Table 32). Body weights (BW), chest Girth (CG), Wither Height (WH) of sampled female population at youngest age group were 16.5 Kg, 57.3 cm and 51.22 cm, respectively, while it was 20.96 Kg, 62.12 cm and 55 cm, respectively, for males. Similarly, Mengstie *et al.* (2010) reported that

male sheep are larger than female sheep with quantitative traits in north western highlands of the Amhara region.

Table 32. Least squares means and standard error (LSM \pm S.E) of body weight and LBMs (cm) for sampled sheep population in study area.

Effect	N	EL	BW	BL	CD	CG	HW	PW	TL	TC	SC
		LSM \pm SE	LSM \pm SE	LSM \pm SE	LSM \pm SE	LSM \pm SE	LSM \pm SE	LSM \pm SE	LSM \pm SE	LSM \pm SE	LSM \pm SE
Overall	574	10.3 \pm 0.07	27.6 \pm 0.5	60.2 \pm 0.3	23.2 \pm 0.08	68.5 \pm 0.6	60.2 \pm 0.5	17.2 \pm 0.54	32.73 \pm 0.54	20.17 \pm 0.3	24.9 \pm 1.06
Mean											
CV		7.6	21	5.95	3.97	9.57	9	10	17.81	16	0.16
R ²		0.24	0.49	0.38	0.38	0.43	0.39	0.37	0.45	0.05	27.56
Sex		Ns	*	*	*	*	*	ns	*	*	
Female	446	10.34 \pm .03	24.9 \pm .25 ^b	59.3 \pm .17 ^b	22.81 \pm .04 ^b	66.87 \pm .3 ^b	58.5 \pm .25 ^b	17.11 \pm .08	31.96 \pm .27 ^b	19.41 \pm .75 ^b	-
Male	128	10.3 \pm 0.14	30.2 \pm .9 ^a	61.1 \pm .6 ^a	23.56 \pm .17 ^a	70.1 \pm 1.2 ^a	61.9 \pm .99 ^a	17.35 \pm .32	33.5 \pm 1 ^a	20.93 \pm 0.6 ^a	24.9 \pm 1.06
Age		Ns	*	*	*	*	*	*	*	*	*
0PPI	220	9.7 \pm .05	18.7 \pm .35 ^d	55.6 \pm .23 ^c	21.9 \pm .06 ^d	59.7 \pm .42 ^d	53.1 \pm .35 ^d	15.3 \pm .11 ^d	26.3 \pm .38 ^d	19.4 \pm 0.21 ^{cd}	19.7 \pm .53 ^d
1PPI	83	10 \pm .15	27.6 \pm .1 ^c	61.5 \pm .7 ^{ab}	23.26 \pm .17 ^{bc}	69.7 \pm 1.25 ^c	61.4 \pm 1 ^c	16.86 \pm .33 ^c	30.7 \pm 1.1 ^c	19.6 \pm 0.62 ^{bc}	22.6 \pm 2.13 ^c
2PPI	125	10.64 \pm .16	30.3 \pm 1 ^b	61.8 \pm .73 ^b	23.46 \pm .18 ^b	71.4 \pm 1.3 ^b	62.9 \pm 1.1 ^b	18 \pm .35 ^{ab}	34.5 \pm 1.18 ^b	19.67 \pm 0.6 ^{ab}	26.5 \pm 2.3 ^b
3PPI	146	10.8 \pm .2	33.8 \pm 1.3 ^a	62.1 \pm .88 ^a	24.11 \pm .23 ^a	73.16 \pm 1.6 ^a	63.5 \pm 1.33 ^a	18.7 \pm .43 ^a	39.3 \pm 1.4 ^a	22 \pm 0.8 ^a	31.00 \pm 2.8 ^a
Sex by age		*	Ns	Ns	Ns	ns	Ns	*	Ns	ns	-
F0	109	9.7 \pm 0.07	16.5 \pm 0.5	54.7 \pm .33	21.6 \pm .08	57.3 \pm 0.6	51.2 \pm 0.5	14.9 \pm .85	25.2 \pm 0.5	18.8 \pm 0.3	-
F1	76	10.4 \pm 0.08	25.8 \pm 0.6	60.2 \pm .4	23 \pm 0.1	68.34 \pm .73	59.95 \pm .6	17.6 \pm .19	30.1 \pm 0.6	19.1 \pm 0.36	-
F2	119	10.5 \pm 0.07	27.3 \pm .47	60.7 \pm .32	23.11 \pm .08	70 \pm .58	60.67 \pm .48	17.63 \pm .15	33.3 \pm .5	19.8 \pm .28	-
F3	142	10.7 \pm .06	30 \pm .43	61.5 \pm .3	23.47 \pm .07	71.8 \pm 0.53	62.3 \pm .44	18.27 \pm .14	38.7 \pm 0.47	19.9 \pm .26	-
M0	111	9.6 \pm 0.07	20.9 \pm .5	56.4 \pm .33	22.2 \pm .08	62.12 \pm 0.6	55 \pm .5	15.6 \pm 0.16	27.4 \pm 0.5	19.5 \pm 0.3	19.7 \pm .53

"Continued..."

M1	7	9.7±0.3	29.4±2	62.1±1.3	23.4±.34	71.1±2.4	62.2±1.99	16.1±0.64	31.4±.5	20±1.2	22.6±2.13
M2	6	10.86±0.3	33.3±2.1	62.3±1.4	23.92±.36	72.75±2.6	64.75±2.15	18.5±0.7	35.3±2.3	20.1±1.28	26.5±2.3
M3	4	10.8±0.38	37.5±2.6	62.5±1.7	24.7±.45	74.5±3.17	65.8±2.6	19.12±0.8	39.7±2.8	24.14±1.57	31.±2.82

Means with different superscripts within the same column and class are statistically different (at $p < 0.05$). Ns = non significant; * Significant at 0.05; 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor, 2 PPI = 2 pair of permanent incisor, and 3pairs of permanent incisors.

4.24.3. Correlation between body weight and other linear body measurements

The association among body weight and linear body measurements of sheep in the study area is presented in Table 33. The high association of LBMs with body weight would imply that these measurements can be used as indirect selection criteria to improve live weight (Kosgey *et al.*, 2006; Solomon, 2008) or could be used to predict body weight (Attach and Elkhidir, 2004; Afolayan *et al.*, 2006; Fasae *et al.*, 2006). Almost all of the parameters considered had positive and significant correlation with live body weight. Among measured linear quantitative variables chest girth ($r=0.78$ for female and $r=0.91$ for male) had the highest positive association. It explains about 78% and 91% of the variation in body weight in females and males, respectively.

The better association between body weight and chest girth was possibly due to relatively large contribution in body weight by chest girth which consists of bones, muscles and viscera (Thiruvankadan, 2005). This suggests that either this variable alone or by combining with other linear quantitative variables (which will be determined later using multiple linear regression analysis in the next chapter) could provide a good estimate for predicting live body weight of sampled population of study area. similar to this study, the strong positive correlation between the dependent variable body weight and the independent variable chest girth to predict the body weight were observed in different sheep breeds for instance Gumez (Solomon, 2007), Menz and Afar (Tesfaye, 2008) and Bonga and Horro (Zewdu, 2008) sheep breed of Ethiopia. Variables such as body length, height at wither and

pelvic widths, which are directly related to the size and weight of the animal, displayed medium to high positive correlations with one another both in female and males animals.

Table 33. Coefficient of correlations between body weight and linear body measurements of sampled population (above the diagonal for males and below the diagonal for females; Female= 446& Male = 128)

Trait	EL	BW	BL	CD	CG	HW	PW	TL	TC	SC
EL		0.56**	0.54**	0.40**	0.57**	0.47**	0.49**	0.407**	0.25**	0.11 ^{ns}
BW	0.48**		0.88**	0.77**	0.915**	0.83**	0.82**	0.74**	0.63**	0.25**
BL	.11**	0.17**		0.74**	0.914**	0.808**	0.78**	0.72**	0.69**	0.18*
CD	0.44**	0.69**	0.11*		0.77**	0.73**	0.64**	0.67**	0.56**	0.23*
CG	0.47**	0.78**	0.17**	.72**		0.86**	0.83**	0.74**	0.68**	0.18*
HW	0.47**	0.78**	0.16**	.66**	0.83**		0.76**	0.63**	0.630**	0.12
PW	0.47**	0.73**	0.16**	.67**	0.73**	0.73**		0.706**	0.62**	0.25**
TL	0.30**	0.41**	-0.13**	0.37**	0.37**	0.38**	0.34**		0.62**	0.28**
TC	0.13**	0.19**	0.09	0.06	0.12*	0.12*	0.23**	0.04 ^{ns}		0.16 ^{ns}

*Correlation is significant at the 0.05 level (2-tailed).ns: non significant

**Correlation is significant at the 0.01 level (2-tailed)

4.24.4. Prediction of Body Weight from Linear Body Measurements

Regression analysis is commonly used in animal research to describe quantitative relationships between a response variable and one or more explanatory variables such as body weight and body measurements (chest girth, chest depth, body length and height at wither) especially when there is no access to weighing equipment (Cankaya, 2008). Multiple linear regression models for predicting the body weight of sheep from linear body measurements are presented in Tables 34 and 35.

In this study, all the body measurements of indigenous sheep were fitted into the regression model and through elimination procedures, the optimum model was identified. Chest girth, height at wither, pelvic width, chest depth, tail length and tail circumference were the best fitted model for female sheep, whereas chest girth, body length, pelvic width and chest depth were the best fitted model for male sheep. However, predictions of body weight from combinations of LBMs, having these multiple variables poses a practical problem under field settings due to the higher labor and time needed for measurement. Moreover, the change in R-square due to inclusion of additional variables in the model was not strong strengthening the preceding argument that chest girth alone could serve as a best predictor of body weight under field condition. Measuring heart girth with tape is easy, cheap and rapid. Thus, body weight prediction from chest girth alone would be a practical option under field conditions with reasonable accuracy.

Thus, body weight of indigenous sheep population of Bensa district could be estimated using the following linear regression equation.

$$y = -20 + 0.67x \text{ for female and}$$

$$y = -29 + 0.8x \text{ for male sheep; where } y \text{ and } x \text{ are body weight and chest girth, respectively.}$$

Table 34. Multiple linear regression analysis of live body weight on different LBMs for female sheep

Equations	Intercept	β_1	β_2	β_3	B ₄	B ₅	B ₆	R ²	A- R ²	SE
CG	-20±1.7	.67±0.02						0.60	0.6	4.2
CG+HW	-27±1.7	0.37±0.04	0.47±0.05					0.67	0.67	3.9
CG+HW+PW	-29.96±1.7	.27±0.04	0.35±0.05	0.9±1.4				0.69	0.69	3.77
CG+HW+PW+CD	-45.6±4.1	0.2±0.04	0.34±0.05	0.75±1.4	1±.2			0.70	0.70	3.70
CG+HW+PW+CD+T	-44±4.1	0.21±0.04	0.32±0.05	0.73±1.4	.93±.2	.06±.02		0.71	0.71	3.67
L										
CG+HW+PW+CD+T	-47.6±4.2	0.21±0.04	0.32±0.05	0.64±1.4	1±.24	0.06±0.02	1.7±0.06	0.72	0.71	3.64
L+TC										

CH = chest girth; HW = height at wither; PW = pelvic width ; CD= chest depth, TL = tail length; R² = R- square; A-R² = adjusted R-square ;SE=standard error.

Table 35. Multiple linear regression analysis of live body weight on different LBMs for male sheep

Equations	Intercept	β_1	β_2	β_3	B ₄	R ²	A- R ²	SE
CG	-29±2	.8±0.03				0.83	.83	3.34
CG+BL	-37.4±3	0.57±0.07	0.4±0.12			0.85	.85	3.2
CG+BL+PW	-37.8±2.9	0.46±0.08	0.37±0.11	0.58±0.2		0.86	0.85	3.1
CG+BL+PW +CD	-50.77±5.74	0.38±0.08	0.33±0.113	0.6±0.20	.88±.33	0.87	0.86	3

CH = chest girth;BL = body length; PW = pelvic width ; CD= chest depth; R² = R- square; A-R² = adjusted R-square ;SE=standard error

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary & Conclusions

Sheep is the most important livestock species which have been adapted to a range of environments extending from the cool alpine climate of the mountains to the hot and arid pastoral areas of the lowlands. It play an important economic role and make a significant contribution to both domestic and export markets through provision of food (meat and milk) and non-food (manure, skin and wool) products. However, sheep production is constrained by various factors in Ethiopia that needs to be addressed by systematically describing and characterizing the production and marketing system, consumer preferences, and phenotypic attributes and thereby prioritize and implement appropriate interventions (research and development) through the involvement of stakeholders to address the challenges.

The existing knowledge on characterization of sheep genetic resources and production and marketing system in various region of the country shows that the information on breed level characterization is inadequate. The present study was, therefore, conducted in Bensa district of Sidama zone of southern Ethiopia to characterize the physical, their environment, consumer preferences, and to identify the sheep population category in the study area. Data were collected from 128 sheep producers who were selected using stratified random sampling technique. For consumer preferences and marketing system, rapid market appraisal was employed in the study area. For assessment of qualitative and quantitative traits, a total of 574 sheep (0PPI to 3PPI) of both sexes were randomly sampled in the study area. Focus group discussions and key informants interview were held to strengthen the findings the survey.

The major production system in the study area was mixed crop-livestock farming. All of the surveyed households across both agro ecologies owned sheep since the sampling frame included only sheep owners. The average numbers of sheep holding per household in highland and mid-altitude were 4.6 ± 0.08 and 4.3 ± 0.07 , respectively. The primary reason for keeping sheep in both agro ecologies were to derive income followed by savings (living bank for rural farmers) and meat but in highland sheep was also kept for milking purposes. The

major feed sources in the study area were private natural pasture, crop residues, fallow land and enset leaf and stems while the source of water were rivers and springs. Generally, water supply is not a constraint in both agro ecologies. Majority of respondents in the study area indicated that sheep flock herded together with cattle and equine. Castration of sheep was not common in the study area. Docking of female sheep was common practice in the study area. The common and economically important diseases in the study area were ovine pasteurellosis (Sonbe), contagious caprine pleuropneumonia (CCPP), and sheep pox, while liver fluke and external parasites such as ticks and lice are the major parasites of sheep.

The average ages of sexual maturity of male and female sheep in the study area were 7.07 ± 0.16 and 7.74 ± 2.46 months, respectively. Age at first lambing, lambing interval, reproductive life time of ewe, average number of lambing per ewe's life time and average number of lambs per lambing of indigenous sheep in the study area were 12.84 ± 0.24 months, 9.59 ± 0.1 months, 8.1 ± 0.11 years, 8.69 ± 0.18 and 1.25 ± 0.24 , respectively. The most important traits of breeding ram selected by the respondent were growth rate, appearance and color in highland and appearance, growth rate, color and tail length in mid-altitude of the study area. On the otherhand, the preferable traits used for selection of breeding ewes were twining ability, appearance, color and lamb across the two agro ecologies. The major sheep production constraints were feed shortage, disease, parasites and market in the study area.

There are four permanent market places for marketing sheep in the district. *Gonjobe*, *Bura* and *Chebe* are primary markets, where as *Daye* and *Hawassa* are secondary and terminal markets, respectively. During crop harvesting time and Christian holidays the demand of sheep was high in the study area. Uncastrated, younger ages with good body condition were the most preferred animals in the study area. Seasonality, lack of access for market and price information, dominance of brokers, tax burden and poor infrastructure were the major marketing constraints. Sheep meat was consumed during various occasions. However, the time is mostly restricted to holidays and some occasions like wedding, births in a family, funerals and during coffee harvest.

Most of the sheep in the study area had patchy coat pattern (51.9%), red color (22.46%) medium and smooth hair (81.96%), flat face profile (73.4%) and long fat tail (99.89%). Sex of the sheep had significant ($p > 0.05$) effect on the body weight and linear body measurements except ear length, pelvic width and tail length and rump length. Dentition classes of sheep contributed significant differences to body weight and the linear body measurements except ear length. The correlation coefficient between body weight and other linear body measurements were positive and significant both for male and female sheep. The result of the multiple regression analysis showed that chest girth alone could accurately predict body weight both in female and male of sampled population of indigenous sheep with the equation $y = -20 + 0.67x$ for females and $y = -29 + 0.8x$ for males, where y and x are body weight and chest girth, respectively

From this study it could be concluded that the sheep production system in the study area was more of extensive production system. The major production constraints in the study area were feed shortage, prevalence of diseases and parasites and lack of market information. The natural uncontrolled mating with small flock size is predominant in the study area. The study revealed that, there is no selection of fast growing animals with desirable traits. Moreover, sheep fattening is not common in the study area. On the other hand, due to the presence of suitable traits there is high demand for the indigenous sheep from domestic markets. However, since farmers in the area follow traditional husbandry practices, without any extension support, they are unable to make use of the existing market opportunity.

The above various constraints of sheep production can justify for the need of appropriate community-based breeding strategies such as incorporating the multi-functional roles that sheep play in these agro ecologies and focus on those functional traits identified as important by the producers. Indigenous sheep populations have potential for meat production and the productive and reproductive performances are reasonable under the existing limiting environmental factors (feed shortage and prevalence of diseases and parasites).

Appearance, growth rate and coat color are the most preferred traits by producers for defining breeding objectives across the two agro ecologies. Marketing of sheep in the study area

involves collection of animals, transportation and distribution to end users. The result of the study shows that indigenous sheep has high potential to fulfill consumer preferences due to attractive appearance, preferred color and high meat quality. As this study indicates targeting on the consumer preferences could largely benefit the producers and helps to plan sustainable community based breeding program in the study area.

In general, indigenous sheep is long fat tailed type with the major coat color pattern varies from patchy, plain or spotted with smooth red, white and red with white dominant, black and white with black dominant. The head profile of indigenous sheep is flat, without wattles. The majority of males are horned while most of females are polled.

The present study revealed that body weight and linear body measurements influenced by sex and age. Almost all of the parameters considered had positive and significant correlation with live body weight. The positive and significant relationship between body weight and linear body measurements indicated that fairly good knowledge of live weight of indigenous sheep could be estimated from chest girth measurements. In the regression analysis, Chest girth was the variable which explained more variation than other variables for both males and females to predict body weight of indigenous sheep populations. Male sheep had higher body weight and linear body measurements than female sheep.

5.2. Recommendations

Based on the current study the following recommendations have been made:

- ❖ The present study showed that sheep producers dispose fast growing animals at younger age through sale at the market. Therefore, community based selective breeding program needed to control negative selection and improve the performance and productivity of sheep particularly males.
- ❖ Since feed shortage in-terms of quantity and quality is among the leading constraints limiting sheep value chain development in the study area, efforts should be made to improve grazing land through top dressing with urea and controlled grazing, introduction of improved fodder grasses and legumes consistent with the respective

farming system, and enhancement of the nutritive value of crop residues through urea treatment.

- ❖ Prevalence of disease and parasites, and poor health management negatively influenced productivity of sheep flock in the study area. Hence, the type, seasonal occurrence and economic losses due to the diseases and parasites should be documented and pertinent control measure should be introduced.
- ❖ The predominant production system of the area is traditional low-input-low-output with little market orientation (producers do not target the market or lack of focus on consumer preference). Thus, effort should be geared to transform the system into market oriented system using value chain framework (involvement of stakeholders).
- ❖ The study showed that producers have no access for market information. Therefore, it is important to disseminate livestock market information on time to actors and service providers through electronic and printed media, extension staff, and through breeders cooperative.
- ❖ The study demonstrated that producers have poor capacity to adopt improved sheep production techniques. Thus, effort should be made to create awareness and develop capacity of producers on the subject.
- ❖ The prevalent sheep commodity development approach focuses on improving the production of the animals and ignores its contribution to income and livelihood of the household. Thus, in order to make sheep development strategies sustainable effort should also be made on improving income and livelihood of the producers, input/service providers and processors/traders. This should be done by government, research and developmental organizations.

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7. APPENDICES

Questionnaires

Questionnaire number (code) _____

Date: _____

Region: _____

Zone: _____

District: _____

Kebele: _____

Enumerator name _____

1. General Information and Socio Economic Aspects

1. Interviewee _____ 2. Household head _____ 3. Position in household a. Household head b. Spouse of head c. Relative d. Son e. Daughter. 4. Age (yrs) a. <31 b. 31–40 c. 41–5 d. 51–60 e. 61–70 f. >70 5. Sex a. Male b. Female 6. Marital status a. Married b. Divorced c. Widowed 7. Education level a. Illiterate b. Writing & reading d. Primary school e. Secondary school f. Religious schools
8. Number of people living in the house by age and sex

Composition	< 31 year	31-40 year	41-50 year	51-60 year	61-70 year	>70 year	Total
Male							
Female							
Total							

9. Land holding (in ha)

S/N	Land holding (in ha)	Land allocated in Timad	Own	Rent
a	Cereal crop			
b	Pulse crop			
c	Sugar cane			
d	Coffee			
e	Enset			
f	Grazing land			
g	Forest land			
h	Vegetables			
	Average total land			

10. Type of grazing land and ownership

- | | Own | Rent | Communal |
|----------------------------|-----|------|----------|
| a. Open grassland | | | |
| b. Tree covered grassland | | | |
| c. Bush/shrub grassland | | | |
| d. Stone covered grassland | | | |
| e. Swampy grassland | | | |

11. What is your major farming activity? a. Livestock production b. Crop production c. both d. others, specify _____

12. Non farming activities? a. hand craft b. trading c. daily labor

13. Rank your farming and non farming activities according to respective criteria

Rank	Major household food source	Major HH cash
1		

2		
3		

14. Number of livestock kept

Animal species	Number of breed kept			
	Loc	Cros	Exotic/pure	Total number
Cattle				
Sheep				
Goat				
Chickens				
Donkeys				
Mules				
Horse				
Others, specify				

15. Population trend in major livestock species

	Increasing	Decreasing	Stable	Reason
a. Sheep				_____
b. Cattle				_____
c. Goat				_____
d. Chicken				_____

16. Numbers of sheep kept

	Number
Ram lambs (<6 months old)	_____
Rams (6-12months old)	_____
Breeding rams (>12 months)	_____
Castrates (older than 1 year)	_____
Ewe lambs (<6 months old)	_____
Ewes (6-12months old)	_____

17. Major crop grown

	Main season	Short rain	Main season	Short rain
a. Barley				
b. Wheat				
c. Teff				
d. Sorghum				
e. Maize				
f. Bean				
g. Pea				
h. Others				

2. Production and Management practices

1. General

1.1. Production system

a. Crop-livestock system

b. Agro-pastoralists

c. Pastoralists

Others (specify) _____

1.2. Purpose of keeping sheep

	Tick	Rank		Tick	Rank
a. Meat	<input type="checkbox"/>	<input type="checkbox"/>	i. Blood	<input type="checkbox"/>	<input type="checkbox"/>
b. Milk	<input type="checkbox"/>	<input type="checkbox"/>	j. Skin	<input type="checkbox"/>	<input type="checkbox"/>
c. Wool/hair	<input type="checkbox"/>	<input type="checkbox"/>	k. Savings	<input type="checkbox"/>	<input type="checkbox"/>
d. Tail fat	<input type="checkbox"/>	<input type="checkbox"/>	l. Income	<input type="checkbox"/>	<input type="checkbox"/>
f. Ceremonies	<input type="checkbox"/>	<input type="checkbox"/>	m. Dowry	<input type="checkbox"/>	<input type="checkbox"/>
g. Wealth status	<input type="checkbox"/>	<input type="checkbox"/>			
h. Manure	<input type="checkbox"/>	<input type="checkbox"/>			

Others (specify) _____

1.3. Do you intend to expand your sheep flock? a. Yes b. No 1.5 if yes, reason _____ if not, reason _____

1.4. Members of household and hired labour responsible for sheep activities
(Tick one or more boxes in each column and row; (M = Male, F= Female))

	Family (≤15y)				Hired labor (<15y)			
	(<=15y)		(>=15y)		(<15y)		(>15y)	
	M	F	M	F	M	F	M	F
a. Purchasing sheep	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Selling sheep	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Herding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Breeding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Caring for sick animals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. Feeding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
g. Milking	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
h. Shearing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
i. Making dairy products	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
j. Selling dairy products	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
k. Others (specify) _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. Feeding, grazing and watering

3.1. Feed source (Tick one or more boxes in each column and rank)

3.2. Grazing method

	Wet season	Rank	Dry season	Rank		Dry season	Wet season
	a. Natural pasture	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	a. Free grazing
b. Established pasture	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	b. Herded	<input type="checkbox"/>	<input type="checkbox"/>
c. Hay	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	c. Paddock	<input type="checkbox"/>	<input type="checkbox"/>
d. Crop residues	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	d. Tethered	<input type="checkbox"/>	<input type="checkbox"/>
e. Fallow land	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	e. Zero-grazing	<input type="checkbox"/>	<input type="checkbox"/>
f. Concentrate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Others(specify)_		
g. improved forages	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
h. Others,specify _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			

3.3. Length of grazing time during wet season (in hours):

Morning from _____ to _____ hours.

Afternoon _____ to _____ hours.

3.4. Length of grazing time during dry season (in hours):

Morning from _____ to _____ hours.

Afternoon from _____ to _____ hours.

3.5. Specify the area of your communal grazing land

_____ hectares for _____ households

3.6. Trend in communal grazing areas?

a. Decreasing b. Increasing c. Stable

Reason _____

3.7. How is sheep flock herded during the day time?

- a. Male and female are separated
- b. Lambs are separated
- c. All classes sheep herded together
- d. Others (specify) _____

3.8. Sheep flock is herded

- a. Together with cattle
- b. Together with goat
- c. Together with camel
- d. Together with calves
- e. Together with equines
- f. All herded together
- g. Sheep herded separately

3.9. Way of herding

- a. Sheep of a household run as a flock
- b. Sheep of more than one household run as a flock
- c. Others (specify) _____

3.10. If the answer is b, how many household mix their sheep together _____

3.11. Crop residues used for sheep

	Wet season	Dry season
a. Wheat	<input type="checkbox"/>	<input type="checkbox"/>
b. Barley	<input type="checkbox"/>	<input type="checkbox"/>
c. Sorghum	<input type="checkbox"/>	<input type="checkbox"/>
d. Maize	<input type="checkbox"/>	<input type="checkbox"/>
e. Bean	<input type="checkbox"/>	<input type="checkbox"/>
f. Pea	<input type="checkbox"/>	<input type="checkbox"/>
g. Lentil	<input type="checkbox"/>	<input type="checkbox"/>
h. Chick pea	<input type="checkbox"/>	<input type="checkbox"/>
Others (Specify) _____	<input type="checkbox"/>	<input type="checkbox"/>

3.12. List the three most important crop residues used during the:

	Wet season	Dry season
1.	_____	_____
2.	_____	_____
3.	_____	_____

3.13. Concentrates used for sheep

	Rank	Type
a. Homemade grain	<input type="checkbox"/>	_____
b. Oil seed cakes	<input type="checkbox"/>	_____
c. Local brewery by-products	<input type="checkbox"/>	_____
d. Flour by-products	<input type="checkbox"/>	_____

3.14. Is there seasonal fluctuation in feed supply?

- a. Yes
- b. No

3.15. At which season of the year do you experience feed shortage? _____

3.16. What is your copping mechanism? _____

3.17. Supplementation regime

- | | | | |
|------------------------------|--------------------------|--------------------------|--------------------------|
| | Dry season | Wet season | (Tick one or more boxes) |
| a. Roughage | <input type="checkbox"/> | <input type="checkbox"/> | |
| b. Minerals (salts)/vitamins | <input type="checkbox"/> | <input type="checkbox"/> | |
| c. Concentrates | <input type="checkbox"/> | <input type="checkbox"/> | |
| d. None | <input type="checkbox"/> | <input type="checkbox"/> | |
| e. Others (specify)_____ | <input type="checkbox"/> | <input type="checkbox"/> | |

3.18. Do you practice fattening of sheep?

- a. Yes b. No

3.19. If yes, which categories of animals do you fatten?

- | | | | | | |
|------------------------|--------------------------|--------------------------|-------------------------------------|--------------------------|--------------------------|
| a. Culled young female | <input type="checkbox"/> | <input type="checkbox"/> | e. Castrates | <input type="checkbox"/> | <input type="checkbox"/> |
| b. Culled young male | <input type="checkbox"/> | <input type="checkbox"/> | f. Older males | <input type="checkbox"/> | <input type="checkbox"/> |
| c. Young females | <input type="checkbox"/> | <input type="checkbox"/> | g. Older female | <input type="checkbox"/> | <input type="checkbox"/> |
| d. Young males | <input type="checkbox"/> | <input type="checkbox"/> | Rank the top 3 in the second column | | |

3.20. Can you tell us the type of feed resources you use to fatten sheep?

- | | | | | |
|--------------------|--------------------------|--------------------|--------------------------|--------------------|
| a. Naturel pasture | <input type="checkbox"/> | c. Concentrate | <input type="checkbox"/> | e. Others,specify_ |
| b. Crop residues | <input type="checkbox"/> | d.improved forages | <input type="checkbox"/> | |

3.21. At which periods of the year do you commonly fatten sheep? _____

Season	Fattening duration	Reason
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____

3.22.If you fatten, do you know consumers/market preference a.Yes b.No

3.23. If yes (list)_____

3.24. Source of water

- | | | |
|------------------------|--------------------------|--------------------------|
| | Dry season | Wet season |
| a. Borehole/water well | <input type="checkbox"/> | <input type="checkbox"/> |
| b. Dam/pond | <input type="checkbox"/> | <input type="checkbox"/> |
| c. River | <input type="checkbox"/> | <input type="checkbox"/> |
| d. Spring | <input type="checkbox"/> | <input type="checkbox"/> |
| e. Pipe water | <input type="checkbox"/> | <input type="checkbox"/> |
| f. Rain water | <input type="checkbox"/> | <input type="checkbox"/> |

3.25. Distance to nearest watering point

- | | | |
|--------------------|--------------------------|--------------------------|
| | Dry season | Wet season |
| a. Watered at home | <input type="checkbox"/> | <input type="checkbox"/> |
| b. <1km | <input type="checkbox"/> | <input type="checkbox"/> |
| c. 1-5 km | <input type="checkbox"/> | <input type="checkbox"/> |
| d. 6-10 km | <input type="checkbox"/> | <input type="checkbox"/> |
| e. >10 km | <input type="checkbox"/> | <input type="checkbox"/> |

3.26. Are lambs watered with the adults?

- a. Yes b. No

3.27. If no, describe watering distance and frequency for lambs?

3.28. Frequency of watering for adult animals

- Dry season Wet season

2.29. Water quality

- Dry season Wet season

- | | | | | | |
|---------------------|--------------------------|--------------------------|-----------|--------------------------|--------------------------|
| a. Freely available | <input type="checkbox"/> | <input type="checkbox"/> | a. Clean | <input type="checkbox"/> | <input type="checkbox"/> |
| b. Once a day | <input type="checkbox"/> | <input type="checkbox"/> | b. Muddy | <input type="checkbox"/> | <input type="checkbox"/> |
| c. Once in 2 days | <input type="checkbox"/> | <input type="checkbox"/> | c. Salty | <input type="checkbox"/> | <input type="checkbox"/> |
| d. Once in 3 days | <input type="checkbox"/> | <input type="checkbox"/> | d. Smelly | <input type="checkbox"/> | <input type="checkbox"/> |
| e. Others (specify) | | | | | |

4. Housing

4.1. Housing/enclosure for adult sheep (*Tick one or more boxes*)

With roof	a. In family house	<input type="checkbox"/>
	b. Separate house	<input type="checkbox"/>
	c. Veranda	<input type="checkbox"/>
Without roof	a. Kraal	<input type="checkbox"/>
	b. Yard	<input type="checkbox"/>
	c. None	<input type="checkbox"/>
	Others (specify)	

4.2. Type of housing materials

	Roof	Wall	Floor
a. Iron sheets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Grass/Bushes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Wood	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Stone/bricks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Earth/mud	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. Concrete	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Others (specify)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

4.3. Are lambs housed with adults?

a. Yes b. No

If no, specify _____

4.4. Are sheep housed together with cattle?

a. Yes b. No

5. Health

5.1. List types of diseases which occur frequently and affect the productivity of sheep in the area and rank them based on importance

Type of disease and parasites	Symptom	Local name	Common name	Scientific name	Season of occurrence	Susceptible age group	Rank	Actions you take	
								Modern(list)	Traditional(list)
parasites									

5.2. Access to veterinary services (*Tick one or more boxes*)

a. Government veterinarian	<input type="checkbox"/>
b. Private veterinarian	<input type="checkbox"/>
c. Shop or market	<input type="checkbox"/>

5.3. Distance to nearest veterinary services (*Tick one box*)

a. < 1km	<input type="checkbox"/>
b. 1–5 km	<input type="checkbox"/>
c. 6–10 km	<input type="checkbox"/>

Others (specify) _____

d. _____

5.4. Has there been any death of your sheep over the last 12 months? 1=Yes 2=No

5.5. What were the major causes for death/loss of your sheep? (Rank)

1=Diseases and parasite infections 2=Nutritional deficiency and toxicity

3=Mechanical causes 4=Predators

5=Undetermined 6= Ecto parasites 7=others, specify _____

5.6. Did you carry out any vaccination or routine medication of sheep in the past 12 months?

a. yes b .no

5.7. If, yes

Disease	Vaccination/routine medication in the past 12 months	Vaccination/routine provider	Total cost of vaccination/routine medication in the last 12 months

6. Production characteristics

6.1. Average weaning age of lambs

a. <3months b. 3-4 months c. 5-6 months d. > 6months

6.2. Milk feeding up to weaning a. unrestricted suckling b. restricted suckling c. Bucket feeding d. Others (specify) _____

7. Reproduction characteristics

7.1. Average age at sexual maturity 7. 2. Age at first lambing 7.3. Lambing interval

a. Male _____ Months Average _____ Months Average _____ Months

b. Female _____ Months Maximum _____ Months Maximum _____ Months

Minimum _____ Months Minimum _____ Months

7.4. Do you fix age at first mating for the females? A. Yes B. No

7.5. Do you fix age at first mating for the males? A. Yes B. No

7.6. Average reproductive life time of ewe years

7.7. Average number of lambs per ewe's life time _____

7.8. Average number of lambs per lambing _____

7.9. Occurrence of multiple births per ewe's life time _____

8. Breeding practices

8.1. Do you have ram? a. Yes b. No 8.2. If yes how many _____

8.3. If more than one, why do you need to keep more than one ram? _____

8.4. For how many years on the average is the same breeding ram serving in your flock? _____

8.5. Is there any special management for breeding ram? a. Yes b. No

8.6. If yes, specify type of management _____

8.7. Purpose of keeping ram

a. Mating

b. Socio-cultural

8.8. Source of ram (s)

a. Born in the flock

b. Purchased, private

c. For fattening Others (specify) _____
 c. Purchased in partner
 d. Rent

8.9. If you do not have breeding ram, how do you mate your ewe?

a. Neighbouring ram
 b. Unknown
 Others (Specify) _____

8.10. Do you practice selection for?

Breeding male a. Yes b. No
 Breeding female a. Yes b. No

8.11. Age of selection

Breeding male _____ months Breeding female _____ Months

8.12. Selection criteria for breeding ram?

	Tick Rank		
a. Appearance/conformation	<input type="checkbox"/>	<input type="checkbox"/>	List the top 3 preferred colour
b. Colour	<input type="checkbox"/>	<input type="checkbox"/>	_____
c. Horns	<input type="checkbox"/>	<input type="checkbox"/>	_____
d. Character	<input type="checkbox"/>	<input type="checkbox"/>	_____
e. Adaptability	<input type="checkbox"/>	<input type="checkbox"/>	
f. Growth	<input type="checkbox"/>	<input type="checkbox"/>	
g. Wool/hair	<input type="checkbox"/>	<input type="checkbox"/>	
h. Age	<input type="checkbox"/>	<input type="checkbox"/>	
i. Libido	<input type="checkbox"/>	<input type="checkbox"/>	
j. Ability to walk long distance	<input type="checkbox"/>	<input type="checkbox"/>	Unwanted colours
k. Tail type/length	<input type="checkbox"/>	<input type="checkbox"/>	_____
l. Pedigree	<input type="checkbox"/>	<input type="checkbox"/>	_____
Others (specify) _____	<input type="checkbox"/>	<input type="checkbox"/>	

8.13. Selection criteria for breeding ewe

	Tick Rank	
a. Size/appearance	<input type="checkbox"/>	<input type="checkbox"/>
b. Colour	<input type="checkbox"/>	<input type="checkbox"/>
c. Lamb survival	<input type="checkbox"/>	<input type="checkbox"/>
d. Lamb growth	<input type="checkbox"/>	<input type="checkbox"/>
e. Age at first sexual maturity	<input type="checkbox"/>	<input type="checkbox"/>
f. Lambing interval	<input type="checkbox"/>	<input type="checkbox"/>
g. Twinning ability	<input type="checkbox"/>	<input type="checkbox"/>
h. Milk yield	<input type="checkbox"/>	<input type="checkbox"/>
i. Ability to walk long distance	<input type="checkbox"/>	<input type="checkbox"/>
j. Tail type/length	<input type="checkbox"/>	<input type="checkbox"/>
k. Wool/hair	<input type="checkbox"/>	<input type="checkbox"/>

8.14. Breeding/mating

a. Controlled
 b. Uncontrolled

8.15. If uncontrolled, what is the reason?

a. Sheep graze together
 b. Lack of awareness
 c. Lack/insufficient number of ram
 d. Others (specify) _____

8.16. Type of mating used

a. controlled b. un controlled

8.17. Could you able to identify the sire of a lamb?
 a. Yes b. No

8.18. If yes, specify the criteria used to identify

19. Do you allow a ram to mate his

	Yes	No	Reason
a. Mother	<input type="checkbox"/>	<input type="checkbox"/>	_____
b. Daughter	<input type="checkbox"/>	<input type="checkbox"/>	_____
c. Sister	<input type="checkbox"/>	<input type="checkbox"/>	_____

8.20. Do you allow your ram to serve ewes other than yours?

	Reason
a. Yes	_____
b. No	_____

8.21. Do you allow your ewe to be served by anyone else ram?

	Reason
a. Yes	_____
b. No	_____

9. Castration and culling

9.1. Do you castrate?

a. Yes
 b. No

9. 2. If yes, reasons for castration

a. Control breeding
 b. Improve fattening
 c. Better temperament
 d. Better price
 Others (specify) _____

9.3. If no, give reason

9.4. At what age do you castrate?

(Tick one or more boxes)

a. < 3 months
 b. 3–6 months
 c. >6 months Specify _____

Season of castration

Reason

9.5. Who castrate for you? a. Myself b. use the service of extension staff c. use other people who are knowledgeable in traditional castration d. Others (specify) _____

9.6. Do you have any specific months for castration? a. Yes b. No.

9.7. If yes, specify! _____

9.8. What are the major characteristics of rams to be castrated (list and rank)? _____

9.9. Do you give supplementary feed for castrated sheep

a. Yes b. No

9.10. If yes, type of supplementary feed

a. _____
 b. _____
 c. _____

9.11. For how long do you supplement castrated sheep ? _____

9.12. Castration method

a. Modern b. Traditional Specify traditional method _____

9.13. Reasons for selling

a. Cash needed b. Disposal/culling

9.14. Which class of sheep do you sell first in case of cash needed?

- a. male lambs less than 6 months
- b. Female lambs less than 6 months
- c. Ram lambs between 6 months and one year
- d. Ewe lambs between 6 months and one year
- e. Breeding ewes
- f. Breeding rams
- g. Castrated
- h. Old ewes
- i. Old rams

Rank

9.15. Average market age in months Male _____ Female _____

9.16. Average culling age due to old age Male _____ Female _____

9.17. Is your sheep number increasing in the last 10 years?

a. Increased b. Decreased c. stable

9.18. What is the trend compared with other livestock?

	Increased	Decreased	c. Same	Reason
a. Compared with cattle	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
b. Compared with goat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
c. Compared with chicken	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____

10. Docking practice

10.1. Do you practice docking? a. Yes b. No

10.2. If Yes, Reason(s) for docking (list)

10.3. Who does docking for you? _____

10.4. How docking is practiced: a. Traditional ,specify _____ b. improved

10.5. For which sex do you practice? a. Male b. Female

10.6. Why do you practice only for females? _____

10.7. At which docking practice takes place? _____

10.8. What is the size of the cut out part in cm? _____

9. Where do you dispose the cut out? / For what purpose are using this part? _____

10.10. Any problem encountered when the practice is undertaken? _____ and how do you solve the problems? _____

11. Milking

11.1. Is the sheep milked? 11. 2. Milk production per day per ewe 11.3. Lactation length

a. Yes Average _____ Litres Average _____ Months

b. No

Maximum _____ Litres Maximum _____ Months
 Minimum _____ Litres Minimum _____ Months

11.4. Frequency of milking
 (Tick one box)

- a. Once a day
- b. Twice a day
- c. Three times a day

11.5. Average weaning age of lambs

- a. < 3 months (Tick one box)
- b. 3-4 months
- c. 5-6 months
- d. > 6 months

11.6. For what purpose you usually use sheep milk?

- a. children consumption b. adult consumption c. processing d. medicine
- e. others, specify _____

11.7. Who in the family consumes sheep milk? a. old people b. sick c. children. d. others _____

11.8. Do you process sheep milk? a. Yes b. No

11.9. Is there any taboo of consuming sheep milk? a. Yes b. No 9. If yes, please mention _____

11.10. Milk feeding up to weaning

- a. Unrestricted suckling
- b. Restricted suckling
- c. Bucket feeding

Others (specify) _____

12. Marketing

12.1. Where do you sell your sheep? a. farm gate b. Farmers in the nearby market c. Distant Market (list name) _____ d. others, specify _____

12.2. Which is most frequent? _____

12.3. Nearby market Distance a. < 2 km b. 2 to 5 km c. 5 to 10 km d. > 10 km

12.4. Which market is best in terms of price? _____

12.5. What is the problem to sale at best market? _____

12.6. To whom do sell sheep a. Consumer b. Trader c. Breeder d. Other Specify _____

12.7. Which is most frequent? _____

12.8. Is there seasonality in sheep price? a. yes b. No

12.9. At which period of time do you get better price? Month Reason

12.10. Reason for sale? a. Purchase of food grain b. Festivals (to fetch better price) c. School fee e. Purchase of veterinary supplies d. To reduce flock size e. saving

12.11. Price of sheep(Birr)	Average	Minimum	Maximum
a. Less than 6 months	_____	_____	_____
b. Ram lamb (6 mths to 1 year)	_____	_____	_____
c. Ram > 1 year	_____	_____	_____
d. ewe lamb (6 mths to 1 year)	_____	_____	_____
e. ewe (> 1 year)	_____	_____	_____

- f. Aged ram _____
- g. Aged ewe _____
- h. Castrated _____

12.12. Do you have access to market information during the last one year? a. yes b. No

12.13. If yes, what kinds of information and who provide for you?

12.14. Do you face any problem in marketing of your sheep?

- a. Tax burden
- b. unwanted broker disorder and high commission fees.
- c. seasonality of market demand and price.
- d. lack of market and price information.
- e. others _____

12.15. Average market age Male _____ months Female _____ months

13. HERD DYNAMICS

13.1. Is your sheep number increasing in the last 12 months?

- a. Increased
- b. Decreased
- c. Stable

12.2. Numbers of animals added to the herd in the reduced from the last 12 months (*Enter numbers*) months (*Enter numbers*)

12.3. Numbers of animals the herd in the last 12

	Males	Females
a. Born	_____	_____
b. Bought	_____	_____
c. Donated/gift	_____	_____
d. Exchanged	_____	_____
e. 'Rebi'	_____	_____
f. Share from 'rebi'	_____	_____

	Males	Females
a. Sold	_____	_____
b. Slaughtered	_____	_____
c. Exchanged	_____	_____
d. Died	_____	_____
e. Predator	_____	_____
f. Donated/gift	_____	_____
g. 'Rebi'	_____	_____

14. Constraints for sheep production

14.1. What are the main constraints for sheep production? Rank them according to their significance.

Constraints	Tick	Rank	Copping mechanism	Improvement options
a. Genotype				
b. Feed shortage				
c. Water shortage				
d. Disease				
e. Drought				
f. Market				
g. Lack of superior genotypes				
h. Predator				
i. Labor				

15. Trait Preference

15.1. Quality of traits perceived by owners for the sheep type

Trait	Not important	Poor	Average	Good	No opinion	Rank

Size						
Colour						
Horns						
Heat tolerance						
Cold tolerance						
Character						
Wool/hair						
Milk yield						
Meat quality						
Growth rate						
Ability to walk						
Fertility						
Longevity						
Disease tolerance						
Drought tolerance						
Tail fat						
Tail Type						
Others						

Appendix Table 1. The standard breed descriptor for qualitative traits of sheep developed by FAO (2012)

Character name	Description
Qualitative traits	Character states
Coat color pattern	plain, patchy/pied, spotted
Coat color type	black, dark red, light red, fawn, grey
Horn presence (at herd level; separately for males and females)	Percent of polled animals, percent of horned animals
Horn orientation (at flock level, separately for males and females)	Tips pointing laterally, upward, backward (indicate also if animal is polled, or horns are loose or just stumps)
Ear orientation	erect, semi-pendulous, pendulous, carried horizontally
Tail shape	cylindrical & straight, cylindrical & turned up at end, bilobbed without appendage, broad without lobe
Ruff	Present, absent
Horn	Present, absent
Face profile	straight, concave, convex, ultra convex
Tail type	thin, fat rump, thick at base, fat

Appendix Table 2. The standard breeds descriptor for quantitative trait of sheep developed by FAO (2012)

Quantitative Measurements	Description
Body weight(BW)	Live body weight (kg)
Body Length (BL)	Measured as the horizontal distance from the point of shoulder to the base of the tail
Chest Girth (CG)	The circumference of the body immediately behind the shoulder blades in a vertical plane perpendicular to the long axis of the body
Wither Height (WH)	the height of an animal from the bottom of the front foot to the highest point of the shoulder between the withers
Chest depth(CD)	Measured as the vertical distance from the top of the pelvic girdle to the ground
Ear Length (EL)	The length of the ear of the external side from its root on the poll to the tip.
Pelvic Width (PW)	The distance between pelvic bones across the dorsum
Scrotum Circumference (SC)	Pushing the testicles to the bottom of the scrotum and the greatest circumference measured
Tail Circumference (TC)	Circumference of the base of the tail
Tail Length (TL)	Distance from the base to the tip of the tail on the outer side of the tail

Appendix Table 3. Breeding practices of sheep in the study area.

Mating system	N	(%)
Controlled	116	90.6
Uncontrolled	12	9.4
Breeding Ram		
Yes	78	60.9
No	50	39.1
Purpose of keeping ram		
Mating	50	64.1
Social	6	7.7
Saving	22	28.21
Source of ram		
Born in the flock	64	82.05
Purchase	14	17.95
Could you able to identify the sire of a lamb		
Yes	84	65.62
No	44	34.38
Docking		
Yes	39	60.94
No	25	39.06

Appendix Table 4. ANOVA for ear length of indigenous sheep for the effect of sex, age and sex by age.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Sex	1	0.14514647	0.14514647	0.24	0.6249
Age	3	33.30065515	11.10021838	18.30	<.0001
SEX*Age	3	5.22588506	1.74196169	2.87	0.0357
Error	566	343.2366768	0.6064252		

Appendix Table 5. ANOVA for body weight of indigenous sheep for the effect of sex, age and sex by age

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Sex	1	760.645257	760.645257	28.19	<.0001
Age	3	6733.272210	2244.424070	83.18	<.0001
Sex* Age	3	50.993578	16.997859	0.63	0.5959

Error	566	15272.01978	26.98237
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Appendix Table 6. ANOVA of body length of indigenous sheep for the effect of sex, age and sex by age.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Sex	1	85.712473	85.712473	6.95	0.0086
Age	3	1864.698686	621.566229	50.43	<.0001
SEX*Age	3	11.446366	3.815455	0.31	0.8185
Error	566	6976.15782	12.32537		

Appendix Table 7. ANOVA for chest depth of indigenous sheep for the effect of sex, age and sex by age.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Sex	1	14.9835987	14.9835987	18.35	<.0001
Age	3	140.3971298	46.7990433	57.33	<.0001
SEX*Age	3	3.3443758	1.1147919	1.37	0.2524
Error	566	462.0404314	0.8163259		

Appendix Table 8. ANOVA for chest girth of indigenous sheep for the effect of sex age and sex by age.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Sex	1	279.025660	279.025660	6.91	0.0088
Age	3	6624.117042	2208.039014	54.71	<.0001
SEX*Age	3	54.623735	18.207912	0.45	0.7166
Error	566	22842.32798	40.35747		

Appendix Table 9. ANOVA for height at withers of indigenous sheep for the effect of sex, age and sex by age.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
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Sex	1	312.355619	312.355619	11.26	0.0008
Age	3	4428.193146	1476.064382	53.22	<.0001
SEX*Age	3	63.470845	21.156948	0.76	0.5153
Error	566	15698.80755	27.73641		

Appendix Table 10. ANOVA for pelvic width of indigenous sheep for the effect of sex, age and sex by age.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Sex	1	1.4272146	1.4272146	0.49	0.4835
Age	3	329.4391952	109.8130651	37.83	<.0001
SEX*Age	3	26.7315254	8.9105085	3.07	0.9485
Error	566	1642.835357	2.902536		

Appendix Table 11 .ANOVA for tail length of indigenous sheep for the effect of sex, age and sex by age.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Sex	1	61.332338	61.332338	1.92	0.1662
Age	3	3750.778759	1250.259586	39.18	<.0001
SEX*Age	3	11.464062	3.821354	0.12	0.0274
Error	566	18062.12072	31.91187		

Appendix Table 12. ANOVA for tail circumference of indigenous sheep for the effect of sex, age and sex by age.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Sex	1	60.5244004	60.5244004	6.12	0.0137
Age	3	153.1603056	51.0534352	5.16	0.0016
SEX*Age	3	65.9905865	21.9968622	2.22	0.0843
Error	566	5597.827073	9.890154		

Appendix Table 13. ANOVA for Scrotum circumference of indigenous sheep for the effect of age and sex by age.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age	3	760.7905003	253.5968334	7.93	<.0001
Error	124	3965.178250	31.977244		



Appendix figure 1. Interviewing a household at *Chelba* Kebele



Appendix figure 4. River water used for sheep at the study area



Appendix figure 2 .Sheep feeding on crop residue



Appendix figure 5. Collectors trekking sheep to *Gonjobe* market



Appendix figure 3. estimating the age of sheep using dentition



Appendix figure 6. Focus group discussion