CHARACTERIZATION OF BONGA AND HORRO INDIGENOUS SHEEP BREEDS OF SMALLHOLDERS FOR DESIGNING COMMUNITY BASED BREEDING STRATEGIES IN ETHIOPIA

M.Sc. Thesis

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CHARACTERIZATION OF BONGA AND HORRO INDIGENOUS SHEEP BREEDS OF SMALLHOLDERS FOR DESIGNING COMMUNITY BASED BREEDING STRATEGIES IN ETHIOPIA

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MASTER OF SCIENCE IN AGRICULTURE
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By

Zewdu Edea

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HARAMAYA UNIVERSITY

As Thesis Research advisor, I here by certify that I have read and evaluated this thesis prepared, under my guidance, by **Zedwu Edea**, entitled in ***Characterization of Bonga and Horro Indigenous Sheep Breeds of Smallholders for Designing Community- based Breeding Strategies in Ethiopia***. I recommend that it be submitted as fulfilling the Thesis requirement.

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DEDICATION

I dedicate this work to my late father Edea Bedada (1931-2001), for nursing me with affection and love and for his dedicated partnership in the success of my life.

STATEMENT OF AUTHOR

First, I declare that this thesis is my bonafide work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for an MSc degree at the Haramaya University and is deposited at the University Library to be made available to borrowers under the rules of the Library. I truly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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Place: Haramaya University, Haramaya

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BIOGRAPHICAL SKETCH

The author, Zewdu Edea, was born on January 21, 1980 in Goro Woreda, Bale Zone. He attended his elementary education at Gulbaduma Elementary School from 1986 to 1991. He pursued his junior secondary education at Meliyu Burka from 1992 to 1993. He attained his secondary high school study at Batu Terara Secondary School from 1994 to 1998. He then joined the then Alamaya University (Now Haramaya University) in 1998 and was awarded a BSc degree in Animal Sciences in 2001. After his graduation, he was employed by the Ministry of Agriculture and served as a junior lecture in Agarfa TVET College for two years. He served in the Oromia Agricultural Research Institute (OARI) at Yabello Pastoral and Dry land Agriculture Research Center, as a junior researcher in livestock production division for three years. In October 2006 he joined the School of Graduate Studies at Haramaya University for a Master of Science study in Animal Genetics and Breeding.

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LIST OF ABBREVIATIONS

ATVET	Agricultural Technical, Vocational and Educational Training
BOKU	University of Natural Sciences and Applied Life Sciences
CSA	Central Statistic Authority
CV	Coefficient of Variation
DAD	Domestic Animal Diversity
DAD-IS	Domestic Animal Diversity Information System
DAGRIS	Domestic Animal Genetic Resources Information System
EARO	Ethiopian Agricultural Research Organization
ESAP	Ethiopian Society of Animal Production
FAO	Food and Agriculture Organization of the United Nations
GLM	General Linear Model
HARDO	Horro Agriculture and Rural Development Office
ICARDA	International Center for Agricultural Research in the Dry Areas
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
LSM	Least Square Means
MoARD	Ministry of Agriculture and Rural Development
NASS	National Agricultural Sample Survey
NRC	National Research Council
OARI	Oromia Agricultural Research Institute
PA	Peasant Association
SAS	Statistical Analysis System
SD	Standard Deviation
SE	Standard Error
SPSS	Statistical Package for Social Science
SUDCA	Sustainable Development Consulting Association

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ABSTRACT

In the framework of designing community-based breeding strategies for indigenous sheep breeds of smallholders in Ethiopia, a survey of production system and on-farm characterization of Horro and Bonga sheep breeds, was undertaken in the Horro and Adiyo Kaka districts, respectively. Purposive and random sampling was employed as sampling technique. Detailed structured questionnaires, focus group discussions, field observations of animals, body measurements, and secondary data collection were employed to produce the data. Body weight, linear body measurements, and qualitative records were taken and observed from 762 Bonga sheep and 816 Horro sheep. For the analyses of quantitative data, the main effects of breed and dentition were fitted to the model within each sex groups. Results revealed that the mean flock sizes for Adiyo Kaka and Horro districts were 11.28 ± 1.27*and* 8.20 ± 2.05, *respectively. Sheep have multi-purpose roles in both production systems. Among the reasons for keeping sheep, source of income was ranked highest. Age at first lambing for Bonga and Horro sheep was 14.9 ± 3.1 and 13.3 ± 1.7 months, respectively. Average lambing intervals were 8.9 ± 2.1 and 9.2 ± 2.4 months, for Bonga and Horro, respectively. Disease, feed shortage, and predators were the most pertinent constraints for sheep production in that order for farmers in Horro. In Adiyo Kaka, disease, labor shortage, predators were ranked as first, second and third based upon their significant influence on sheep productivity. The mean body weight, body length, chest girth, wither height, tail circumference and tail length for Bonga females were 31.87 ± 0.19kg, 69.16 ± 0.15 cm, 72.92 ± 0.17cm, 68.12 ± 0.14cm, 15.92 ± 0.30 cm and 32.07 ± 0.37 cm, respectively. The corresponding values for males of the same breed were 29.70 ± 1.17kg, 68.27 ± 0.89cm, 70.0 ± 1.026cm, 66.53 ± 0.85cm, 20.85 ± 0.97cm and 35.40 ± 0.96cm, respectively. For Horro females, the values in the same order were 27.65 ± 0.21, 67.40 ± 0.164cm, 73.81 ± 0.19cm, 69.43 ± 0.16cm, 16.08 ± 0.15cm and 37.52 ± 0.95, respectively. The values of the measurements for males, on the other hand, were 31.66 ±1.23kg, 69.30 ± 0.94cm, 76.12 ±1.08cm,71.66± 0.90cm,23.46±0.97cm and 37.52 ± 0.95cm,respectively.Within each sex, it was found that breed had significant effect on live body weight and most of the body measurements. Accordingly, Horro females had significantly (P<0.01) greater values for chest girth, wither height and tail length than Bonga females. On the contrary, Bonga ewe's had significantly (P<0.01) higher values than Horro with respect to body weight, body length, chest width, pelvic width and ear length. Horro male had higher values (P< 0.01) for chest girth; wither height and scrotal circumference than Bonga males. With the exceptions of ear length, tail circumference, tail length and body condition score, within the range of age studied, age was found to have a significant influence (P< 0.01) on most body measurements in females. The mean body weight and body measurements of animals at dentition 1 and 2 were significantly lower than those of the dentition class 3 to 4-years-old sheep. The correlations between body weights and body measurements at different ages were positive* *and significant ($P<0.01$). The highest correlation coefficient was found between body weight and chest girth in both of the breeds, sexes, and age groups. The regression analysis to predict body weight from linear measurements indicated that body weight, in most of the cases, could be predicted with a higher level of accuracy from more than one independent trait. However, for practical point of view, the use of chest girth as estimator variable for body weight was suggested due to ease of measurement under farmers' conditions. To realize full benefits of the forthcoming breeding strategies, concurrent improvement in the non-genetic factors (disease and feed) is central.*

1. INTRODUCTION

Ethiopia's sheep population, estimated at 24 million heads, is found widely distributed across the diverse agro-ecological zones of the country (CSA, 2004). Approximately 75% of the sheep are kept in small scale mixed farms in the highland regions, which cover regions of over 1500 altitude and receive over 700 mm of annual rainfall, while the remaining 25% are found in the lowlands (Tibbo, 2006). Sheep are traditionally kept in smallholdings and are associated with the small-scale resource poor livestock keepers.

In Ethiopia, sheep and their products provide direct cash income through the sale of live sheep and hides. Sheep are living bank for their owners and serve as source of immediate cash need and insurance against crop failure especially where land productivity is low and erratic rainfall, severe erosion, frost, and water logging problems. Thus, sheep in the small holder farming system provide continuous service to the economic stability and effective operation of the crop production system (Gryssels and Anderson, 1983). Sheep also play an important role in cultural, social livelihoods and religious values for large and diverse human population. Efficient use of sheep will result in enhanced farm family nutrition and increased farm productivity. Hence focus on their development can be one way of reducing poverty and ensuring food self sufficiency among the poor.

In Ethiopia, in spite of the large population of sheep and the great role of sheep both to the livelihood of resource-poor farmers and the national economy at large; the current level of on-farm productivity in the smallholder production systems is low. Their productivity is constrained by various complex factors involving biological and environmental aspects as well as socioeconomic factors. The sheep sub-sector has received only diminutive attention in the country for its improvement. Past efforts initiated by government and non-governmental organizations for sheep improvements were limited to crossbreeding of indigenous sheep with exotic breeds for distribution of crossbred rams to the farmers. This approach was rarely successful due to incompatibility of the genotypes with the farmers' breeding objectives and the production systems (Tibbo, 2006). Little attempts were made to develop strategies for genetic improvement of the indigenous sheep breeds at the national level.

The essential procedure for genetic improvement of livestock involves identification of the breeds or strains of livestock and the type of environment in which they are kept, description of the breed characteristics, their adaptation as well as production potentials in those environments (Workneh, 1992). Therefore, it doesn't appear that the conventional breed improvement that is top-bottom approach can be expected to produce worthwhile improvement in sheep production across the whole spectrum of production system (FAO, 1990).

For sustainable genetic improvement of traditionally managed sheep, development of community- based strategy which takes into consideration the need, knowledge and aspiration of local community and participation of all stakeholders is important. This will come into practice only when sheep owners and other actors participate in the process of identifying the constraints and deciding on the alternative breeding strategies. Ideally, designing and implementation of sustainable breeding programmes require a good understanding of the production system and the alternative importance of the different constraints in the system; clear understanding of selected breeding objectives supported by the farmers and accurate methods of identifying the superior genotypes (Baker and Gray, 2003).

Given the current and future growing demand for sheep products and role of sheep in food production in the subsistence Ethiopian agriculture, a step towards sustained use of the existing resource is justifiable. Their improvement also play great role to reduce poverty among the rural poor and to produce more food to feed the ever-increasing human population. In recognition of the drawbacks of the past interventions and due to absence of sound breeding strategies for smallholders sheep breeds; ILRI in collaboration with ICARDA, BOKU and Ethiopian Research and development Institutions are designing community-based breeding strategies for selected smallholder indigenous sheep breeds of Ethiopia.

In the designing of community-based breeding strategies for small holder sheep owners, information needs to be collected on production system, breed description, breeding objectives and socio-economic condition of the farmers. The information will provide the basis to identify potential opportunities. Furthermore, a good understanding of the environment in addition to knowledge of available breed resources is required to make appropriate decisions on breed choice and necessary improvement interventions. Information on morphological characterization of Horro and Bonga sheep breeds are either based on limited samples of the wide variation of the whole population or not updated. Lack of breed level information would hinder their efficient utilization and conservation. Thus, this particular research proposal is part of the project on designing community- based breeding strategies for selected indigenous sheep breeds of Ethiopia. The objectives of this study were:

1. To characterize the productive and, reproductive performances and physical characteristics of Horro and Bonga indigenous sheep breeds and the production systems for designing community-based breeding strategies; and
2. To develop prediction equation for estimation of body weights from various body measurements in Horro and Bonga sheep breeds under field conditions.

2. LITERATURE REVIEW

2.1. Origin of Sheep

Sheep belong to the sub-family Caprinae, family Bovidae. The genus *Ovis* include all sheep, while domesticated sheep belong to the species *Ovis aries.* Records of domestication of sheep date back to as early as 7000 in near east. The home of wild sheep is the mountain ranges of central Asia, from where sheep spread westwards into Europe and eastwards into North America during the Pleistocene period (Ryder, 1983). Unlike other livestock species where the number of presumed wild progenitors is limited, for domestic sheep (*Ovis Aries*), a large number of wild and possibly ancestral species and sub-species exists (Ryder, 1984). Further, all the wild species are capable of interbreeding with one another, as well as with domesticated sheep producing fertile hybrids (Franklin, 1997). Several wild sheep, notably the mouflon, urial, and argali have been proposed as ancestors of domestic sheep or are believed to have contributed to specific breeds (Ryder 1984). Therefore, to distinguish domestic sheep from their wild relatives, all domestic sheep are classified as *Ovis aries.* The taxonomy of wild sheep is controversial hindering unequivocal identification and classification for conservation management of this important genetic resource for the major agricultural species (Geist, 1991). This difficulty arises from the bewildering number of breeds and the marked changes produced by domestication. Sheep are extremely versatile and since domestication they have spread throughout the world and currently there are more than 850 distinct breeds of sheep scattered throughout the world. Accordingly, several Eurasian wild sheep of the highly polymorphic genus *Ovis* have been proposed as ancestors of domestic sheep or are believed to have contributed to the specific breeds.

2.2. Origin of Ethiopian Sheep Breeds and Genetic Diversity

A number of theories have been advanced as to the time and the routes by which sheep were introduced into Ethiopia. African sheep are thought to be of Near Eastern origin (Epstein, 1954; Epstein, 1971). 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 constitutes 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; Epstein, 1971; Ryder, 1984). Accordingly, African sheep have been traditionally described and classified based on their tail type (Epstein, 1971; Ryder, 1984). Ethiopia is believed to be one of the major gateways for domestic sheep migration from Asia to Africa. Ethiopia has a vast genetic resource of sheep. Although in the country as many as 14 sheep breeds/types have been identified so far, sizable populations of sheep are non-descript due to indiscriminate breeding and mixing of breeds. They are widely distributed across the major agro-ecological zones and geographical regions. About 75% of the sheep population inhabited the highland part of the country while the remaining 25% are distributed in the lowlands (Tibbo, 2006). Indigenous sheep genetic resources have developed specific adaptations to survive and produce under adverse local environmental conditions (climatic stresses, poor quality feed, seasonal feed and water shortage, endemic disease and parasite challenge) that make them suitable for use in the traditional, low-input production system (IBC, 2004). As a result they are less subjected to selection for functional traits and their productivity is low.

Sheep types in Ethiopia are highly affiliated to specific ethnic communities. A number of traditional breeds are reared by and named after specific communities. As could be noted, the indigenous sheep breeds are usually named after specific ethnic groups (e.g. Afar) or geographical locations (e.g. the Horro, Menz). Similarly, the classification of these major types is largely based on morphological or physical characteristics. Most of the investigations done up to now have been carried out on research stations, on-farm performance studies are very few. This in turn affects the understanding of the factors which influence sheep production at the farm level and also the introduction of specific interventions by development organizations.

According to the review by Workneh *et al*. (2004), there are six recognized indigenous sheep breed types in the country which falls into three breed groups: the fat-tailed hair type, the fat-tailed coarse wool sheep and the fat-rumped hair sheep. Sisay (2002) classified the sheep population of Amhara region based on their geographical location into four major clusters.

These include: the central highland sheep, rift valley, north- western highland sheep and north-western lowland sheep.

Recent molecular study of the Ethiopian sheep population by Solomon *et al*., (2007) classified the 14 sheep population into six breed groups and nine breeds (Table 1). However, the study is not covered areas like Benishangul Gumuz, some areas of southern Ethiopia and Tigray which might leave room for presence of other sheep breeds or strains. The study indicated low but significant genetic differentiation among the populations. For long past Bonga sheep breed was consider as the same breed with Horro sheep breed. The same study identified Bonga and Horro as separate breeds out of the cluster. Horro breed is the most dominant sheep in the western part of the country. It is named after one of the localities it inhabits and is distributed in the area which lies within 35 ^{o} to 38 ^{o} E and 6 ^{o} to 19 N ^{o}. The altitude of the natural habitat of Horro sheep is between 2500 and 3000m (Galal, 1983). Bonga sheep is widely distributed in the south west parts of the country in wet highland ecologies.

Table 1. Indigenous sheep breeds in Ethiopia

Breed group	Breed	Population
Short-fat-tailed	Simien	Simien
	Short fat –tailed	Sekota, Farta, Tikur, Wollo, Menz
Washera	Washera	Washera
Thin-tailed sheep	Gumuz	Gumuz
Long-fat-tailed	Horro	Horro
	Arsi	Arsi- Bale, Adilo
Bonga	Bonga	Bonga
Fat-rumped sheep	Afar	Afar
	Black Head Somali	Black Head Somali

Source: Solomon *et al.,* (2007)

2.3. Major Sheep Production Systems in Ethiopia

According to FAO (2000), a production environment encompasses all input-output relationships, over time, at a particular location. The relationships will include biological, climatic, economic, social, cultural, and political factors, which combine to determine the productive potential of a particular livestock enterprise. Animal uses, genetic variance, and abundance of genetic diversity change across production systems. As different production systems evolve varying pressures are placed upon the existing breeds (FAO, 2004). Marked differences between production systems, such as product needs and prices, disease occurrence, spread and control methods and climatic differences will often require, for each environment, the use of quite different genetic resources to realize sustained production of food and agriculture (FAO, 2000).

The major sheep production systems in Ethiopia include the traditional management system (the pastoral and agro-pastoral and mixed crop- livestock systems) and the government ranches, characterized by different production goals and priorities, management strategies and practices, and constraints (Tibbo, 2006). Generally, the mixed crop-livestock systems are the most densely populated and hold the largest number of ruminant livestock. In the mixed farming system of the highlands of Ethiopia sheep depend mostly on grazing fallow lands, waterlogged lands, natural pasture and crop residues usually with no extra-supplement and receive minimum health care.

In the lowland part of the country small ruminant production is associated with the purely livestock based nomadic and transhumance pastoral production systems based largely on range, primarily using natural vegetation. The pastoral systems are found mainly in the medium-to-low potential areas where crop production is difficult due to low and erratic rainfall. In this system though there are cultivations in some areas, livestock production forms an integral part of the socio-cultural life for the vast and diverse human populations. Most of the livelihoods of the inhabitants depend on livestock products and live animals sales or exchange (Coppock, 1994). Risk avoidance is an important integral part of the breeding objectives in those areas. People moves periodically with their livestock in search of feed and water for their animals. In the lowlands of Ethiopia, livestock is comprised of large sheep flocks, 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 (EARO, 2000). The government ranch is accounted for very small proportion of sheep production system in Ethiopia. It was found in government sheep breeding, and multiplication centers (Tibbo, 2006). This include government owned ranches such as Horro Guguduru ranch, which was closed due to high sheep mortality, the Debre Berhane and Amed Guya ranch involved in the production and distribution of crossbred rams to the farmers.

2.4. Socio-Economic Importance of Sheep

Sheep are of great importance as major sources of livelihood (Kosgey, 2004) and contribute to the sustenance of landless, smallholder and marginal farmers especially to the poor in the rural areas throughout the developing countries. The ownership of small ruminants is regarded as a safe investment for the family as well as to gain social prestige within the community. They are sold to meet compelling family financial obligations or slaughtered for consumption at home or festivals. The small size of the animal, their high reproductive efficiency, low initial investment make them suitable for rearing in the small holder farmer (Ademosum, 1994).

In Ethiopia, together with goat they provide about 12% of the value of livestock products consumed and 48% of the cash income generated at farm level, 46% of the value of national meat production, 25% of the domestic meat consumption with production surplus, 58% of the value of hide and skin production, 40% of fresh skins and hides production and 92% of the value of semi-processed skins and hides (Zelalem and Fletcher, 1991). The annual national mutton and goat meat production is 78 and 62 thousand MT, respectively, largely because of the high average off take rates estimated at about 35% for sheep and 38% for goats (Workneh, 2006). Sheep and goats, respectively, contribute some 20.9% and 16.8% of the total ruminant livestock meat output or about 13.9% and 11.2% of the total domestic meat production, with a live animal and chilled meat export surpluses. Per capita consumption of sheep and goat meat (kg/person per year) in Ethiopia is 2.1 kg (EARO, 2000). The share of small ruminants to the total milk output is estimated at 16.7% with the major production coming from goats (ILCA, 1991).

2.5. Animal Genetic Resources Characterization

Domestic Animal Diversity (DAD) is the spectrum of genetic differences within each breed, and across all breeds within each domestic animal species, together with the species differences; all of which are available for the sustainable intensification of food and agriculture production (FAO, 2000). Farm animal genetic resources have values and roles as source of food, energy, fuel and fertilizer, social and cultural assets, income, and in risk management (Bodo, 1987; FAO, 1999). Animal genetic diversity allows farmers to select stocks or develop new breeds in response to environmental changes, threats of disease, new knowledge of human nutrition requirements, changing market conditions and societal needs, all of which are largely unpredictable (FAO, 2000). Important economic gains may occur from the appropriate choice of the livestock genetic resources correctly utilized in a given production system. By using the right type of animal, without changes either in nutrition, health, or other inputs, profit can be considerably increased. Conversely, losses can result from the inappropriate choice of breed or crossbred. The choice of germ-plasm is an integral element in the production system and it must be carefully matched to the other available inputs (Madalena, 1993). Breed characterization has a paramount importance for efficient utilization and conservation of farm animal genetic resources. Absence of adequate information on the characteristics of breeds potentially leads to miss decision and genetic erosion through cross breeding, replacement and dilution.

The first phase of characterization is surveying to identify populations based on morphological descriptors and describe their geographical distribution, uses, and husbandry and production environments. Morphological or phenotypic characterization has been suggested and used to describe and classify wild species and breeds of farm animal species.

Characterization of animal genetic resources includes all activities associated with the description of animal genetic resources aimed at better knowledge of these resources and their state (FAO, 2000). There are two types of breed characterization: phenotypic and genotypic characterization. The genetic relationship between breeds can be quantified by estimating allelic frequencies from biochemical or DNA analysis (NRC, 1993). The classical description of breeds (coat color, horns, tails type, *etc.*) is based upon phenotype. Phenotypic characterization can be complementary to the powerful biotechnological tools for measuring genetic diversity at the level of the genome.

2.6. Determinants of Success and Failures in Breeding Programmes

Despite the large number and importance of adapted indigenous sheep breeds in the country, less emphasis has been given for their development. Breeding strategies implemented in developing countries in the past has been concentrated on the importation of higher-producing exotic temperate breeds that were developed for high-input, production environments, and often neglect desirable characteristics of indigenous breeds. Those efforts did no include intangible benefits in the estimation of economic values of breeding goal traits. Due to misassumption by planner and funding agencies farmers are pushed by economic forces to adopt germ- plasm for short benefits without properly accounting for long -term sustainability (Kiwuwa, 1992). In Ethiopia crossbreeding of the indigenous sheep breeds with exotic breeds (Bleu du Maine, Merino, Rambouillet, Romney, Hampshire, Corriedale, and Awassi) were made since early 1960 to improve growth and wool yield (Tibbo, 2006).

However, such genetic improvement programmes failed due to poor planning and due to the fact that they were implemented without considering all the needs of sheep owners and stakeholders in decision making and the program had no regard for the potential of indigenous breeds (Hassen *et al*., 2002; Kosgey, 2004). According to these authors, Ethiopian indigenous sheep breeds can be as productive if not more productive than exotic sheep breeds if proper strategies are designated to improve their genetic make up and the environment. Workneh *et al*. (2003) also reported higher net benefits for the indigenous goat flocks of the Short eared Somali than their crosses with the Anglo-Nubian goat breed under improved management in Eastern Ethiopia. Besides lacking sustainability the conventional approach further contributed to the erosion of local breeds adapted to the lower input mixed farming and pastoral production systems found throughout the developing world (ILRI, 1999).

Failure on the part of the conventional approaches could also be associated to lack of analysis of the different socio-economic and cultural roles that livestock play in each situation, usually leading to wrong breeding objectives and neglect of the potentials of various indigenous breeds of livestock. As a whole, definition of comprehensive breeding objectives incorporating the specific, immediate and long-term social and economic circumstances of the target groups as well as ecological constraints were found lacking in the past livestock development projects (Kosgey *et al.,* 2006). As described by Kosgey (2004) designing of sustainable community-based breeding programmes in developing countries at the first step need detail understanding of the socio-economic related factors that influence small ruminant production. This is due to the fact that socio-economic factors have a decision making effect on animal and farm management (Verbeek *et al*., 2007).

There are many important circumstances that determine the scope of opportunities and constraints of the breeding programme. According to Kosgey *et al.* (2006) determinants of success in breeding programme includes, agricultural policy and market, environmental conditions, characteristics of animal populations and infrastructure available. Similarly, these authors stated that in designing breeding strategies it is a pre-request to consider the environmental conditions, the production system, and the purpose for which the animals are bred and the market demands. Infrastructure includes a broad range of essential inputs, which must be available for the breeding programme to be successful. These embrace trained staff, facilities for breeding animals and logistics for dissemination of germ plasm, methods, and means for recording, handling of data and evaluation of animals, decision-making bodies and finances (Kosgey *et al.,* 2006). Furthermore, to improve any breed or population it is important to know the genetic potential of the population and its performance under the prevailing environmental conditions. Likewise, Ethiopia is endowed with diverse sheep genetic resources and there is promising potential for improvement if the relative merits and appropriate exploitation of these merits is in place (Tibbo, 2006).

2.7. Need for Livestock Genetic Improvement

Currently there is rapid human population growth, dramatic urbanization and economic growth in developing countries. Demand for livestock products will enormously increase and it has been postulated that in developing country demands for meat and milk up to 2020 is expected to increase dramatically by 2-8% and 3.3%, respectively per year (Delgado *et al.,* 1999). The current level of livestock productivity in Ethiopia is far below to meet this demand. Contribution from sustainable increase in livestock production would therefore be desirable in order to meet the demands of the human population on livestock and their products. Increases in production of food of animal origin can be achieved through rational utilization of existing animal genetic resources.

Improvement in the performance of small ruminants (sheep and goat) can be achieved through improvement in management (better feeding, housing, and health care) and through genetic improvement by the use of genetically superior animals (Singh and Acharya, 1981). Considering the huge potential the country is endowed with for sheep breeds and population, systems on how to deliver genetic improvement for these resources under traditional production circumstances will contribute in poverty reduction and improvement in the well being of the rural resource poor pastoralist and farmers. However, lack of sustainable breed improvement strategy remains the most challenging for developing countries and Ethiopia is not an exceptional. The presence of genetic variation among the indigenous sheep breeds for productivity and survival (DAGRIS, 2004; Tibbo, 2006) is untapped opportunity to improve the productivity of these recourses either through between breed selections or within breed selection.

2.8. Indigenous Knowledge and Community/Village- based Breeding Strategies

Farmers and pastoralists have a deep understanding of how to influence animal populations with regard to desired characteristics under their respective environmental conditions. As the pastoralist and farmers pass on their knowledge and cultural identity orally from one generation to the next, their animal related knowledge is not systematically documented to the understanding of outsiders. To bring sustainable improvement in the small holders flock through community- based strategies a good understanding of the community’s indigenous knowledge of their animals is crucial (Sölkner-Rollefson, 2003).

Community-based management of Animal Genetic Resources is defined as a system of animal genetic resources and ecosystem management in which the community is responsible for decisions on defining, prioritizing, and implementing actions on all aspects of conservation and sustainable use of animal genetic resources. Community-based breeding enhances the efficient utilization and conservation of indigenous farm animals by maintaining genetic variation and minimizing counterproductive effects of livestock production on the natural environment (Wollny, 2003). Further community-based breeding strategies can serve as the most sustainable means of improvement and conservation of indigenous animal genetic resources and has received increasing attention (Rege, 2003). A village breeding programme is characterized by smallholder farming communities, often at subsistence level, combined with a low probability of changes in the environment, i.e. major constraints of disease, feed and land shortage are prevailing (Wollny, 2003).

Presently, community-based genetic improvement strategies are being advocated for smallholder (Kahi *et al.,* 2005). Unlike the conventional top-bottom approach, community-based breeding strategies basically needs detailed understanding of the community's indigenous knowledge of farm animals regarding breeding practices and breeding objectives, considered the production system holistically and involves the local community at every stage starting from the planning and operation of the breeding programme (Baker and Gray, 2003; Sölkner-Rollefson, 2003).

2.9. Flock structure and Ownership Patterns

The flock structure or flock composition refers to the age and sex profile of the flock i.e, the relative numbers of sheep with respect to age and sex. The flock owner determines the flock composition 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 production objective. Information on flock structure shed light on 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 for casting flock productivity (ILCA, 1990). In Africa, sheep ownership pattern vary and individual ownership is greatest in the dry areas (Wilson, 1982). Zelalem and Fletcher (1991) indicated that sheep flocks in *dega* were significantly larger than sheep flocks in *woindega*. 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.

Flock structure is the proportion of the flock which is formed by different age and sex classes. It may indicate the production objectives of the producers. Low proportion of young animals in the flock would imply high pre weaning lamb mortality or adult mortality is minimal. On the other hand it may mean that more lambs were sold during the year. In pastoral areas like Afar where the livelihood is primarily dependent on milk, they keep female animals that account for over 90% of the total flock (Wilson, 1982). Study carried out in the central highlands of Ethiopia indicated that out of the total sheep considered 64.4% were females, 28.1% males and 4.6% castrates (Abebe, 1999). Results of production system study conducted in eastern Wollegga and western Shoa zones (Solomon *et al*., 2005) have also indicated that about 72.2% of the sheep flocks are female animals of which 65.2% are above 1 year of age.

2.10. Reproductive Performances

Good reproductive performance is a prerequisite for any successful genetic improvement and it determines production efficiency. Study suggests that differences exist in reproductive performance between indigenous sheep breeds and their variation allow for the selection of suitable breeds for a given environment (Mukasa- Mugerwa and Lahlou-Kassi, 1995).

Where breeding males are available in the flocks, age at first parturition is a good indicator of early sexual maturity in ewes. It is an economically important trait as greater population turnover and more rapid genetic progress can be obtained when sheep produce their first progenies at an earlier rather than later age. Early maturing females are also known to have a relatively long and fruitful reproductive life (Mukasa-Mugerwa and Lahlou-Kassi, 1995). The most important components of reproductive performance in sheep are age at first lambing, lambing interval, litter size and ewe productive life.

2.10.1. Age at first lambing

The age at first lambing of African sheep seems to have wide variation and might be attributed to breed, husbandry and management practices. Poor nutrition and disease can also leads to delayed age at first lambing through limiting early animal growth. Year and season of birth in which the ewe lamb was born influence age at first lambing through their effect on feed supply and quality. The type of birth of the ewe significantly affects the age at which the ewe first lambed. Offspring of young and old ewes mature later than those from dams in the intermediate age groups (Wilson, 1986). The age at first lambing for some of indigenous breeds is given in Table 2.

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

Breed/type	AFL(months)	Source
Gumuz	13.67	Solomon (2007)
Menz	16.5	Gautsch (1987))
Menz	15-22	Abebe (1999)
Menz	17.06	Niftalem (1990)
Local Sheep in Adaa Liban	17.07	Samuel (2005)
Thin-tailed sheep	13.70	Mukasa-Mugerwa *et al*. (1986)
Washera	15.46	Mengiste (2008)
Blackhead Ogaden	23.56 ± 3.63	Fikrte (2008)
Yankasa	533.1days	Osuhor *et al*. (1997)
Djallonke	429.8±71.9	London (1993)

Under most traditional system, sheep are not breed at an early age with the assumption that breeding prior to attainment of adequate body weight may depress subsequent lambing (Wilson and Durkin, 1983). On comparison of productivity of indigenous sheep in the highlands of east Africa average age at first lambing was shorter (495 days) for Menz (Gautsch, 1987). Improvement in management and early introduction of maiden ewes for breeding will modify age at first lambing (Sulieman *et al.,* 1990). Age at first lambing is related to season of birth (Niftalem, 1990; Gbangboche *et al*., 2006). The difference attributed to the variation in availability and quality of feed resource across the difference seasons. But, none significant of season of birth on age first lambing was reported for Washera sheep (Mengiste, 2008). Wilson and Murayi (1988) investigated that lambs born for twins had longer age at first lambing than their counterpart single born lambs.

2.10.2. Lambing interval

Lambing interval is defined as the interval between two consecutive parturitions. It has three phases: the gestation period, the postpartum anoestrus period and the service interval. Lambing interval has an important influence on a sheep production enterprise. Lambing interval is one of the main components of reproductive performance which is affected by the breed (Wilson and Durkin, 1988), season (Abebe, 1999), year of lambing (Niftalem, 1990), season (Mengiste, 2008) parity of ewes, post-partum body weight and management practice (Gautsch, 1987), type of management, nutrition, type of mating (Mukasa-Mugerwa and Lahlou-Kassi, 1995; Gbangboche *et al*., 2006). Management practices and restrictions on breeding also prolong the interval between lambing (Suleiman *et al.,* 1990). Ewes with higher post –partum weights showed reduce lambing intervals (Gautsch, 1987). Mengiste (2008) working on Washera sheep reported shorter lambing interval for ewes lambed in wet season than those delivered in dry season of the year. The same author found that as parity increase the lambing interval showed a decreasing trend.

Through the provision of satisfactory nutrition and proper management in the tropics, it is practically possible to attain three lambings in two years (Agyemang *et al.,* 1985; Gautsch *et al.*, 1986) Coop and Devendra (1982) stated that frequent lambing put more stress on the ewe unless provided with appropriate diet. In the Shale type sheep the interval following the birth of male lamb was on average longer than that following female animal (Wilson and Durkin, 1983). A longer lambing interval on the station flocks of African long fat-tailed sheep in Rwanda than most of the intervals reported from African traditional systems where no practice to control breeding were practiced (Wilson and Murayi, 1988). Lambing interval for different sheep breeds is summarized in Table 3.

Table 3. Lambing intervals (LI) of some African sheep breeds/types

Breed/type	Country	LI (days)	Source
Menz	Ethiopia	381-409	Niftalem (1990)
Local sheep around Dire Dawa	Ethiopia	336-338	Aden (2003)
Menz	Ethiopia	229-273	Abebe (1999)
Gumuz	Ethiopia	199.2±33.9	Solomon (2007)
Washera	Ethiopia	271.1±3.6	Mengiste (2008)
Shuger	Sudan	449	Sulieman *et al*. (1990)
Dubasi	Sudan	425	Sulieman *et al*. (1990)
Sahel	Mali	261	Wilson and Durkin (1983)
Washera	Ethiopia	271.1±3.6	Mengiste (2008)
Black head Ogaden	Ethiopia	313.8	Fikrte (2008)

2.10. 3. Litter size

Litter size is largely determined by ovulation rate but is also modified by fertilization rate and embryonic and fetal losses (Gatenby, 1986). The main factors influencing ovulation rate in the ewes are breed and level of nutrition while season and age related factors are also important. Ovulation rates vary among breeds, increase with ewe age up to 6-7 years and among seasonal breeders are greatest in the first half of the breeding season (Haresign, 1985). Level of nutrition has effect on litter size in that, poor nutrition during service period lead to reduced ovulation rates and increase embryonic mortality and consequently decrease litter size (Gautsch, 1987). The percentage of ewes having twins in tropical sheep breeds, generally range between 0 and 50% (Gatenby, 1986) and while under traditional management conditions the percentage tends to fall below 10%. Mean litter size of Horro sheep was reported to be 1.34 (Solomon and Gemeda, 2000). The authors also reported that litter size increased with parity from 1.26 at the first parity to 1.44 for parities five and above. Litter sizes of 1.14 ± 0.01 and 1.04 were reported for Menz sheep under village condition (Agyemang *et al.,* 1985). Litter size is influenced by the plane of nutrition, as the availability and quality of feed impact rate ovulation and embryo survival (Gatenby, 1986; Gautsch, 1987).Some representative litter size of indigenous sheep of Ethiopia is presented in Table 4.

Table 4. Litter size of Ethiopian indigenous sheep breeds

Breed /Type	Production System	Litter size	Source
Menz	On- station	1.08	Gautsch (1987)
Menz	On-farm	1.14	Agyemang *et al.* (1985)
Menz	On-station	1.13	Mukasa-Mugerwa *et al.* (2002)
Gumuz	On-farm	1.17	Solomon (2007)
Horro	On-station	1.34	Solomon and Gemeda (2000)
Horro	On-station	1.14	Mukasa-Mugerwa *et al.* (2002)
Horro	On-station	1.34	Abegaz *et al.* (2002)
Menz	On-farm	1.02	Niftalem (1990)
Thin tailed	On-farm	1.30	Mukasa-Mugerrw and Teklye (1988)
Afar	Pastoral	1.03	Wilson (1982)
Black Head Somali	On- station	1.04	Galal (1983)
Washera	On-farm	1.11	Mengiste (2008)

2.11. Disease and Mortality of Sheep

Although indigenous sheep breeds are fairly well adapted to the tropical environments, the majority of animals are raised traditionally under extensive free-roaming management systems with no specialized input into housing care, nutrition or disease treatment or prevention. The type and impact of diseases on production varies with the level of management. Pre-weaning lamb mortality before weaning in traditionally managed flocks in the tropics has been reported as 10 to 30% (Gatenby, 1986) representing a serious reduction in biological efficiency because resources invested in dams to initiate and maintain pregnancy are wasted.

Difference in pre-weaning mortality could be attributed to breed differences. Tibbo (2006) working on indigenous sheep breeds of Ethiopia reported a pre-weaning mortality of 33.1% for Horro and 19.2% for Menz sheep. Solomon and Gemeda (2000) reported mean pre-weaning mortality rate of 19.5% for Horro sheep under on-station management at Bako Agricultural Research Center and indicated factors like sex, type of birth, and ewe age/parity and birth weight of lambs to have an effect on lamb mortality. The survival and death rate of lamb up to weaning is affected by the age of the ewe, type of birth, season of birth and birth weight of the lamb (Sulieman *et al.,* 1990). Litter size and mortality are positively associated and the higher the litter size the higher the mortality rate. This is mainly due to the fact that twins have lower body weight than single birth. Gemeda *et al*. (2005) working on Horro sheep found that survival rate was significantly affected by birth weight of lambs. The lightest lambs generally had the highest mortality rate. Similarly, Niftalem (1990) reported that lambs born to heavier dams had a significantly higher survival rate at all level of the specified age, than those of lighter ewes.

Sulieman *et al*. (1990) indicated that the rate of prenatal loss was lower with smaller litter size. Similarly, higher survival of single born lamb as compared to twins was reported for Horro and Menz sheep breeds in Ethiopia (Tibbo, 2006). The same author also indicated that the survival rate of lambs vary depending on birth weight, sex, parity and season of birth. Lambs born with lighter body weight, to first parity and during dry season have lower chance of survival than lambs born to higher parities and wet season.

As reported by Kassahun (2000) the survival rate between birth and weaning (90 days) for Menz lambs (89%) was significantly higher than that for the Horro (76%). He also indicated that Menz lambs had a much better post-weaning survival rate from birth to 180, 270 and 365 days of age (81, 71 and 62%) compared to Horro (51, 39 and 37%), respectively.

Post weaning mortality of 54.5% and 25.9% were investigated for Horro and Menz sheep breeds, respectively (Tibbo, 2006). Nevertheless, Gemeda *et al*. (2005) reported mortality rates of about 2.7% for lambs older than 3-month but lower than 12-months and 13.5 % for those older than 12-month of age for Horro sheep under farmers' management. A mortality rate of 5 % was reported for West African long-legged sheep (Wilson, 1986). For Djallonk sheep flock, the mean mortality rate from four months age was 19.4% (Fall *et al.,* 1982). Year and month of birth had significant effects on post weaning and adult mortality rate.

2.12. Body Weight and Linear Body Measurements

Studies indicated that variation exits between indigenous sheep breeds for body weight traits (Kassahun; 2000; Sisay; 2002; Tibbo, 2006; Solomon; 2007). Among the indigenous sheep breeds Horro and Bonga sheep breeds are large sized breeds and are superior in their body weight Solomon *et al*. (2007) to most of the local sheep breeds. According to Attah *et al.* (2004), body measurements are indices of skeletal development and indirectly help to determine carcass composition. Measurements of various body conformations are of value in judging the quantity characteristics of meat and also are helpful in developing suitable selection criteria (Islam *et al.,* 1991). Summaries of body weight and linear measurements in indigenous sheep are shown Table5. Knowing the body weight of a sheep is important for a number of reasons, related to breeding (selection), feeding and health care and for market age determination. However, this fundamental knowledge is often unavailable for sheep in the small scale farming sector, due to unavailability of scales

The chief method of weighing animals without scale is to regress body weight on a certain number of body characteristics, which can be measured readily. Works carried out by Kassahun (2000) on indigenous sheep breeds of Horro and Menz and by Mengiste (2008) on Washera sheep indicated that body weight could be estimated from chest girth measurement with fair accuracy. But the work of Kassahun (2000) was limited to only male of both breed under station management conditions. Close relationships between weight and linear measurements was reported for Dall’s sheep (Bunnell, 1980) for Yankasa sheep (Fasae *et al.,* (2005).

Table 5. Linear body measurements of indigenous sheep breeds

Breed/type	Parameters				Source
	BW (Kg)	WH (cm)	BL (cm)	CG (cm)	
Horro (Ewe 1 Yr)	15.5 ± 1.30	59.2 ±1.20	57.6±1.5	58.1 ±1.4	Tibbo *et al*. (2004)
Horro (Ram 1 Yr)	16.8 ± 1.27	59.9 ±1.20	58.1±1.5	58.0 ±1.3	Tibbo *et al*. (2004)
Bonga Female	32.00	64.00	63	72.0	Tibbo and Ginbar (2004)
Bonga female	-	65.8 ± 2.7	-	78.8 ± 5.9	Solomon (2004)
Bonga male	48.00	73.00	69	85.0	Tibbo and Ginbar (2004)
Horro female	-	65.2 ± 3.00	-	79.6 ± 2.2	Solomon (2004)
Horro male (1 Yr)	-	61.91 ± 0.62	60.38 ± 0.94	61.11 ± 0.7	Kassahun (2000)
Menz male (1Yr)	-	59.89 ± 0.44	58.12 ± 0.67	61.53 ± 0.50	Kassahun (2000)
Gumuz (Ewe)	31.40	63.59 ± 2.80	65.95 ± 2.5	76.07 ± 4	Solomon (2007)
Gumuz (Ram)	34.63	68.31 ± 3.80	68.31 ± 3.8	77.94 ± 4.9	Solomon (2007)
Central high land - Female	24.64	61.79 ± 4.80	58.27± 5.3	71.57 ± 5.8	Sisay (2002)
Central high land - Male	29.43	64.72 ± 5.90	61.3 ± 6.3	73.78 ± 7.4	Sisay (2002)
Rift valley - Female	24.71	60.02 ± 3.30	56.98 ± 5.1	71.82 ± 4.3	Sisay (2002)
Rift valley - Male	27.46	60.94 ± 3.90	55.78 ±5.6	72.97 ± 5.9	Sisay (2002)
Washera -female	28.3 ± 0.3	69.1± 0.20	59.5 ± 0.2	77.1 ± 0.3	Mengiste (2008)
Washera -male	32.3 ± 2.8	70.0 ± 1.90	61.5 ± 1.8	82.3 ± 2.8	Mengiste (2008)

BW = Body weight; WH = Wither height; BL = Body length; CG = Chest girth; [-]No data available

Designing of community - based breeding strategies basically needs detailed understanding of the community's indigenous knowledge of farm animals regarding breeding practices and breeding objectives, clear understanding of the production system and constraints and opportunities and knowing the existing genetic resources. However, overviews of this review suggest that there is little and inconclusive information on the above basic component of community based-breeding strategies for indigenous sheep breeds of Ethiopia. Therefore, there is a need to fill such gaps before implementing the breeding strategies.

3. MATERIALS AND METHODS

3.1. Study Areas

3.1.1. Location and area coverage

The survey was conducted in Adiyo Kaka district of Kaffa zone of Southern Nations, Nationalities and Peoples' Region and in Horro district of Horro Guduru Wollega zone of Oromia regional state. Adiyo Kaka and Horro are located at 509 km south west and 310 km west of the capital Addis Ababa, respectively. Adiyo Kaka is located in 36 ^{o} 47'E longitude and 7 ^{o} 26 'N latitude with altitude ranging from 500 to 3500 meters. For Adiyo Kaka the maximum and minimum annual temperature is 36 ^{o}C and 3 ^{o}C, respectively (SUDCA, 2007). Its main rainy season occurs between May and September and the dry season lasts from October to April. The altitude ranges from 1800 to 2835 (HARDO, 2006). The map of the study areas are presented in Fig. 1.

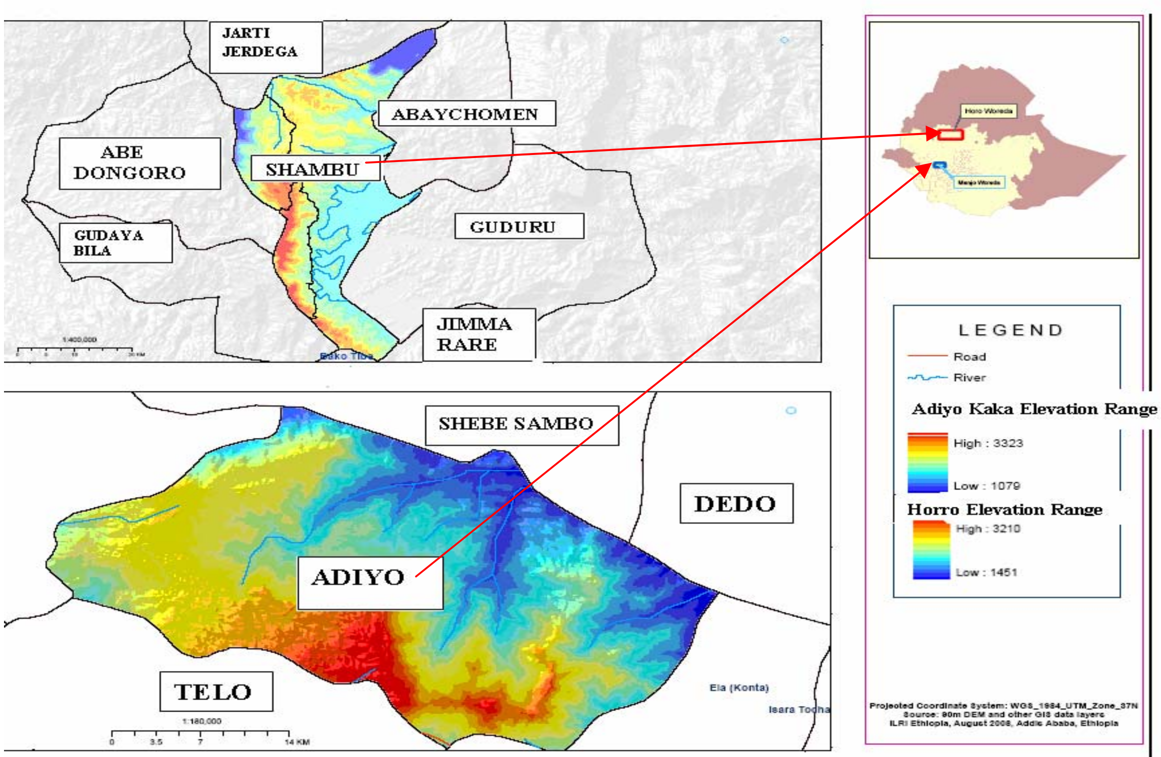

Figure 1. Maps of the study areas

3.1.2. Agro-ecology and land use pattern

Adiyo Kaka district consists of 20.45% *dega* (highland >2300 m.a.s.l), 61.53% *Woinadega* (intermediate highland 1500-2300 m.a.s.l) and 18.02% (lowland < 1500 m.a.s.l). The land use pattern is composed of 30,925. 5 ha covered with annual crops, 418,205 ha perennial crops, 7599.3 ha grazing land, 17,944.98 ha forest and bush land and 10, 352 ha man made forestlands (SUDCA, 2007). The major soil type in the district is red soil. Agro-ecologically, *dega* (highland), *woinadega* (mid-highland) and *kola* (lowland) accounted for about 43% (33525 ha), 56% (43661 ha) and 1% (7767ha) of the total land areas of Horro district. Clay and sandy soils are the major soil types of the zone. The average land holding per household is 1.08 and 1.5 ha for Adiyo Kaka and Horro, respectively.

3.1.3. Livestock and human population

Livestock production is one of the major economic basis in both of the districts. The total livestock population in Adiyo Kaka district is estimated at 143,784 heads, out of which 88,116 (61.3%) are cattle, 31,469 (21.9%) sheep, 13,234 (9.2%) goats and 10,965 (7.2%) equines. The population of chicken is estimated to be 49,628. The district has a total human population of 107,398 (52,472 males and 54,926 females) with 13,994 households (SUDCA, 2007). The total livestock population in Horro district is estimated at 185, 792 heads, out of which 115,917 (62.4%) are cattle, 37589 (20.1%) sheep, 9963 (5.4%) goats and 22323 (12.1%) equines. The Population of chicken is about 34,991. Horro has an estimated human population of 75,311(40,555 males and 34,756 females) with 13,520 households (HARDO, 2006).

In both of the districts Agricultural production is characterized by a mixed crop-livestock production system. Sheep production has always been an integral part of the traditional subsistence mixed crop-livestock production system in this area. Sheep are kept mainly as a primary investment and a source of cash in times of need.

3.2. Procedures and Methods of Data Collection

A multi- stage purposive sampling technique was employed where first districts known for the two sheep breeds in their respective production system were identified. Followed by identifying potential PAs and villages. Road accessibility, potential for sheep population, and practice of communal grazing system were used as criteria in selecting the sites. In addition to secondary data, discussions were held with zonal and district agricultural experts and development agents at the village level to select the sites. To confirm the information obtained from secondary sources and discussion, field tour was made by the team composed of the district livestock department and researchers from Bako and Bonga Agricultural Research Centers. Community and stakeholders sensitization workshops were also made in each site prior to the commencement of the survey work to brief the communities and the relevant stakeholders about the objectives of the project.

A set of detailed structured questionnaire were prepared to collect information on general socio-economic household characteristics, flock structure, breeding management, feeds and feeding management, diseases prevalence and production constraints in one visit interviews. The questionnaire is presented in Appendix Table 1. The checklist of issues governing focus group discussion and secondary data collection are also presented in Appendix Table 2 and 3, respectively. General information list of FAO (2000) and Oromia livestock breed survey questionnaire (Workneh and Rowlands, 2004) was used as a checklist in designing the questionnaire. The questionnaires were pre-tested prior to commencement of interview and necessary rearrangements were made to make sure that farmers easily understand it. The pre-tested questionnaires were administered to 229 (114 from Adiyo Kaka and 115 from Horro) randomly selected sheep owner by research staffs of Bako Agricultural Research center and Bonga Agricultural Research Center at Horro and Bonga, respectively under close supervision of the researcher. Summarized details of sample size are shown in Table 6.

To substantiate the information collected through individual farmer interview, focus group discussions were held with elderly farmers, village leaders and socially respected farmers who are known to have better knowledge on the present and past social and economic status of the study areas. The points for discussion included: history of origin and introduction of existing sheep breed(s); distinctive features of the sheep breed as well as their desirable and undesirable characteristics, status of the existing sheep breed, and major constraints for sheep production and suggested solution for the respective constraints. Participants for group discussion were identified with assistance from the local MoARD staff and Peasant Association administrators. Besides, secondary data on human and livestock population, agro-ecology, land use pattern, topography, soil type, and climate were gathered from Zonal and district Agriculture and Rural Development offices.

Prior to taking the actual live and linear measurements, flocks of sheep were identified with help of local development agents and village leaders or chiefs. In this case a flock is defined as a 'group' of animals grazing predominantly in the same pastures, with probability of mating between individual animals from different homesteads being about the same as that among animals of the same homestead. In the case of Adiyo Kaka where communal utilization of grazing lands is limited particularly during rainy seasons, flocks having the opportunity to share grazing lands with chance of mating between individual animals from different homesteads at least during dry season were considered as a flock.

From each survey sites 40 flocks within 50 km radius of the selected community were randomly identified and used to characterize the two breeds for qualitative and quantitative characteristics. Where the flock was large enough, 20 females having at least one pair of permanent incisor were randomly selected and characterized. In flocks where the number of adult females were less than 20 animals; all females having at least one pair of permanent incisor in the flock were subjected to measurement. Since in most of the cases the number of adult males were small, record were made on all available males in the flock and in some cases where the number of males with at least one pair of permanent incisor was nil per flock, data were taken from the younger males.

A total of 9 discrete or qualitative traits were examined (Appendix Table 4) for both female and male sheep. The qualitative variables included: coat pattern, coat color type, head profile, ear orientation, presence, or absence of ruff, mane, wattle, tail conformation, and body condition. Likewise, nine quantitative traits for both male and female were measured and recorded (Appendix Table 5): Body weight (BW), body length (BL), chest girth (CG), wither height (WH), pelvic width (PW), chest width (CW), tail length(TL), tail circumference (TC) and ear length (EL). In addition, scrotal circumference was measured and recorded for males. Linear measurements were taken using standard textile measuring tape. The live body weight (BW) was measured using a 100kg portable weighing scale graduated at 500gm interval.

The age of animals was estimated from dentition to support the age information given by farmers. Based on dentition, sampled sheep were categorized as 0 dentition (only for males), one pair of permanent incisors, two pairs of permanent incisors, three pairs of permanent incisors and four pairs of permanent incisors following Wilson and Durkin (1984). 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). Details of condition score is presented in Appendix Table 6. The score of an animal was done by feeling the back bone with the thumb and the end of the short ribs with fingers tips immediately behind the last ribs.

Table 6. Summary of sample size by district

Breed	Flock	Number of animals used for body weight and linear measurements					Number of farmers interviewed
		Female				Male	
		1PPI	2PPI	3PPI	4PPI	0-4PPI	
Bonga	40	85	102	169	325	74	114
Horro	40	61	138	90	503	28	115
Total	80	146	240	259	528	102	229

Estimate ages of sample population: 1PPI = 15.5 months; 2PPI months= 22.5 months; 3 PPI = 28 months; 4 PPI = 39 months (Wilson and Durkin, 1984).

3.3. Data Management and Analysis

The SPSS statistical computer software (SPSS for window, release 15.0, 2006) was used to analyze the survey data. F test was carried out as appropriate to assess statistical significance. An index was calculated to provide overall ranking of the reasons of keeping sheep according to the formula: Index = Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] given for particular purpose of keeping sheep divided by Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all purpose of keeping sheep. Similar indexes were calculated for ranking selection criteria for breeding females and males, constraints for sheep production and sheep diseases.

Qualitative data from individual observation were analyzed separately for both of the breeds and sexes following the frequency procedures of SPSS version 15 (2006). Chi-square test was employed to test for independence between the categorical variables. The General Linear Model (GLM) procedure of SAS (2003) was employed to analyze quantitative variables to determine effects of class variables (breed and dentition). The effects of class variables and their interaction were expressed as Least Square Means (LSM) ± SE. Means were separated using Tukey Karamers. Due to the low number of males in each dentition class analysis was done for both sexes independently. Within each sex, breed and dentition were fitted as fixed factors.

Correlations (Pearson's correlation coefficient) between body measurements under consideration were computed for both of the breeds within each sex and dentition categories. The stepwise REG procedure of SAS (2003) was used to determine the relative importance of live-animal body measurements in a model designed to predict body weight. Live weight was regressed on the body measurements separately for both breeds, for males and females (sex-specific), for each dentition class and for the pooled data by sex categories for both breeds. Due to inadequate sample size of males in each dentition classes, dentition 0 and 1 were pooled together. Similarly, males with dentition 2 and above were grouped together. The choice of the best fitted regression model was assessed using coefficient of determination (R^2).

Model used for the least - squares analysis in females and males was:

$Y_{ijk} = \mu + B_i + D_j + (B \times D)_{ij} + e_{ijk}$

Where: Y_{ijk} = Observed body weight or linear measurements

μ = Overall mean

B_i = the fixed effect of i th breed (i = Bonga, Horro)

D_j = the fixed effect of j^{th} dentition classes (j = 1PP, 2PPI, 3PPI, 4PPI)

$(B \times D)_{ij}$ = Breed by dentition interaction effect

e_{ijk} = random error

Multiple linear regression model for adult females

$Y_j = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + e_j$

Where:

Y_j = the dependent variable body weight; β_0 = the intercept; X_1, X_2, X_3, X_4, X_5, X_6 and X_7 are the independent variable body length, chest girth, height at wither, chest width, pelvic width, tail circumference and body condition, respectively.

β_1, β_2, β_3, β_4, β_5, β_6 and β_7 are the regression coefficient of the variable X_1, X_2, X_3, X_4, X_5, X_6, and X_7

e_j = the residual error

Multiple linear regression model for adult males

$Y_j = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + ej$

Where:

Y_j = the dependent variable body weight; β_0 = the intercept; X_1, X_2, X_3, X_4, X_5, X_6, X_7 and X_8 are the independent variable body length, chest girth, height at wither, tail circumference, chest width, pelvic width, scrotal circumference and body condition, respectively.

β_1, β_2, β_3, β_4, β_5, β_6, β_7 and β_8 are the regression coefficient of the variable X_1, X_2, X_3, X_4, X_5, X_6, X_7 and, X_8

e_j = the residual error

Estimation of inbreeding

Rate of n inbreeding was calculated from effective number of breeding animals for both within a closed and open flock (mixing flock). Effective population size (Ne) is used because it is the most common description for assessing the expected inbreeding in a population. Estimates of average change in percentage inbreeding was made with expression:

$\Delta F = 1 / (2\ Ne)$

Where,

ΔF = Rate of in inbreeding

Ne = the effective population number

$N_e = 4\ N_m \times N_f / N_m + N_f$

Where, N_m = number of breedable male

N_f = number of breedable female

4. RESULTS AND DISCUSSION

4.1. Demographic and Socio-economic Characteristics of the Households

Detail of household general characteristics is presented in Table 7. Family size was significantly (P<0.01) different between the two sites. The larger family size in Adiyo Kaka was attributed to polygamy. Average family size similar to Horro (7.3) was reported in Southern Ethiopia by Takele (2006). Figures for both districts obtained in this survey were higher than the average values at the national (5.2) level (CACC, 2003). The age of respondents ranged from 18 to 80 years with a mean of 37.7 years for Adiyo Kaka and ranged from 20 to 80 years with a mean age of 41.6 years for Horro district.

Table 7. Demographic and socio-economic characteristics of the households

Descriptor	Horro (n=115)	Adiyo Kaka (n=114)	Overall (N=229)
	Mean ± SD	Mean ± SD	Mean ± SD)
Family size	7.3± 2.47	8.6 ± 4.46	7.9 ± 3.65
	Percent	Percent	Percent
Sex of household head			
Male	93	96.5	94.8
Female	7.0	3.5	5.2
Educational level			
Primary school	48.7	70.2	59.4
Secondary school	28.7	3.5	16.2
Illiterate	19.1	22.8	21.0
Read and write	2.6	3.5	3.1
Religion school	0.9	0	0

Of the total interviewed most of them were male headed. In contrast to this report, higher proportion of illiterate (59.7%) and lower level of primary and secondary attendants (21.7% and 5.4 %) were reported in southern Ethiopia (Takele, 2006). This survey result illustrates that the higher proportion of farmers having primary and secondary educational background would be an opportunity to utilize them for instance in recording simple records which are of paramount importance in decision making.

4.2. Livestock Holding and Flock Structure

The average reported livestock possessions are presented in Table 8. Respondents in Adiyo Kaka had significantly higher number of sheep (P< 0.001). But, there was no significant difference (P> 0.05) between the two districts in for cattle, goat, mule and donkey holding. Horse holding was significantly higher (P< 0.05) in Horro district than their counterpart in Adiyo Kaka.

Table 8. Livestock holdings per households in the study area

Descriptor	Horro (n=115)	Adiyo Kaka (n=114)	Test	
	Mean ± SD	Mean ± SD	F-value	P-value
Cattle	9.3 ± 6.94	8.7 ± 5.70	0.44	0.507
Sheep	8.2 ± 2.05	11.3 ± 1.27	15.282	0.000
Goats	4.7 ± 4.77	3.8 ± 3.19	1.14	0.289
Chicken	6.7 ± 6.22	5.3 ± 3.69	3.163	0.077
Horse	3.2 ± 2.81	2.4 ± 1.46	4.014	0.033
Mule	1.1 ± 0.38	1.4 ± 1.03	0.529	0.475
Donkey	2.2 ± 1.67	1.6 ± 1.16	0.235	0.633

Sheep were ranked as the first (76.8% in Adiyo Kaka and 62.6% in Horro) important livestock species followed by cattle (Table 9). The usual reasons for ranking sheep as the most important species were sheep could serve as immediate source of income, short generation interval, require low initial capital and high prolificacy. Out of the 114 farmers interviewed in Adiyo Kaka, 93.9% reported livestock as their main source of income, whereas about 97.4% of respondents indicated that crop production was their source of food. Similarly, from the total 115 respondents in Horro 87.7% of them depend on crop for their family food and 74. 8% depend on livestock for their source of income.

Table 9. Ranked livestock species according to their importance (%)

Species	Adiyo Kaka				Horro			
	Rank1	Rank2	Rank3	Index	Rank1	Rank2	Rank3	Index
Cattle	22.3	66.9	3.6	0.35	31.3	51.4	9.9	0.34
Sheep	76.8	19.6	2.7	0.45	62.7	33.8	12.7	0.45
Goat	0	4.5	18.9	0.04	1.2	2.7	19.7	0.05
Chicken	0	3.6	27.0	0.06	3.6	4.1	19.7	0.06
Horse	0.9	2.7	37.0	0.08	1.2	8.1	38.1	0.09
Mule	0	0	10.0	0.02	0	0	0	0

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular species of livestock divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all species

The proportions of adult females out numbered males' population (Table 10). Females accounted for about 60 and 80% of the total flock in Adiyo Kaka and Horro, respectively. The proportion of castrates (5.9%) and intact males greater than 1 year (5.8%) were larger for Adiyo Kaka as compared to Horro which are 2.9% and 3.6%, respectively. The high proportion of intact or castrates in Adiyo Kaka is related to the objective of meat production. In support of this investigation, Wilson (1986) noted that the higher proportion of males in the traditional systems indicate the objectives of wool, hair or meat production. Solomon (2007) working on Gumuz sheep reported that about 42.58% of the flock was composed of adult females.

The proportion of breeding ewes in this particular study are below observations of Berhanu (1995) (54.4%) in south western Ethiopia, and Solomon *et al*. (2005) (49.7) in East Wollega and West Shoa Zones under farmers management conditions. This implies that flocks in the study sites are more composed of other sex and age classes; particularly for Adiyo Kaka case more young males were kept for fattening purposes. About 5.8% intact males which were the same as for Bonga flocks was obtained for Gumuz flocks (Solomon, 2007) and for sheep flocks in Eastern Wollega and in West Shoa (Solomon e*t al.,* 2005), but lower than the reports of Berhanu (1995) (8.6%), Agyemang *et al.* (1985) (2.4%) and Abebe (1999) (12.5%).

About 2.8% and 2.9% castrates which were similar to the proportion of castrates in Horro, but lower than Bonga was reported by Berhanu (1995) and Niftalem (1990) in south west and central highlands of Ethiopia, respectively.

The lower number of young rams as compared to young ewe lambs in the study sites was because of the tradition of marketing young ram lambs. It was noted that high quality rams are used for breeding only in rare circumstances, rather they are meant for sale at earlier age. However, if they are not sold at early age they are castrated and fattened for sale. The ratio of rams greater than 1 year old to ewes in Bonga flocks was 1: 6.4. The corresponding value for Horro flocks was 1:13.4. A sex ratio comparable to Bonga flock has been reported for thin-tailed Gumuz sheep breed in Metema area (Solomon, 2007) and for flocks under small scale mixed farms in the highlands of Ethiopia (Berhanu, 1995). In contrast to the present result for Horro flock a much higher proportion of male to female ratio which was 1:7.5observed in the cool highlands of Ethiopian for Menz sheep flocks (Abebe, 1999). Solomon *et al.,* (2005) reported male to female ratio of 1:12 which was close to the result for Horro.

Farmers in Adiyo Kaka hold significantly (P<0.01) higher number of sheep than their Horro counter parts. This might be attributed to high death rate in Horro flocks reported in past by disease out break. An average lower flock sizes of 4.2, 5.0, 6.7 and 6.97 were reported for south west of Ethiopia (Berhanu, 1995), Alaba (Tsedeke, 2007), Fentale (Shiferaw, 2007) and around Dire Dawa (Aden, 2003). Larger flock sizes of 16.02 and 24 were reported for Gumuz sheep in Metema (Solomon, 2007) and in central highlands for Menz flocks (Abebe, 1999), respectively.

Small flock size investigated in this study was identified as the limiting factor in applying within breed selection at the household level and therefore calls for an approach for designing a selection scheme applicable to the whole village level, which in fact is the objective of our mega project. Furthermore, it points to the fact that the level of inbreeding is high (Jaitner *et al.,* 2001).

Table 10. Flock size and structures in the study areas

Categories	Adiyo Kaka				Horro			
	N	Mean ± SD	Range	% of total flock	N	Mean ± SD	Range	% of total flock
Lambs less than 6 months	460	4.04 ± 1.6	0-10	35.8	222	1.93 ±1.3	0-7	23.5
Lambs between 6 months and 1 year	258	2.26 ± 1.6	0-23	20.1	206	1.79 ±1.9	0-20	20.0
Intact male older than 1 year	74	0.65 ± 1.5	0-7	5.8	34	0.29 ± 0.8	0-6	3.6
Female older than 1 year	417	3.66 ± 2.7	0-20	32	454	3.95 ± 2.8	0-16	48.1
Castrates	76	0.66 ± 1.7	0-10	5.9	27	0.23 ± 0.9	0-5	2.9
Total	1285	11. 28 ±1.3	1-50	100.0	943	8.20 ± 2.1	2-50	100.0

4. 3. Flock Ownership Patterns

The ownership of sheep flock in Adiyo Kaka by one person, two, three, and more than four persons were 31.8%, 37.7%, 20.2% and 13.2%, respectively. The corresponding values in Horro were 23.6 %, 44.1 %, 28.3 %, and 20.5%, respectively. More than two persons ownership pattern observed in this survey was not observed in small flocks in the Menz areas of the central highlands (Abebe, 1999). The same author reported that medium and large flocks had ownership pattern of 48.9, 45.27, 4.73, 1.12% and 36.17, 49.95, 9.87, 4.01% for one, two, three and four or more persons, respectively. Head and spouse together accounted for 33.3 % of ownership of sheep in Adiyo Kaka and 41.7% ownership in Horro, respectively. The whole family together accounted for 22.8% ownership of sheep in Horro. As compared to men (28.9% in Adiyo Kaka and 15.7% in Horro) spouse individually have less ownership pattern (0.9% and 2.6% for Adiyo Kaka and Horro, respectively). Higher ownership by women for sheep (40.7 %) (NASS, 1989) and small ruminant (68.7 %) (WID,1993) was reported in Gambia.

4. 4. Land holding (ha), Land use systems and Trend

Most of the households owned all the land they used. In rare cases some households cultivated or use others land on grain share basis, communal grazing lands, and relatives lands. Over all, only 0.6 ± 0.52ha the land was allocated for grazing while most of the remaining land was used for growing food crops (Table 11). Fallow land holding in Adiyo Kaka was significantly (P < 0.01) higher than in Horro (0.5 ± 0.31 ha against 1.2 ± 0.82 ha). This is due to the fact that fallow land is the dominant source of feed for livestock in Adiyo Kaka. However, farmers in Horro do hold significantly (P<0.01) higher total land and grazing lands compared to farmers in Adiyo Kaka.

Table 11. Land holding (ha) and land use systems of the households

Descriptor	Horro (n=115)	Adiyo Kaka (n=114)	Overall (N=229)	Test	
	Mean ± SD	Mean ± SD	Mean ± SD	F-value	P-value
Total land (ha)	2.4 ± 1.60	3.4 ± 2.68	2.9 ± 2.26	10.31	0.002
Crop land (ha)	2.1 ± 1.45	2.7 ± 2.27	2.4 ± 1.89	6.12	0.014
Fallow land (ha)	0.5 ± 0.31	1.2 ± 0.85	1.1 ± 0.82	10.25	0.002
Grazing land (ha)	0.6 ± 0.44	0.7 ± 03	0.6 ± 0.52	0.011	0.918

Unlike in the Adiyo Kaka district where communal grazing land was rare, in Horro it was practiced by 83.3% of the sampled respondents. Private grazing land ownership was more reflected in Adiyo Kaka (98.8%) as compared to Horro which was practiced only in about 13.9% of the respondents. In the intensively cultivated areas of Horro, permanent communal grazing lands comprised mostly of the swampy bottom lands. Major features of these areas as indicated by farmers were the slow grass growth during much of the wet season (due to water logging) and harbor snail which is host for liver fluke. Decreased trend in communal grazing land becomes an increasingly important constraint in Horro. Encroachment of cropping in to the grazing land (66.7%) and population growth (26.4%) were reported as the driving factors for the declining trend. Other factors mentioned were flooding, investment, distribution for farming and overgrazing.

The violation of the rule of management and utilization of communal grazing lands was raised as threat for communal land by key informants during the group discussion session. To solve the lack of ownership sense of communal grazing lands, key informants proposed privatizing the existing communal lands. However, this does not always need to be the best alternative because individual tenure could deny farmers extensive grazing lands. According to Verbeek *et al*. (2007) communal lands could be sustainable when non-members are excluded, rights are clearly defined and understood, and when there is cooperation between members living in common areas.

4.5. Trend in Livestock Population and Land holding

The majority of the farmers in Horro reported a decreasing trend in cattle (76.6%) and sheep (85.2%) population. In contrast, for Adiyo Kaka, about 62.9 % and 66.3% respondents reported an increasing trend for cattle and sheep, respectively. Respondents in Horro associated the declining trend in livestock population to disease and feed shortage. Attractive market price, better awareness on the importance of livestock and improvement in farmers' income were indicated as the reasons behind the growing livestock population in Adiyo Kaka district. Similarly, a decreasing pattern for land holding was observed by about 74% of respondents in Horro and 43% of the farmers in Adiyo Kaka. Human population growth, land degradation, and soil erosion are some of the mentioned factors for declining landholding across the two production systems.

4. 6. Purpose of Keeping Sheep

The reasons for keeping sheep are rational and are related to the farmers' needs in the long or short term. The results of this survey revealed that sheep play multi-functional roles in both production systems with similar production objectives. Table 12 presents ranked purposes of keeping sheep, respectively. The results indicated the relative importance of tangible benefits of sheep keeping (such as regular source of income, meat, and manure). Most farmers in both sites keep sheep primarily as source of income. Functions like ceremony received relatively low ranking among the reasons for keeping sheep in both production systems. Having sheep for manure was ranked higher among farmers in Horro than smallholders in Adiyo Kaka. Similar multi purpose functions of sheep rearing were reported for sheep keepers in the central highlands of Ethiopia (Abebe, 1999). In contrast to these findings, Kosgey (2004) reported low ranking of small ruminants for breeding purpose among the smallholders and pastoralists in Kenya.

Multiple functions are particularly important in low and medium input production environments. Different studies addressed the importance of multiple values of indigenous livestock breeds in developing countries in low input system (Kosgey, 2004; Mwacharo and Drucker, 2005; Wurzinger *et al*., 2006; Zewdu *et al.,* 2006).

Table 12. Ranked purpose of keeping sheep as indicated by respondents (%)

Purpose of keeping	Adiyo Kaka				Horro			
	Rank 1	Rank 2	Rank 3	Index	Rank1	Rank2	Rank 3	Index
Income	100.0	76.0	12.9	0.776	95.6	52.7	34.9	0.718
Meat	0	22.6	62.4	0.179	0.9	20.0	22.6	0.109
Saving	0	0.0	18.3	0.030	1.8	19.1	8.5	0.088
Ceremony	0	0.0	6.5	0.010	0.0	0.9	2.8	0.007
Manure	0	0.9	0	0.003	0.0	7.3	31.1	0.077

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular purpose divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all purpose.

4.7. Labor Profile in Sheep Husbandry and Decision Making

Sheep management tasks were undertaken mainly by family members and involvement of individuals out side the family is less common across the study sites. Detail roles of each housed members in sheep husbandry in Adiyo Kaka and Horro was presented in Table 13 and 14, respectively. Most activities related to selling (97% for Adiyo Kaka and 92% for Horro), purchasing (95.6% for Adiyo Kaka and 97.2% for Horro) and breeding (96.4% for Adiyo Kaka and 92.5% for Horro) were mainly performed by males above 15 years of age particularly by head of household.

Table 13. Household responsibility of routine husbandry practices in Adiyo Kaka district (%)

Responsible bodies	Activity					
	Purchasing	Selling	Herding	Breeding	Sick animas care	Supplementation
Males ≥ 15 years	95.6	97.3	81.3	96.4	91.97	78.2
Female ≥ 15 years	38.3	60.7	90.2	9.0	71.2	95.5
Male <15 years	2.6	1.8	58.0	16.2	30.6	40.9
Female<15 years	0.90	-	39.3	-	13.5	21.8
Hired labor	-	-	1.8	-	-	-
Neighbor	-	-	-	1.8	-	-

N.B. A given activity can be carried out by more than one household member

Though men play a significant and dominant role in marketing decision, women also play a substantial role in decision making related to purchasing and selling. Generally, women are less frequently involved in activities related to breeding management in Adiyo Kaka (9%). However, women in Horro (47.3%) more frequently participate in activities related to breeding (selection, castration, culling and mating) than their Adiyo Kaka counter parts. In Adiyo Kaka, it is culturally prohibited for women to involve in mating or breeding activities. In agreement to this finding Verbeek *et al. (*2007) reported that breeding decisions were made mainly by male members of the households. In Horro, activities such as health care (90%) and supplementation (89.5%) were mainly undertaken by housewife. Similarly, in Adiyo Kaka about 71.7% and 95.5% of health care and supplementation were the duties of women. In Adiyo Kaka, herding was mainly the responsibility of women (90.2%). Similar result was reported from smallholders farmers in Kenya (Verbeek *at al.,* 2007). The authors indicated that women in the smallholders households participated more in decision - making than those in pastoral systems. Children below 15 years commonly participate in herding of sheep (58.3% for Adiyo Kaka and 66.7% for Horro) with sons taking the higher share than daughters (39.3% for Adiyo Kaka and 48.6% for Horro). The higher share of boys in sheep herding than girls was reported by Verbeek *et al., (*2007) for small holder farmers in Kenya.

Table 14. Household responsibility of routine husbandry practices in Horro district (%)

Responsible bodies	Activity					
	Purchasing	Selling	Herding	Breeding	Sick animas care	Supplementation
Males ≥ 15 years	92.4	97.2	75.2	92.5	88.7	85.7
Female ≥ 15 years	57.1	78.3	58.1	47.3	90.6	89.5
Male <15 years	5.7	11.3	66.7	11.8	37.7	45.7
Female<15 years	-	4.7	48.6	6.5	30.2	34.3
Hired labor	-	-	3.8	3.2	-	-

N.B. A given activity can be carried out by more than one household member

The share of each household member in sheep husbandry primarily depends upon the number, age of children found in the family and the type of grazing system practiced. In the families where the numbers of children were less or they were enrolled in school, the role of household head and spouse were greater. Similarly, where tethering was the major grazing system, the role of men and women were by far greater than the role of children in relation to herding. The various decision-making levels related to sheep‘s ownership in the survey areas depict relatively gender imbalance which is a product of strong cultural background biased against women.

In the past, most small ruminant breeding progrmmes failed partly because they primarily focused on men, without appreciating the role of women and children in the routine small ruminant management activities (Kosgey *et al.,* 2006). Generally, this study demonstrated that women and children are involved in sheep husbandry practices. Thus, for any development interventions related to sheep improvement, women and children should be involved and training in relation to breeding management and other husbandry practices could potentially enhance the success of the programme (Verbeek *et al.,* 2007).

4. 8. Feed resources and Grazing management

Feed availability and quality primarily depends upon the climatic and seasonal factors. The present survey also demonstrated the extent of the problem in the study areas. The different feed resources reported in the area were natural pasture, fallow land, crop residue, crop after math and hay (Table 15). It was observed that grazing on fallow land was the major feed resource for farmers in Adiyo Kaka district during the rainy season when most of the farm land was covered with crops (94.7%).

The importance of fallow lands as feed resource for sheep was also reported by Berhanu (1995). Natural pasture was the predominant source of feed for sheep during the main rainy season in Horro (93.0 %). Crop after math, fallow land, and crop residues serve as the main feed resources for dry season in Adiyo Kaka. The role of fallow land as feed resource for farmers residing in Horro district especially in dry season was less significant as compared to Adiyo Kaka where it serves the main feed resource both for dry and wet seasons. Across the two production systems it was identified that feed availability is seasonal. Periods of critical feed shortage ranges from June to November for Adiyo Kaka and April to May for Horro, when most of the farm lands are covered with food crops. To cope with feed shortage farmers provide supplements such as grains, crop-residues, tree leaves, and local brewery by-products.

Table 15. Feed resources used in the study areas during rainy and dry seasons

Feed resources	Adiyo Kaka				Horro			
	Rainy season		Dry season		Rainy season		Dry season	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Natural pastures	76	67.3	57	51.4	107	93.0	104	91.2
Crop residues	-	-	45	40.2	-	-	69	60.5
Fallow land	107	94.7	99	87.6	33	28.7	26	5.3
Crop aftermath	-	-	95	85.6	-	-	67	58.8
Hay	3	2.7	1	0.9	21	18.3	32	28.1

N.B. More than one response was possible

The use of crop residues as sources of feed for sheep was more frequently reported in Horro than Adiyo Kaka, and crop residues like barely, *teff*, wheat, maize stover, and bean and pea straws were used during the dry season.

In addition to natural pasture, supplementary feeding of animals was practiced by vast majority of the farmers both in dry and rainy seasons in both the areas. Supplementation during the dry season was reported by 97% and 86.8% of the farmers in Adiyo Kaka and Horro districts, respectively. The major supplementary feeds identified were grains (boiled bean, pea and maize), non-conventional feeds like *Atella* of *Tella, Areke and Borde,* which are the by products of locally made beverages. The use of common salt as supplement for sheep was well recognized and practiced by majority of farmers in the study sites. The same practice was reported around Metema areas by Gumuz sheep keepers (Solomon, 2007) and in Jimma (Berhanu, 1995). But, none of the respondents reported the use of conventional supplements and improve forages. To alleviate the existing feed shortage there is need to look in to efficient utilization of the existing resources which could include hay making and conservation of crop residues. Introduction of improved forages in to the existing system is one of the options but so far no attempts have been done especially in Adiyo Kaka.

Sheep generally grazed for 7.4 hours and 9.6 hours a day in Adiyo Kaka during wet and dry season, respectively. The corresponding results for Horro district were 9.1 and 9.8 hours for rainy and dry season, respectively. In Adiyo Kaka, during wet season animals were kept for longer hours at home. This is to reduce risk of bloating and high incidence of predator. Further grazing hours are extended during dry seasons as strategy to cope with feed shortage. Longer grazing hours of 10 to 11 were reported in Lallo-Mama district of central Ethiopia (Abebe, 1999). Berhanu (1995) reported an average grazing of 9 hours in Jimma areas of Southern Ethiopia.

Management with respect to feeding or grazing was different for dry and rainy or cropping seasons. During the rainy season the majority (62.2%) of sheep owners in Horro herded their animals where as in Adiyo Kaka more than half (53. %) of the farmers practiced tethering (Fig. 2). However, during the dry season 37.4% and 43.9% of respondents in Horro and

Adiyo Kaka, respectively freely released their sheep to roam around (Fig. 3). It was noted that tethering was more frequent in Adiyo Kaka than in Horro (Table 16).

Table 16. Management systems practiced by owners with respect to grazing and season (%)

Grazing management	Horro		Adiyo Kaka	
	Rainy season	Dry season	Rainy season	Dry season
Herding	62.6	12.1	10.5	21.9
Tethering	5.3	-	53.5	1.8
Herding and tethering	32.5	0.9	32.5	13.2
Free grazing	-	37.4	-	43.9
Free grazing and herding	-	50.5	2.6	17.6

The main reasons for practicing tethering include to avoid crop damage, stock are relatively secured against theft and can be easily protected from predation or extreme weather and to use the limited grazing properly. Similar management practices were identified in south western Ethiopia by Berhanu (1995) and by Workneh (1992) in densely populated parts of southern Ethiopia. Although tethering is labor intensive most families use unpaid own or family labor. Access to fresh grass was provided by shifting the tethering sites. Systems that did not involve tethering were most often practiced by farmers with large flocks and sufficient grazing and labor. The limitations of tethering with regard to animal performance and grazing land condition warrant further investigations.

Figure 2. Bonga ewe tethered at fallow land

Figure 3. Horro flock grazing in communal grazing land

According to the respondent in both the sites, river was the major water source in both the wet and the dry seasons. It account for 39.6% and 90.6% of the total source of water during dry season in Adiyo Kaka and Horro districts, respectively. Spring, rain and pipe water were also serve as source of water for sheep. Pipe water as source of water only reported in Horro areas. The majority of farmers (77.2%) in Adiyo Kaka indicated that their animals do not drink water during rainy season. Where as none of the respondents in Horro reported the same cases. A watering distance of less than 1 km was reported by 53.2% and 87.5% of the farmers in Adiyo Kaka and Horro districts, respectively. Generally water supply is not a constraint in both the areas.

4. 9. Housing

Adequate housing protects animals from extreme temperature (rain, cold, excessive heat and wind), predator and theft. It further provides opportunities for intensive feeding and controlled breeding. In the study area, different types of housing were reported (Table 17).

Table 17. Reported housing systems for sheep

Type of housing	Adiyo Kaka		Horro	
	Frequency	Percent	Frequency	Percent
In the family house	96	42.47	32	27.8
In separate sheep house	80	35.39	40	34.8
Kitchen	50	22.12	30	26.1
Gada (Attached to the main family house)	-	-	13	11.3

The majority of the farmers a cross the study districts house their sheep during the night. Substantial number (42.47%) of sheep keepers in Adiyo Kaka kept sheep at night in the main family house. Farmers in Adiyo Kaka share the main family house with sheep because of the fear of theft and predators. About 34.8% of the respondents in Horro housed their sheep in separate house constructed purposively for sheep. In rare cases in Adiyo Kaka farmers kept their sheep during dry season in open fenced barn. About 54.4% of the farmers in Adiyo Kaka and 17.4 % in Horro used floor constructed from wood slightly raised above the ground. Up lifted wooden floor was commonly used among the Bonga sheep keepers to reduce the contact of animals with their feaces (Fig. 4). In Adiyo Kaka, usually other livestock like cattle and goat are kept in the same family house with sheep separated by some barriers or tied separately.

Figure 4. Sheep housing systems in Adiyo Kaka: Open enclosure (left) and woody floor (right)

4.10. Fattening and Castration

Fattening was practiced by 53.3% and 89.5% of the respondents in Horro and Adiyo Kaka areas, respectively. This is why higher proportion of young males was found in Bonga flocks than in Horro flocks. It was noted that within the same age categories females were less proportionally used for fattening compared to males. They are fattened when they get older or are culled. This points to the fact that females are kept for breeding to replace the flock. The type and number of animal to be fattened depends on the wealth status of the farmer. Farmers with large flock size do have the potential to retain male lambs for subsequent castration and fattening. The poor farmers sold younger males at earlier age. Similar observation was made by Solomon e*t al.,* (1991) in Maasai group ranches where about 13% and 8% of castrates were retained by the rich and the poor households, respectively.

Crop residues, salt, grain, home leftovers, and non-conventional local brewery by products such as *atella* of *areke* and *tella* were supplement for fattened sheep by farmers in Adiyo Kaka. In both districts, the respondents indicated that they provide albendazole for fattening animals. Similarly, respondents in Horro were providing crop residues, salt, grain, non-conventional local brewery by products such as *Atella* of *areke* and *tella* and albendazole. Unlike in Adiyo Kaka where there was no tradition of using hay as source of feed for sheep, in Horro about 6.9 % of the farmers reported the use of hay as supplement for fattening of sheep.

Though the reasons are diverse and many, availability of natural pasture and grain, weather conditions and target for specific market were the main reasons for fattening to be undertaken during particular periods. In Horro, farmers frequently practice fattening following the main rainy season due to better forage production, warmer temperature and target for specific market. Similarly, farmers in Adiyo Kaka fatten sheep in onset of dry season.

Castration was practiced by 98.2 % of the farmers in Adiyo Kaka and 58% in Horro. Average ages of castration were 10.8 ± 2.5 months for Adiyo Kaka and 18.3 ± 7.8 months for Horro. Castration at this age allowed a ram to stay in the flock and breed for a maximum of up to the age of one year and six months in Adiyo Kaka. Castration was primarily practiced to improve the fattening potential and is a means of getting higher sale prices at a later date. In some rare cases it was practiced to improve ram temperament so as to avoid ram run from the flock. Usually better rams with good body conformation and having potential for fattening are subjected to castration. Castration was exclusively done traditionally using local materials such as wood, hammer, and stone.

4.11. Origin of the Breeds, Distribution and Current status

The breed kept, origin and trends were assessed so as to have information with regard to the type of sheep breed raised by the farmers, possible origin places, or routes and whether the population of the breed is declining, stable or increasing. For both of the study sites farmers had not traced back the origin of the breeds, rather they pointed out that the breeds were kept for long past by their ancestors. The output of group discussions indicated that Telo and Horro districts were indicated as where Bonga and Horro sheep breeds are predominantly distributed, respectively. The name Bonga which is commonly used to name the breed is not familiar for the owners of the breed. Some key informants noted that the name 'Bonga sheep' was derived from the town of Bonga where the breed is marketed. In Adiyo Kaka, farmers recognized that in the past sheep with horns were common in their flocks unlike the present flocks where almost all population is devoid of horn. This might be due to low preference of farmers for horned animals and thus selection against them.

In contrast Bonga sheep keepers, in Horro were well familiar with the name 'Horro' used to describe the breed. The Horro sheep breed derived its name from Horro people who maintain the breed in the Horro district of Horro Guduru Wollega zone of Oromia, which is the major natural breeding tract of the breed. During the focus group discussions it was reported that Horro sheep are predominantly concentrated around Shambo areas in Horro district. Horro sheep were also reported to be distributed in former regions of western Shoa, Kaffa, and eastern Illubabor (Galal, 1983).

According to the early works of Epstein (1971) and Ryder (1984) fat-tailed sheep entered in to Africa at the beginning of the second millennium through Suez and Bab el Mandeb. Groups that entered through Bal el Mandeb extended from Ethiopia to east Africa. The breeds are commonly known as Abyssinian. Ethiopian Bonga is grouped under fat-tailed hair sheep of sub-group East African fat-tailed (DAGRIS, 2004). For the long past, Bonga breed is assumed to be similar with Horro sheep breeds. However, the recent molecular characterization by Solomon *et al.,* (2007) confirmed that the breed is different from Horro.

Based upon the results of group discussion and individual interviews, the population of Horro sheep is at a decreasing trend. The possible reasons reported for this trend were mainly disease and feed shortage. To the contrast, both the outcomes of group discussion and interview showed that the population of Bonga sheep is at increasing trend. Involvement of more farmers in sheep production due to better benefit earned from the current better sheep market and high preference of sheep to goat which are blamed for destruction of farm crops were mentioned as the main reasons for the reported trend. In variance with the views of the Bonga sheep producers, secondary data from officials indicated the concern of genetic erosion of the breed owing to early disposal of breeding animals without producing offspring.

4.12. Typical Features of Bonga and Horro Sheep Breeds

Based on the outcomes of focus group discussions and key informant interviews, the typical features of Bonga and Horro were identified. For Bonga breed the coat color is dominated by red brown and the tail is wide and long with straight pointed end and twisted end. Both male and female are polled; the ear is long, the hair is short and smooth. The breed is judged as good for traits like growth rate, meat quality, fattening potential, twining rate and temperament. Similarly, farmers in Horro describe their breed as large in body size, the coat color is red or brown, have no horn, the tail is long and broad tail with the majority of the population having straight pointed end tail. Fast growth rate, mothering ability, twining rate, and early lambing were considered as the special merits of the breed. Body size and color for males and females, tail conformation (for male) and twining are the proposed traits in that order for improvement in Horro. Sheep owners in Bonga suggested traits such as body size and coat color for males and females, tail conformation (for male), lambing interval and twining rate for genetic improvement in that order.

4.13. Breeding Management

Mating was predominantly uncontrolled and no report of controlled breeding. Out of total 229 farmers interviewed, about 56.3% and 29.6% kept their own breeding males in Adiyo Kaka and Horro, respectively. When breeding males were not reared in their flocks, the majority of the farmers got the service from neighbors' rams (93.5% for Adiyo Kaka and 34.5% for Horro). The majority (75.8%) of breeding rams for farmers in Horro were originated from own flock and 24.2% were purchased from market. Similarly, for Adiyo Kaka, about 84.2% of the rams were born in the own flock and 15.8% were purchased from market. On average breeding ram was kept for two years with the range of 1 to 4 years for Bonga and 1 to 8 years for Horro.

Gains from breeding programmes are achieved only when inbreeding depression is well controlled or minimized (Kosgey, 2004). Rate of inbreeding of 22% and 45% were estimated for Bonga and Horro, respectively under closed breeding management condition. For open flocks (mixed flocks) the estimated change in inbreeding per generation was 6.4% for Bonga and 8.9% for Horro flocks. Mixing of flocks dramatically reduced the inbreeding level in both of the flocks. As stated by Gatenby (1986) inbreeding was higher in small flocks kept by smallholders and in flocks having only limited breeding rams. On the top of this we investigated that inbreeding was commonly practiced by most of the farmers (87.3%). Example, mating of sire to own daughter was common practice. The predominance of uncontrolled mating in both production systems and small flock sizes would potentially increase the level of inbreeding. The majority of breeding rams were originated from their respective flocks, which might imply that the relationship of animals within a flock is narrow and inbreeding is wide spread and increasing. The low level of inflow of animals of unrelated population either through purchase or other means may further increase the level of inbreeding within the small flock size.

According to Kosgey (2004) inbreeding can be minimized by communal herding which allows breeding female from other flock to mix with breeding male of different flocks, early castration of undesired males and rotational use of breeding males. It was reported that of the total ram owners about 94.4% share their ram to others. In areas such as Horro where most of the community practiced communal sharing of grazing lands; the level of inbreeding could be minimized through the use of unrelated breeding rams from the sub-populations. But this appears to be rarely practiced among the farmers in Adiyo Kaka areas. Controlled breeding scheme which involve rotational utilization of breeding males among the smallholders could be an alternative for Bonga flocks. This need strong extension services to organize farmers to use the existing males efficiently.

Mixed herding and tradition of sharing ram could potentially help to minimize the risk of inbreeding. For the upcoming breeding program this could be an opportunity and it has to be strengthened. Farmers should also need to be convinced about the disadvantages of inbreeding and benefits of improved animals and they should develop interest of keeping better males for breeding rather than selling at younger age or castrating for fattening.

Selection of parents of the next generation in both the rams and ewes was very common among the sampled farmers. Overall 79.7% and 94.7% of the farmers practice selection for breeding ram and breeding females, respectively. Males were selected at 7.5 ± 3.0 and 4.39 ± 2.2 months for Bonga and Horro, respectively. The respective figure for females was 7.4 ± 3.01 and 4.5 ± 1.9 months for Bonga and Horro, respectively. Farmers in Horro usually select animals for breeding at the earlier ages. The ranking of important traits as perceived by farmers for the breeds in the two study sites are summarized in Tables 18 and 19 for males and females, respectively.

Table 18. Ranked selection criteria for breeding rams (%)

Characters	Adiyo Kaka				Horro			
	Rank1	*Rank2*	*Rank3*	*Index*	*Rank1*	*Rank2*	*Rank3*	*Index*
Body size	40.5	35.8	16.5	0.349	54.4	33.3	17.1	0.412
Color	26.1	30.3	30.2	0.282	11.8	28.0	38.6	0.216
Growth rate	3.6	4.6	11.3	0.052	0	1.3	5.7	0.014
Mating ability	2.7	2.8	2.8	0.027	0	0	1.4	0.002
Tail conformation	27.0	23.9	34.9	0.273	27.9	29.3	24.3	0.280
Temperament	0	0.9	0.9	0.005	0	0	0.0	0.002
Age	0	0.0	0.9	0.002	1.4	0	0.0	0.007
Horn	0	0	2.8	0.009	0	1.3	1.4	0.007
Pedigree	0.0	0.0	0.0	0.000	4.4	6.7	8.6	0.059

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular trait divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all traits

Traits like body size, color, and tail formation were all considered as important in both of the sites and given due emphasis in selecting breeding rams. Large body size, red or brown coat color, tail with long, broad and twisted at the end are the most preferred traits by most of the farmers in Adiyo Kaka. Similar traits were preferred for males by the farmers in Horro. However, in contrast to Adiyo Kaka farmers, farmers of Horro preferred male with broad and straight pointed tail. Temperament and age were given relatively little emphasis in selecting breeding animals. Like for males, size, color and tail formation were the most highly rated traits in selecting breeding females in both communities. Lambing interval, mothering ability, age at first lambing and twining rate were also considered in selecting breeding female. Breeding programs should be geared towards functional traits top ranked and management practices such as better feeding and health should go inline with genetic improvement programs. This survey further confirmed the importance of considering trait like coat color in designing sustainable breeding strategies.

Table 19. Ranked selection criteria for breeding females (%)

Characters	Adiyo Kaka				Horro			
	Rank1	*Rank2*	*Rank3*	*Index*	*Rank1*	*Rank2*	*Rank3*	*Index*
Body size	26.3	37.2	12.8	0.279	63	23.1	6.7	0.403
Tail conformation	9.6	10.9	31.2	0.137	6.8	16.7	0	0.089
Pedigree	0.9	0	0	0.004	7.8	13.9	0.9	0.233
Color	30.7	15.5	18.35	0.238	14.6	35.2	26	0.233
Mothering ability	5.3	10.9	7.3	0.075	7.8	0.9	2.9	0.046
Lamb growth	2.6	5.5	4.6	0.039	0	0.9	2.9	0.007
Age at first lambing	2.6	0	4.6	0.020	0	0	60.6	0.101
Lambing interval	7	8	8.3	0.076	0	1.8	0	0.006
Twining rate	13.2	10.9	12.8	0.124	0	7.4	0	0.024
Longevity	0	0.9	0	0.003	0	0	0	0

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular trait divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all traits

4. 14. Coat Color Preferences

Preference of farmer for a particular coat color might be associated with socio-cultural practices, market demand, disease tolerance, and environmental factors. Among the wide range of colors, farmers do have preference only for certain types of colors. Coat colors such as solid red or light brown colors were more preferred by both of the communities. In contrast black, mixed, spotted, grey and white were not preferred across the two sites. Black colored animals were less preferred by almost all respondents because of less demand for black sheep in the market. Less preference of white coat color by farmers in Adiyo Kaka was associated with the belief that white colored animals are more prone to predator as they could easily be identified by predator. The reported preference for coat color pattern match the observed patterns in sample flocks, where in the two populations uniform colors were more common than mixed ones. The effect was more pronounced in Horro flocks than Bonga flocks; where more of the animals in Horro flocks were dominated by plain brown color.

4.15. Reproductive Performances

Puberty in the ewe lamb is the point in which she first exhibits estrus. From the point of farmers, puberty is the age at first service. Results revealed that age at first mating for both sexes is not fixed and sheep are left to nature to reproduce. Reproductive performance of Horro and Bonga sheep are summarized in Table 20. Age at first service for both breeds were 8.5 ± 2.5 and 7.2 ± 2.4 months for females and males, respectively. Horro female lambs reach age at first mating earlier ($P<0.01$) than Bonga ewe lambs. The age at first service in this study seem to be lower than that reported (10 months) previously in traditional systems for Menz sheep (Mukasa-Mugerwa and Lahlou-Kassi, 1995). These values for Bonga are however higher than the values obtained for Gumuz (7.21 ± 1.75 months) sheep (Solomon, 2007).

Average age at first lambing of 14.9 ± 3.1 months and 13.3 ± 1.7 months were reported for Bonga and Horro sheep, respectively. Significant ($P<0.01$) difference was observed between the two breeds for age at first lambing. Horro females gave birth at earlier age than Bonga females. The mean age at first lambing for both breeds was shorter than the 16.5 months reported by Gautsch (1987) for Menz sheep, 15-22 months for the same breed by Abebe (1999). This could be attributed breed difference or environmental difference. Bonga and Horro sheep breeds perform better than most indigenous breeds and this is an opportunity for the upcoming breeding strategy as greater population turnover and more rapid genetic progress could be obtained.

There was no difference ($P>0.05$) between the two breeds in lambing interval. The average lambing interval for Bonga and Horro sheep were 8.9 ± 2.1 months and 7.8 ± 2.4 months, respectively with an overall mean of 8.9 ± 2.2 months. It appears that this value is longer than what had been reported for Gumuz sheep (6.64 ± 1.13) by Solomon (2007). However, it is shorter than what had been reported for Menz sheep (Niftalem, 1990) and for sheep around Dire Dawa by Aden (2003). The shortest lambing interval generally occurs in traditional systems where uncontrolled breeding is the norm. Wilson and Murayi (1988) obtained a longer lambing interval for on station managed long fat-tailed sheep in Rwanda than most of the intervals reported from African traditional systems where controlled breeding was not practiced.

Thus in effect the two breeds, under traditional management production systems lamb three times in two years. This is in agreement to the findings of (Gautsch *et al*., 1986; Mukasa-Mugerwa *et al*., 1986; Wilson, 1991) who indicated that through provision of better nutrition and management in organized farms of tropics it is practically possible to attain three lambing in two years. Such breeding schedule would permit the exploitation of the full reproductive potential, while at the same time avoiding overstressing females. Therefore, to achieve such optimum reproductive performances from the Bonga and Horro breeds the prevailing feeding regime needs to be adequate enough throughout the year.

Higher longevity under adverse conditions is one of the adaptation traits of tropical livestock. The average reproductive life span of Horro and Bonga ewes were 7.9 ± 3.1 years and 7.4 ± 2.7 years, respectively. Long term reproductive performance (long living, high fertility, ability to produce more offspring) of dams should be given more importance in selection programs.

Table 20. Reproductive performances of Bonga and Horro sheep breeds

Characters	Bonga			Horro			
	Minimum	Maximum	Mean ± SD	Minimum	Maximum	Mean ± SD	
Age at first service of male (month)	4	15	7.51 ± 2.14	4	18	7.1 ± 3	*
Age at service of female (month)	5	15	9.3 ± 2.2	3.5	19	7.8 ± 2.4	**
Age at first lambing (month)	9	21	14.9 ± 3.1	11	19	13.3 ± 1.7	**
Reproductive life span of female (yrs)	3	10	7.4 ± 2.7	2.0	15	7.9 ± 3.1	*
Lifespan lamb crop (number)	5	20	12.2 ± 1.8	7	25	15.3 ± 4.3	**
Lambing interval (month)	5	16	8.9 ± 2.1	5.0	15	7.8 ± 2.4	Ns
Twining rate (percent)	10	80	36.30 ± 4.7	3	100	39.8 ± 19	Ns

Ns = Non-significant ($P > 0.05$);*$P < 0.05$; **$P < 0.01$

As a base for initial selection, ancestral information is more important in the absence of any records. On average Bonga ewe delivers 12.20 ± 1.8 lambs in her life time. For Horro sheep it was 15.3 ± 4.3. Similar result was obtained for Gumuz sheep in Metema areas (13.47 ± 1.76) (Solomon, 2007). Significant difference ($P < 0.01$) was reported for life time crop production for the two breeds. The figure reported for Horro is large and this will provide base for selection of better replacement stock. Production of large number of progeny in ewes life span provides ample scope for selection and genetic improvement.

A twining rate of 39.9 % or litter size of 1.40 and 36 % or litter size of 1.36 were obtained for Horro and Bonga sheep breeds, respectively with an overall of 38.2%. No significant ($P> 0.05$) difference was observed between the two breeds regarding this trait. On the other hand 1.14 ± 0.01 litter size were reported for Menz sheep under village condition (Agyemang *et al.*, 1985). The higher twining rate obtained in this study for Horro from their natural breeding environment compared to on-station results (1.14) might be due to the environment by breed interaction effects; where the breed performed poorly when it was kept in the cool highlands of Debre Berhan (Tibbo, 2006).

There is no on-station information for Bonga so far generated on reproductive performance to make possible comparison. According to Mukasa- Mugerwa and Lahlou-Kassi (1995) litter size was the one primary trait directly influenced by ovulation rate and controlled by genotype and environmental factors. Litter size in the current study could thus be explained by this scenario. The two breeds under investigation showed relatively better multiple births under the prevailing feed shortages. It appeared that these breeds do have potential for twining rate which is a key trait in selection as more animals will be available for selection programs.

4.16. Weaning Practices

Weaning is a crucial period in the management of ewes and lambs. It is the practice of removing lambs from the milk diet provided by the ewe. Early weaning allows ewes to return to breeding condition earlier and have accelerated lambing but create stress to lambs and ewes. None of the respondents reported purposive weaning. Lambs were naturally weaned when the lambs could not get milk from their dam. The overall reported average weaning ages for both sexes and breeds was 4.8 ± 1.3 months, with range of 1 to 9 months. This figure was more than what had been reported for the thin tailed Gumuz sheep (3.95± 0.9 months) (Solomon, 20007). Non significant (P>0.05) difference was observed for age at weaning for the two breeds. Weaning ages of 3-4 months, which is shorter than the present result, was reported for indigenous sheep breeds of Ethiopia by Tembely *et al. (*1994). Weaning weight is affected by season, breed, sex, and type of birth. Alaku (1985) working on indigenous and imported sheep breeds in Sudan reported heavier and single lambs weaned earlier with greater average daily gain than lighter and twins lambs. The effect of unrestricted suckling particularly for long period on onset of oestrus need further study.

4. 17. Acquisition and Disposal Practices of Sheep

Major routes of flock entry and exit for both districts are shown in Table 21. Most of the animals for Bonga sheep flocks were born on the farm (64.4%) and if not born within the flock, they were purchased from market (22.0%). For Horro, of the total animals added into the flock about 81% and 8.7% of them were through birth and purchase, respectively. Ribi accounted for 10.6% and 9.5% of animals added into the flock in Bonga and Horro, respectively. Tsedeke (2007) reported that birth at home constitutes about 54.9% and purchase constitutes 18.5% in sheep in Southern Ethiopia. The same author indicated that gifts from family and relatives and share holding, respectively contribute 14.2% and 12.4% of the total sheep acquisitions.

In contrary to this particular finding, Kosgey *et al*. (2006) reported inheritance as the main source for indigenous sheep and goat breeds for smallholders and pastoral communities in Kenya. The figure for 'ribi' in the present study was lower than what was previously reported from Menz area, where 14.7% of the flocks were in the form of 'ribi' (Abebe, 1999). Most of the animals in Adiyo Kaka left the flocks in the form of commercial sale (32.2%) followed by death. To the contrast, for Horro, the highest share was accounted for death (47.6%) and next via sale. An off take of 25.1% for commercial sales and 7.8% slaughter were reported around

Debre Berhan area (Agymang *et al.,* 1985). Higher mortality representing 45.5% of total exit in sheep was reported by Tsedeke (2007).

Table 21. Modes of entry and exit for flock

Means of entry and Exit	Adiyo Kaka	Horro
	Percent	Percent
Entry		
Home reared	64.4	81.0
Purchased	22.0	8.7
Ribi	10.6	9.5
Gift	1.6	0.8
Exchange	1.4	-
Exit		
Mortality	25.6	47.6
Slaughter	8.4	5.4
Sales	32.2	28.1
Predator	13.7	4.9
Lost	1.9	3.9
Ribi	15.7	7.6
Exchange	2.1	-
Gift	0.3	2.4
Theft	-	0.15

Ribi is a common cultural practice offering the “ribi-taker” a traditionally formal access to profit from sheep for his inputs such as labour, grazing land and housing facilities. The foundation animals remain the property of the “ribi-giver”. Labour shortage, feed scarcity and large flock size were the main reasons for giving sheep as ribi for others. Ribi also serve as mechanism of helping the poor within the community and to establish and strengthen social relationship.

The limitation of such ownership is that it makes decision making about the fate of the animal difficult because the ribi taker alone has no right to decide on the fate of the animals. This may pose problem in deciding to sell, to castrate and cull the animals. This need due consideration in implementing community based breeding strategy in the long term as it affect the decision power of the owners either to keep the best animals for breeding or culling of unwanted animal.

Body size, color, and health were the parameters for culling of male sheep. Unlike the females, age was less frequently mentioned as criteria for culling of males. This implies that males are subjected to sale at earlier age. Size, color, long lambing interval, infertility, old age, and health were the parameters for culling female sheep. Size, color, and infertility are the most frequently reported criteria for culling of females in that order among the respondent in Horro. For Adiyo Kaka infertility, size and color were ranked as first, second and third reasons for culling females sheep. Culling of ewes for old age was more practiced among farmers in Adiyo Kaka.

Lambs were rarely culled; only when the magnitude of the financial problem was such that it would require the sale of large numbers of sheep. In such cases, breeding ewes, female lambs, and rams could be sold. It was observed that the magnitude of infertility is more prominent in the Bonga flocks as compared to Horro flocks. An average culling age of 3.2 and 7.8 years were reported for Bonga males and females, respectively. For males and fameless of Horro breed it was 3.8 and 8.2 years. The figure for Horro for both sexes is larger than what has been reported for Menz sheep in the central highlands of Ethiopia (Abebe, 1999).

4. 18. Disease Prevalence and Mortality

In Adiyo Kaka, farmers mentioned pasteurellosis, coenuruses, diarrhea and lung worm in that order, as the most common diseases of sheep at different seasons of the year. Similar diseases were reported across different part of the country by different authors (Berhanu, 1995; Abebe, 1999). In Horro, lung worm, liver fluke (bovine fasciolosis) and coenuruses (*Azurit)* were the first, second and third ranked sheep diseases. Diseases such as coenuruses, lung worm, diarrhea, and pneumonia were common for the two study sites. However, disease such as liver fluke was reported only in Horro areas. This is because of the difference in nature of grazing areas. The high prevalence of liver fluke in Horro is associated with the fact that often sheep graze on swampy areas which are suitable for its host, freshwater snail.

The cold environmental temperature prevailing in the survey sites might have predisposed the animals to respiratory diseases such as lung worm and pasteurellosis. Most farmers treat liver fluke using albendazole which is a broad anthelmentic. Animal health expert reported concerns of resistance developed owning to improper utilization of the drug by the farmers. The majority of the respondents in Adiyo Kaka (91.2%) have no access for veterinary services and they rather depend on unsubscribed drug from open market or shop. In Horro, farmers obtained drugs from government clinics (32.4%) and from both government and private clinics (41.7%). It was reported that farmer in Adiyo Kaka have to travel 25 km (Bonga town) to purchase livestock drugs. Generally, animal health services in Adiyo Kaka is characterized by lack of drugs in the vicinity, inadequacy of service and lack of skilled man power to deliver proper livestock health services.

Therefore, for the breeding strategy to be realistic farmers should be encouraged to adopt proper and cost effective disease control measures and drugs should be available for farmers and the limited animal health services need to be strengthened. Use of albendazole to treat internal parasites like liver fluke in Horro was frequently reported. Besides, seventy and fifty percent of farmers in Adiyo Kaka and Horro, respectively reported the use of albendazole for fattening sheep. Unsystematic use of modern drugs like albendazole especially those purchased from open markets for fattening purpose and treatment of parasites without consultation of veterinarians may lead to drug resistance. Community -based animal health workers programs could be one of the strategy.

Sheep mortality during the last 12 months was assessed based upon the recall of sheep owners. Mortality rates for different sexes and age groups of Bonga and Horro sheep is summarized in Table 22. It was found that mortality of lambs less than six months of age was higher (56.9% in Bonga and 47.4% in Horro flock) than adults. This is in agreement with the findings of Solomon (2007) who reported lamb mortality of 51.25% for Gumuz flocks under farm condition. Mortality of ewes in Horro flocks was by far larger than what was observed for the Bonga flocks (24.3% against 14.3%). However, the overall death rate was higher in Bonga flocks as compared Horro. It was comparable with the report of ILCA (1990) which stated that annual mortality rate of between 25 to 35 was common in small ruminants. Mukasa-Mugerwa *et al.* (1986) reported an annual flock mortality of 22.4% in Adaa district. However, the present findings were higher than the overall mortality rates observed in Gumuz (Solomon, 2007) and Menz flocks (Agyemang *et al.,* 1985). Disease (75%) followed by predator (70.4%) were the most frequent causes of death for farmers in Adiyo Kaka. Similarly, farmers in Horro rated that disease (87%) and predator (61. %) were the major causes of mortality.

The extremely high mortality rate observed in this particular study shows that for the upcoming breeding strategy, serious attention should be given for disease prevention and control measures to maintain more animals for selection and to achieve reasonable genetic gain. As pointed out by Gatenby (1986) maximum productivity in a given system of production is obtained when disease control is optimal. The importance of non-genetic factors intervention in small ruminant improvement was further illustrated by Workneh *et al.* (2003). They demonstrated that improvement in feeding and health care is potentially successful than breeding strategies implemented independently. Therefore, under the prevailing high disease risk, genetic improvement strategies alone do not appears to bring sustainable improvement. There is a need to address the health issues prior to implementing the actual breeding programmes.

Table 22. Reported mortality in different age categories

Sheep categories	Adiyo Kaka			Horro		
	No.	% of total mortality	% total flock	No.	% of total mortality	% total flock
Lambs less than 6 months	188	56.9	14.6	109	47.4	11.6
Young sheep between 6 months and one year	63	19.1	4.9	47	20.4	5.0
Male greater than one year	33	10.0	2.7	18	7.8	1.9
Female greater than one year	49	14.7	3.8	56	24.3	5.9
Total	333	100.0	26	230	100.0	24.4

4.19. Docking

In Adiyo Kaka over 90.4% of the sampled farmers practiced docking. Though the reasons for docking are many and diverse, 35.3% and 18.6% were related to beauty (physical attractiveness) and better body condition. Ease of mating, ease of lamb suckling, ease of delivery and hygiene are also reported reasons for docking. To confirm whether docking has effect on body weight and body condition score a separate analysis was done to compare docked and undocked sheep of the same age groups. Results indicated there was no significant (P>0.05) effect of docking on body weight and condition score. This is in agreement with report of Karim (1980) who obtained non-significant difference between undocked and docked Dubasi desert sheep for weight gain and carcasses characteristics. Further, Shelton (1990) working on fat-tailed Karakul sheep investigated non-significant difference in body weight of docked and undocked ewes or growth rate of their offspring. The same investigator observed that more of docked ewes lambed and mated earlier than non-docked ewes. It is suggested that, more studies are required for a better understanding of the effect of docking. On the contrary, none of the farmers practice docking in Horro.

4. 20. Sheep Marketing

Farmers mainly sold their sheep to traders, consumers and to lesser extent to other farmers. Even though farmers across the study sites sell their animals when financial problems force them to sell, they do prefer to sell their sheep during holidays and festivals. Selling to cope with the existing feed shortage or disease is very low. Sheep are primarily sold in the nearby market where local traders were the principal actors in the marketing process. It was noted that neither there was organized form of marketing system nor it was competitive.

As indicated by farmers sheep price is related to the local holidays and festivals. It was reported that better price is fetched during holidays such as Ethiopian New Year, Christmas, and Easter. The present pricing system in which agreement on price is reached by a long bargaining between sellers and buyers leaves the greater opportunities for benefiting the middlemen. Information on market price, supply, grades, and standards are not available to farmers. Some of the problems associated with sheep marketing include: seasonality of demand, long distance trekking, and lack of feeding and watering facilities along the trekking roads, lack of market information and absence of transportation facilities. There are no responsible bodies who supply farmers with update market information.

As reported by Seleka (2001) appropriate market incentives are necessary drives for genetic improvement. Though market was not mentioned as the top constraint across the study sites, improving of marketing facilities would be enable farmers to get better prices for their animals more than what they are getting currently. For instance, value addition to the improved genotype for example in terms of fattening could play an important role in attracting interest from buyers and thus increase benefit to the farmers.

Overall females were sold at the age of 8.2 ±3.4 months where as males were sold at 8.7 ± 4.0 months. Age of marketing was significantly ($P< 0.01$) different for the two breeds and for both sexes. Accordingly males were sold at early age in Horro (7.5 months) against as compared to their counter parts in Bonga (10.3 months). Similarly, farmers in Horro dispose their female sheep at earlier age (6.7 months against 9.5 moths). Mostly farmers reported that they sold sheep primarily to meet their cash need (86.4%) and the remaining 16.6% sold sheep as a means to cull unwanted animals. For the same age category males were sold at better price than their females counterpart.

4. 21. Constraints of Sheep Production

Good understanding of the relative importance of the different constraints is fundamental prior to initiating any genetic improvement programme (Baker and Gray 2003). Production constraints, which were defined by sheep owners in both areas, are presented in Table 23. Disease, feed shortage, and predators were the most pertinent constraints for sheep production in that order for farmers in Horro. In Adiyo Kaka, disease, labor shortage, predators were ranked as first, second and third based upon their significant influence on sheep productivity. Labor shortage was mentioned as one of the critical problems in sheep husbandry especially in Bonga.

Weakening of traditional management of communal grazing lands, over grazing, encroachment of cropping in to the grazing land, human population growth were the main factors for declining and shrinkage of the primarily grazing land especially in Horro district. Soil erosion, decline in fallow land productivity and size, deforestation, poor management of the sloppy topography are observed as the agents aggravating the feed shortage problem in Adiyo Kaka. Poor veterinary services and absence of transportation facilities were also identified as limiting factors. The swampy nature of communal grazing areas in Horro district associated with high incidence of internal parasites such as liver fluke infestation also influence sheep production

Table 23. Households ranking of constraints for sheep production (%)

Constraints	Horro				Adiyo Kaka			
	Rank1	*Rank2*	*Rank3*	*Index*	*Rank1*	*Rank2*	*Rank3*	*Index*
Feed shortage	16	62	10.3	0.307	17	17	8	0.135
Disease	77.8	20	5.1	0.470	51	33	33	0.367
Market	0.9	0	7.7	0.017	0.9	0.9	8	0.018
Predator	1.9	10.9	28.2	0.094	21.8	38.7	8	0.219
Labor shortage	1.9	2.2	9	0.032	4.5	66	17.2	0.237
Genotype	0	1.1	12.8	0.025	0	0	0	0
Drought	0	2.2	18	0.037	0	0	0	0
Lack of education	0	0	1.3	0.002	0	0	0	0
Water	0	0	5.1	0.008	0	0	0	0
Theft	0	0	2.6	0.004	0	1.9	0	0.005
Capital	0	0	0	0	3.6	0	0	0.015

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular constraints divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all constraints.

4.22. Extension Services

Of the total respondents in Horro and Adiyo Kaka, about 70 and 43.6% respectively reported that they were beneficiaries of extension services rendered by the MoARD. Services like credit, advisory and animal health are in place. Based on the experience in Kenya, (Kosgey *et al.,* 2006) strong extension services are required to successfully run the breeding strategies. Strong extension services are required to create awareness on the values of improved animals as well as convincing the farmers not to dispose superior males through, castration or marketing and on animal health services. The extension system should appreciate and utilize the traditional systems for transfer of knowledge and information and it has to be more of participatory for full participation of farmers.

4.23. Characterization of Qualitative Traits

The major qualitative traits of the Bonga female sample population are presented in Table 24. Out of the sampled 702 ewes, 63.8 % were plain, 33.0% patchy and 3.1% had spotted coat pattern. Plain brown (46.9%), brown, and white with brown dominant (21.5%) coat color patterns were the dominant colors. Brown and white with white dominant (10.0%), solid white (9.1%), creamy white (4.8%), black with white (2.6%), and solid back (2.8%) and grey (0.7%) coat were also observed in plain pattern and mixed in patchy or spotted patterns. About 51.2% proportion of light to dark brown coat color for the breed was reported by Solomon (2004).

As indicated in coat color preferences ranking, black coat had the least preference among the wide ranges of coat colors and this was confirmed by small proportions of animals exhibiting black coat color in the sampled population. In females, nearly 79.3% and 20.7% had straight and slightly convex head profile, respectively. Bonga sheep have a characteristic of fat-tailed with tail just at the hocks and in some cases it hangs below the hocks. In 69.6% of the population the tail was straight down pointed while the rest 30.3% had slightly twisted tail. The predominant ear form or orientation observed in about 89.5 % of the sample population was semi-pendulous. Only 10.5 % of them carry horizontally oriented ears. Of the total female, 81.1% of them were docked. Females were predominantly devoid of horn and ruff. Only about 5.8% of females sampled had toggles. A picture of representative Bonga ewe is depicted in Fig. 5.

Table 24. Summary of the qualitative traits in the female and male Bonga sheep

Character	Attributes	Sex				Total	
		Female		Male			
		No.	%	No.	%	No.	%
Coat colour pattern	Plain	448	63.8	100	63.7	548	63.8
	Patchy	232	33.0	48	30.6	280	32.6
	Spotted	22	3.1	9	5.7	31	3.6
	Overall	702	100.0	157	100.0	859	100.0
Coat color type	White	64	9.1	14	8.9	78	9.1
	Brown	329	46.9	74	47.1	403	46.9
	Black	20	2.8	1	0.6	21	2.4
	Grey	5	0.7	2	1.3	7	0.8
	Creamy white	34	4.8	8	5.1	42	4.9
	White and black with white dominant	11	1.6	7	4.5	18	2.1
	Brown and White with brown dominant	151	21.5	31	19.7	182	21.2
	Brown and White with white dominant	70	10.0	15	9.6	85	9.9
	Black and white with black dominant	18	2.6	5	3.2	23	2.7
	Overall	702	100.0	157	100.0	859	100.0
Head profile	Straight	557	79.3	35	22.3	592	68.9
	Slightly convex	145	20.7	122	77.7	267	31.1
	Overall	702	100.0	157	100.0	859	100.0
Tail conformation	Straight and tip down ward	91	69.6	43	62.3	134	67.0
	Straight and twisted end	40	30.5	26	37.7	66	33.0
	Overall	131	100	69	100.0	200	100.0
Wattle	Present	41	5.8	3	1.9	44	5.1
	Absent	661	94.2	154	98.1	815	94. 9
	Overall	702	100.0	157	100.0	859	100.0
Ruff	Present	-	-	21	13.4	21	13.4
	Absent	-	-	136	86.6	136	86.6
	Overall	-	-	157	100.0	157	100.0
Ear form	Horizontal	74	10.5	11	7.0	85	9.9
	Semi-pendulous	628	89.5	146	93.0	774	90.1
	Overall	702	100.0	157	100.0	859	100.0
Dock	Docked	569	81.1	-	-	569	81.1
	Not docked	133	18.9	-	-	133	18.9
	Overall	702	100.0	-	-	702	100.0

Figure 5. Typical Bonga adult female

Coat pattern is more or less similar between the two sexes in Bonga breed. The coat patterns of male sheep were 63.7% plain, 30.6% patchy and 5.7% were spotted. Brown (47.1%) and brown with white with brown dominant (19.7%) were the major colors frequently observed in the male sample population (Table 24). Other kinds of plain, patchy, and spotted coat patterns with different colors were also observed. The ear was semi- pendulous (93.0%) and wattle was observed in rare cases (1.9%). The head profile was slightly convex (77.7%). Ruff was observed in about 13.4% of the sampled male population. Like the females, all males were devoid of horn. Picture of Bonga male is depicted in Fig. 6.

Figure 6. Bonga male sheep

Of the total sampled Horro females about 87.5% were plain, 10.4% patchy and only 2.1 % had spotted coat pattern. Brown (55.6%), creamy white (tan) (20.6 %), brown and white (12.3%) were the observed coat colors in females. Though rare, plain white (4.2%) and solid black (5.9%) colors were observed. The facial profile was almost straight (98.3%) with only 1.7 % having slightly convex head profile. Wattle was observed among 6% of the total sampled populations. The majority of females had long and semi-pendulous ear orientation (97.2%). Out of the sampled female animals 70.3% had straight tail with downward tip, while 29.7 % had tail with twisted end. Details of physical descriptions of Horro ewe are presented in Table 25. Picture of Horro ewe is shown in Fig. 7.

Table 25. Summary of the qualitative traits in the female and male Horro population

Character	Attribute	Sex				Total	
		Female		Male			
		No.	%	No.	%	No.	%
Coat color pattern	Plain	715	87.5	60	87.0	775	87.5
	Patchy	85	10.4	9	13.0	94	10.6
	Spotted	17	2.1	-	-	17	1.9
	Overall	817	100.0	69	100.0	886	100
Coat color type	White	34	4.2	4	5.8	38	4.3
	Brown	454	55.6	44	63.8	498	56.2
	Black	48	5.9	-	-	48	4.4
	Grey	9	1.1	-	-	9	1.0
	Creamy white	168	20.6	13	18.8	181	20.4
	White and black with white dominant	1	0.1	1	1.4	2	0.2
	Brown and White with brown dominant	61	7.5	7	10.1	68	7.7
	Brown and White with white dominant	39	4.8	-	-	39	4.4
	Black and white with black dominant	3	0.4	-	-	3	0.3
	Overall	817	100.0	69	100	886	100.0
Head profile	Straight	803	98.3	18	26.1	821	92.7
	Slightly convex	14	1.7	51	73.9	65	7.3
	Overall	817	100.0	69	100.0	886	100.0
Tail form	Straight and tip down ward	574	70.3	43	62.3	617	69.6
	Straight and twisted end	243	29.7	26	37.7	269	30.4
	Overall	817	100.0	69	100.0	886	100
Wattle	Present	49	6.0	3	4.3	52	5.9
	Absent	768	94.0	66	95.7	834	94.1
	Overall	817	100.0	69	100.0	886	100.0
Ear form	Horizontal	23	2.8	-	-	23	2.6
	Semi-pendulous	794	97.2	69	100.0	863	97.4
	Overall	817	100.0	69	100	886	100
Ruff	Present	-	-	24	34.8	24	34.8
	Absent			45	65.2	45	65.2
	Overall	-	-	69	100.0	69	100.0

Figure 7. Typical Horro adult female

Plain (87%) and patchy (13%) were the observed coat patterns of the sample Horro sampled male population in the study areas. Brown (63.8%), creamy white (18.8%) and brown with white (10.1%) were the dominant color types observed in male population (Table 25). In all observed males the head profile was slightly convex and the ear orientation was semi-pendulous. Ruff was observed in 34.8 % of the males. Wattle was identified only in 4.3% of the sampled male population. More than half of the males (62.7%) had tails hanging straight downwards and 37.7% of them carry tails with slightly twisted end. The higher proportion of male sheep with long and straight downward pointed tail might be due to selection against twisted end tail animals.

Like females, most males were polled. It was noted that ruff was mainly sex and age dependent. They were totally absent in females and more readily observed in adult males as compared to young growing males. A plate of typical Horro ram is illustrated in Fig. 8. The chi-square test of independence of categorical variables in the two breeds sample population indicated that among the variables considered in this study coat pattern, coat color, tail conformation and ear orientation were found to significantly ($P<0.01$) differ between the two breeds. More of the animals in Horro had plain coat pattern, brown coat color, and semi-pendulous ear orientation.

Figure 8. Typical Horro ram

4.24. Live Body Weight and Linear Measurements

Information on live body weight and linear measurements of the existing breeds has mandatory role in the selection programme. The body weight and linear measurements for Bonga and Horro female sheep at various ages are presented in Table 26.

Breed effect: The results of least squares analysis (Appendix Table 7) indicated that in females breed was found to significantly influence ($P < 0.01$) body weight and other body measurements except tail circumference and body condition score ($P > 0.05$). Bonga females had significantly higher values for body weight, body length, chest width, pelvic width, and ear length ($P < 0.01$). To the contrast, Horro ewes had greater values for chest girth, wither height, and tail length ($P < 0.01$).

Results for body weight and linear measurements of male Bonga and Horro sheep revealed that Horro males had significantly larger ($P < 0.01$) chest girth, wither height, chest width, scrotal circumference and body condition score than Bonga males (Table 27). Bonga male on the other hand had longer ($P < 0.01$) ear length than Horro male. However, non-significant ($P < 0.05$) differences were observed for body weight, body length, pelvic width, tail circumference and tail length between males of the two breeds. For Horro and Bonga males, respectively the over all scrotal circumferences was 27.17 ± 0.48cm and 23.02 ± 0.47cm.

Age effect: In females of the two breeds age was found to strongly influence ($P < 0.01$) live body weight and other linear measurements with the exception of ear length, tail circumference, tail length and body condition scores ($P > 0.05$). Accordingly, animals in dentition group 3 and 4 had higher values than those between 1 and 2 dentition categories. This shows that younger animals (in dentition one and two) were still growing compared to animals at advanced age. Yet the older animals (> 3 pairs of permanent incisors) had higher values than the middle age animals (2- 3 pairs of permanent incisors) in most of the parameters considered. This scenario is however not surprising since the size and shape of the animal is expected to increase as the animal is growing with age.

There was wide variability as the age of the animals increased for body measurements such as BW, BL, CG, and WH. This implies that these variables might be best explaining the growth pattern of the animals. To the contrast, variables such as PW, EL, TL TC, and BCS were less influenced by age and showed less variation as age advances. This indicates that these variables attain their maximum growth at early age.

For body weight, body length, chest girth and wither height in females of both breeds, larger variation was observed between animal in dentition 2 and 3. This was attributed to the fact that animals at theses life phase shows fast growth rate compared to at the later ages. Where as lower variation observed between animals in dentition 3 and 4 most probably because the matured body weight of the animal was almost fully attained. This is in accordance with the report of Samuel and Salako (2008) who reported a sharp decline in difference between body weight and other traits between age groups 3-4 years and 4-5years in West African Dwarf goat. Further, this finding was in consonance with the work of Jeffery and Berg (1972) who reported that at maturity, linear body measurements are essentially a constant**,** thereby reflecting heritable size of the skeleton. Maturity age of three year was reported for Horro sheep breed under station management conditions (Solomon and Gemeda, 2000).

The fact that the two breeds reached their highest body weight and linear measurements (BL, CG, and WH) at their oldest age group (4PPI) is explained by physiology, as large sized animals continue to grow until maturity (Mekasha, 2007). This further confirmed that the two breeds under consideration are classified as large and late maturing. This is in agreement with findings of Mekasha (2007) that large sized indigenous bucks reach maturity at later age as compared to early maturing small sized bucks.

Likewise, in males dentition significantly ($P<0.01$) affected body weight, body length, chest girth; wither height, tail length, and scrotal circumference ($P<0.05$). However, non-significant ($P>0.05$) effect of dentition in males was observed for pelvic width, ear length, body condition, and chest width and tail circumference (Appendix Table 8).

Generally the observed phenotypic difference between the two breeds is in support of the in-depth molecular studies undertaken by Solomon *et al.,* (2007). Body condition scoring was used as a subjective assessment of the level of body reserve in farm animals. It is an indirect reflection of the nutritional status of animals. Despite the lower body weight recorded for Horro ewe, body condition score was not significantly (P>0.05) different between females of the two breeds. This might be attributed to the difference in breed and management practices. Nsoso *et al*. (2003) reported that body weight in Tswana goat did not always parallel with body condition scores. They indicated that body condition score reflects body lipids more than body weight as the later is affected by gut contents which vary according to the type and quantity of feed available. To the contrast, body condition score in males was affected by breed (P<0.05); Horro had better BCS than their counterpart Bonga. The inconsistency in BCS across the two sexes might be explained as factor other than sex of the animals (management) influence BCS.

Scrotal circumference is an indirect measure of testicular mass / ram fertility and used to asses breeding soundness of ram and it has high heritability (Söderquist and Hulten, 2006). Scrotal circumference differed significantly between the two age- classes (P<0.05) and breeds (P<0.01). Animals at advanced age group (≥ 2PPI) had larger scrotal circumference (25.80 ± 0.57cm) than animals at younger ages (1PPI) (24.39 ± 0.36cm). Horro male had larger scrotal circumference of (27.17 ± 0.48 cm) as compared to Bonga male (23.02 ± 0.47 cm27.17 ± 0.48cm). The difference could be related to the difference in age as most sampled Bonga male were from an age of one pair of permanent incisors (1PPI). The influence of age on SC in sheep (Söderquist and Hulten, 2006) and in goat was reported (Mekasha, 2007).

The values obtained for body weight in this study for Horro breed is re lower than those obtained by Solomon (2007) which was 35 kg. The much lower values in body weight in the present study might be due to difference nutritional status of the animals or due to the fact that animals of different age groups were considered. For this particular study, body measurements were taken during the dry season of the year and for Horro critical feed shortage was observed and might be resulted lower body weight. However, the present findings regarding the body weight for Bonga females was close to the reported 32 kg by

Tibbo and Ginbar (2004). In agreement to the present findings, Tibbo *et al.* (2004) reported 65.4 ± 1.5 and 67.3 ± 1.2cm body lengths and wither height, respectively for Horro ewe at an age of 24 months. Scrotal circumference obtained for Bonga ram is within the range of earlier report of Tibbo and Ginbar (2004) which was 22 to 30cm. The observed scrotal circumference for Horro male is close to the earlier report which is 27cm for the breed (Solomon and Thwaites, 1997).

The results of the present study indicated that the sheep were lean (2.52 ± 0.03) for Bonga ewe and 2.44 ± 0.03 for Horro ewe. Though the difference was not significant, Bonga females were found in better body condition. Therefore, the present condition of surveyed flocks is not satisfactory to maintain optimum productivity. Therefore, there is a need for strategic feeding at least to reduce weight loss during the dry season.

Table 26. Least squares means (LSM) ± standard error (SE) for the main effect of breed and dentition and breed by dentition interaction on the live body weight(Kg) and body measurements(cm) in female Bonga and Horro sheep breeds

Effects & level	N	BW	BL	CG	WH	CW
Over all	1487	30.76 ± 0.27	68.28 ± 0.11	73.36 ± 0.13	68.77 ± 0.11	14.15 ± 0.05
C.V		14.35	4.97	5.19	4.69	11.12
R^2		0.29	0.19	0.24	0.17	0.08
Breed		**	**	**	**	**
Bonga	688	31.87 ± 0.19	69.16 ± 0.15	72.92 ± 0.17	68.12 ± 0.14	14.52 ± 0.07
Horro	792	27.65 ± 0.21	67.40 ± .164	73.81 ± 0.19	69.43 ± 0.16	13.78 ± 0.08
Age groups		**	**	**	**	**
1PPI	146	26.81 ± 0.37^{a}	66.19 ± 0.29^{a}	70.62 ± 0.33^{a}	67.17 ± 0.27^{a}	13.63 ± 0.13^{a}
2PPI	247	28.62 ± 0.29^{b}	67.38 ± 0.22^{b}	72.31 ± 0.25^{b}	68.26 ± 0.21^{b}	13.92 ± 0.10^{a}
3PPI	259	30.81 ± 0.29^{c}	68.99 ± 0.22^{c}	74.35 ± 0.25^{c}	69.41 ± 0.21^{c}	14.36 ± 0.10^{b}
4 PPI	825	32.79 ± 0.16^{d}	70.56 ± 0.13^{d}	76.19 ± 0.14^{d}	70.26 ± 0.12^{d}	14.68 ± 0.06^{c}
B × D		Ns	Ns	Ns	**	Ns
Bonga						
1PPI	85	28.69 ± 0.48^{a}	67.20 ± 0.37^{a}	70.19 ± 0.4^{a}	66.82 ± 0.35^{a}	14.07 ± 0.17^{a}
2PPI	102	31.12 ± 0.42^{b}	68.41 ± 0.33^{a}	72.20 ± 0.37^{b}	68.10 ± 0.31^{ab}	14.24 ± 0.15^{ab}
3PPI	169	32.79 ± 0.34^{c}	69.63 ± 0.26^{ab}	73.93 ± 0.29^{c}	68.33 ± 0.25^{bc}	14.79 ± 0.12^{bc}
4 PPI	325	34.88 ± 0.25^{d}	71.40 ± 0.19^{c}	75.34 ± 0.22^{d}	69.22 ± 0.18^{c}	14.97 ± 0.09^{c}
Horro						
1PPI	61	24.92 ± 0.57^{a}	65.18 ± 0.44^{a}	71.03 ± 0.49^{a}	67.51± 0.42^{a}	13.18 ± 0.20^{a}
2PPI	138	26.12 ± 0.57^{b}	66.36 ± 0.29^{a}	72.43 ± 0.33^{a}	68.42 ± 0.28^{a}	13.59 ± 0.14^{a}
3PPI	90	28.84 ± 0.47^{c}	68.37 ± 0.36^{b}	74.76 ± 0.41^{b}	70.49 ± 0.34^{b}	13.93 ± 0.17^{ab}
4 PPI	503	30.71 ± 0.19^{d}	69.71 ± 0.15^{c}	77.03 ± 0.17^{c}	71.29 ± 0.15^{b}	14.39 ± 0.07^{b}

^{a,b,c,d} means on the same column with different superscripts within the specified dentition group are significantly different (P<0.05); Ns = Non-significant (P>0.05); ** P < 0.01; BW = Body weight; BL = Body Length; CG = Chest Girth; WH = Wither height; CW = Chest width ; 1PPI = 1 Pair of Permanent Incisors; 2 PPI = 2Pairs of Permanent Incisors; 3PPI = 3Pairs of Permanent Incisors ; 4PPI = 4Pairs of Permanent Incisors; B × D = Breed by Dentition interaction.

Table 26. ***(Continued)***

Effects and level	N	PW	EL	TL	TC	BC
Over all	1487	20.33 ± 0.05	11.55 ± 0.03	33.62 ± 0.21	16.00 ± 0.17	2.48 ± 0.023
C.V		7.32	8.05	11.20	20.00	28.46
R^2		0.04	0.01	0.07	0.01	0.03
Breed		**	**	**	Ns	Ns
Bonga	688	20.52 ± 0.06	11.62 ± 0.04	32.07 ± 0.37	15.92 ± 0.30	2.52 ± 0.03
Horro	792	20.15 ± 0.07	11.48 ± 0.05	35.18 ± 0.19	16.08 ± 0.15	2.44 ± 0.03
Age groups		**	Ns	Ns	Ns	Ns
1PPI	146	19.92 ± 0.13 [a]	11.48 ± 0.08 [a]	33.16 ± 0.49 [a]	15.99 ± 0.41 [a]	2.44 ± 0.06 [a]
2PPI	247	20.22 ± 0.09 [ab]	11.47 ± 0.06 [a]	33.60 ± 0.45 [a]	15.50 ± 0.37 [a]	2.47 ± 0.05 [a]
3PPI	259	20.49 ± 0.09 [bc]	11.63 ± 0.06 [a]	33.93 ± 0.41 [a]	16.35 ± 0.34 [a]	2.52 ± 0.05 [a]
4 PPI	825	20.69 ± 0.05 [c]	11.61 ± 0.03 [a]	33.81 ± 0.28 [a]	16.16 ± 0.23 [a]	2.49 ± 0.03 [a]
B × D		Ns	Ns	Ns	Ns	**
Bonga						
1PPI	85	20.21 ± 0.16 [a]	11.59 ± 0.10 [a]	31.52 ± 0.85 [a]	16.83 ± 0.70 [a]	2.38 ± 0.08 [a]
2PPI	102	20.43 ± 0.14 [a]	11.57 ± 0.09 [a]	32.05 ± 0.83 [a]	15.14 ± 0.68 [a]	2.46 ± 0.07 [a]
3PPI	169	20.49 ± 0.12 [a]	11.67 ± 0.07 [a]	32.40 ± 0.71 [a]	16.15 ± 0.59 [a]	2.58 ± 0.05 [a]
4PPI	325	20.94 ± 0.08 [b]	11.64 ± 0.05 [a]	32.29 ± 0.53 [a]	16.22 ± 0.43 [a]	2.65 ± 0.039 [a]
B × D		**	Ns	Ns	Ns	**
Horro						
1PPI	61	19.62 ± 0.19 [a]	11.38 ± 0.12 [a]	34.79 ± 0.49 [a]	15.15 ± 0.41 [a]	2.51 ± 0.09 [a]
2PPI	138	20.01 ± 0.13 [ab]	11.38 ± 0.08 [a]	35.16 ± 0.33 [a]	15.87 ± 0.27 [a]	2.49 ± 0.06 [a]
3PPI	90	20.51 ± 0.16 [b]	11.59 ± 0.09 [a]	35.46 ± 0.41 [a]	16.56 ± 0.34 [a]	2.46 ± 0.07 [a]
4 PPI	503	20.45 ± 0.07 [bc]	11.59 ± 0.04 [a]	35.33 ± 0.17 [a]	16.10 ± 0.14 [a]	2.33 ± 0.03 [a]

[a ,b,c,d] means on the same column with different superscripts within the specified dentition group are significantly different ($p < 0.05$); Ns = Non-significant ($P>0.05$); ** $P< 0.01$; PW = Pelvic Width; EL = Ear Length; TL = Trail Length; TC = Tail Circumference; BCS= Body Condition Score; 1PPI = 1 Pair of Permanent Incisors; 2 PPI = 2Pairs of Permanent incisors; 3PPI = 3Pairs of Permanent Incisors ; 4PPI = Pairs of Permanent Incisors; B × D = Breed by Dentition interaction.

Table 27. Least squares means (LSM) ± standard error (SE) for the main effect of breeds and dentition and breed by dentition interaction on the live body weight(kg) and body measurements(cm) in male Bonga and Horro sheep breeds

Effects and level	N	BW	BL	CG	WH	CW	SC
Over all	102	30.68 ± 0.85	68.78 ± 0.65	73.06 ± 0.75	69.09 ± 0.62	14.74 ± 0.25	25.09 ± 0.34
C.V		21.45	7.09	7.72	6.77	12.55	8.37
R2		0.19	0.22	0.35	0.38	0.10	0.53
Breed		Ns	Ns	**	**	**	**
Bonga	74	29.70 ± 0.17	68.27 ± 0.89	70.0 ± 1.03	66.53 ± 0.85	14.07 ± 0.35	23.02 ± 0.47
Horro	28	31.66 ± 1.23	69.30 ± 0.94	76.12 ± 1.08	71.66 ± 0.90	15.42 ± 0.36	27.17 ± 0.48
Age groups		**	**	**	**	Ns	*
1PPI	76	27.83 ± 1.06	66.19 ± 0.81	70.89 ± 0.93	66.96 ± 0.77	14.758 ± 0.31	24.39 ± 0.36
≥ 2PPI	26	33.54 ± 1.33	71.36 ± 1.01	75.23 ± 1.17	71.24 ± 0.97	14.73 ± 0.39	25.80 ± 0.57
B × D		**	**	**	**	Ns	Ns
Bonga							
1PPI	66	27.22 ± 0.77	65.78 ± 0.59	68.38 ± 0.67	65.32 ± 0.56	14.52 ± 0.23	22.44 ± 0.29
≥ 2PPI	8	32.19 ± 2.21	70.75 ± 1.69	71.63 ± 1.94	67.75 ± 1.6	13.62 ± 0.65	23.60 ± 0.89
Horro							
1PPI	10	28.43 ± 1.97	66.60 ±1.51	73.40 ±1.73	68.60 ± 1.44	15.00 ± 0.58	26.33 ± 0.66
≥2PPI	18	34.89 ± 1.47	72.00 ± 1.13	78.83 ± 1.29	74.72 ± 1.07	15.83 ± 0.44	28.00 ± 0.70

Ns = Non-significant (P>0.05); * P < 0.05; ** P< 0.01; BW = Body Weight; BL= Body Length; CG = Chest Girth; WH = Wither Height; CW = Chest Width; SC = Scrotal Circumference; 1PPI = 1 Pair of Permanent Incisors; ≥ 2 PPI = 2 or more Pairs of Permanent Incisors; B × D = Breed by Dentition interaction.

Table 27***. (Continued)***

Effects and level	N	PW	EL	TC	TL	BCS
Over all	102	19.48 ± 0.32	10.98 ± 0.12	22.15 ± 0.69	36.46 ± 0.68	2.97± 0.10
C.V		12.37	8.20	23.27	13.87	26.56
R^2		0.11	0.11	0.11	0.22	0.17
Breed		Ns	**	Ns	Ns	*
Bonga	74	19.03 ± 0.45	11.33 ± 0.17	20.85 ± 0.97	35.40 ± 0.96	2.71 ±0.138
Horro	28	19.92 ± 0.47	10.65 ± 0.18	23.46 ± 0.97	37.52 ± 0.95	3.23 ± 0.15
Age groups		Ns	Ns	Ns	**	Ns
1PPI	76	18.86 ± 0.40	10.95 ± 0.16	21.30 ± 0.83	34.35 ± 0.82	2.82 ± 0.13
>2PPI	26	20.09 ± 0.51	11.03 ± 0.19	23.00 ±1.09	38.58 ± 1.07	3.12 ± 0.16
B × D		Ns	Ns	Ns	Ns	Ns
Bonga						
1PPI	66	18.82 ± 0.29	11.40 ± 0.11	19.91 ± 0.60	33.09 ± 0.59	2.55 ± 0.09
≥ 2PPI	8	19.25 ± 0.84	11.25 ± 0.32	21.79 ± 1.85	37.71 ± 1.82	2.89 ± 0.26
Horro						
1PPI	10	18.90 ± 0.75	10.50 ± 0.29	22.70 ± 1.55	35.60 ± 1.52	3.10 ± 0.23
≥ 2PPI	18	20.94 ± 0.56	10.81 ± 0.22	24.22 ± 1.16	39.44 ±1.14	3.36 ± 0.17

Ns = Non-significant (P> 0.05); *P < 0.05; ** P<0.01; PW = Pelvic Width; TC = Tail circumference; SC = Scrotal circumference; BCS = Body Condition Score; 1PPI = 1 Pair of Permanent Incisors ≥ 2PPI = 2 or more Pairs of Permanent Incisors; B × D = Breed by Dentition interaction.

4.25. Correlation between body weight and body measurements

The correlation coefficient indicating the relationship between live weight and other body measurements in Bonga and Horro sheep are shown in Table 28 and 29. With body weight most independent parameters depicted positive and highly significant (P<0.01) correlation. The highest relationship between chest girth and body weight were observed in Bonga female of dentition two (0.81) and in male of the same breed for the pooled data (0.88).

Table 28. Coefficients of correlation between body weight and other body measurements for Bonga sheep within age groups and sex

Trait		Age group						
		1PPI		2PPI	3 PPI	4PPI	1- 4PPI	
		M	F	F	F	F	M	F
BCS	N	60	86	110	167	325	67	688
	r	0.59**	0.65**	0.70**	0.64**	0.69**	0.71**	0.66**
BL	N	60	86	110	167	325	67	688
	r	0.52*	0.52**	0.41**	0.56**	0.57**	0.68**	0.64**
CG	N	60	86	110	167	325	67	688
	r	0.83**	0.67**	0.81**	0.78**	0.72**	0.88**	0.79**
WH	N	60	86	110	167	325	67	688
	r	0.63**	0.59**	0.35**	0.42**	0.48**	0.72**	0.52**
PW	N	60	86	110	167	325	67	688
	r	0.57**	0.24*	0.35**	0.36**	0.41**	0.61**	0.39**
TC	N	60	-	-	-	-	-	-
	r	0.59**	-	-	-	-	0.55**	-
SC	N	60	NA	-	-	-	67	NA
	r	0.49**	NA	NA	NA	NA	0.35**	NA

*P<0.05; ** P<0.01; BL=Body Length; CG= Chest Girth; WH= Wither height; PW = Pelvic Width; TC=Tail Circumference; SC = Scrotal circumference; BCS= Body Condition Score; 1PPI = 1 Pair of Permanent Incisors; 2 PPI = 2 Pair of Permanent Incisors; 3PPI = 3 Pair of Permanent Incisors; 4PPI = 4 Pair of Permanent Incisors; M = Male; F = Female, NA = Non-applicable; (-) = No value taken.

Of the linear body measurements, chest girth with exception in Horro males had the highest correlation with body weight at various ages and in both sexes. In Horro, the highest correlation coefficient between the dependent variable body weight and the independent variable chest girth were established in females from pooled data (77%) and in male (85%).

Table 29. Coefficients of correlation between body weight and other body measurements for Horro sheep within age groups and sex

Trait		Age group					
		1PPI	2PPI	3 PPI	4PPI	1-4PPI	
		F	F	F	F	M	F
BCS	N	61	138	90	502	20	792
	r	0.43**	0.45**	0.19Ns	039**	0.35Ns	0.29**
BL	N	61	138	90	502	20	792
	r	0.42**	0.61**	0.52**	0.56**	0.85**	0.63**
CG	N	61	138	90	502	20	792
	r	0.71**	0.69**	0.72**	0.73**	0.85**	0.77**
WH	N	61	138	90	502	20	792
	r	0.48**	0.55**	0.58**	0.45**	0.77**	0.56**
PW		61	138	90	502	20	792
	r	0.26*	0.55**	0.43**	0.39**	0.84**	0.43**
TC	N	61	138	90	502	20	792
	r	0.68**	0.55**	0.48**	0.53**	0.74**	0.45**
SC	N	NA	138	90	NA	20	-
	r	NA	NA	NA	NA	0.79**	NA

Ns = non-significant; *P< 0.05; ** P< 0.01; BL= Body Length; CG = Chest Girth; WH = Wither height; PW = Pelvic Width; TC = Tail circumference; SC = Scrotal Circumference; BCS = Body Condition Score; 1PPI = 1 Pair of Permanent Incisors; 2 PPI = 2Pairs of Permanent Incisors; 3PPI = 3 Pairs of Permanent Incisors; 4PPI = 4 Pairs of Permanent Incisors; M = Male; F = Female; NA = Non-applicable.

It was found that the correlation between body weights and body measurements in pooled data from 1 to 4 dentition class were higher than those at different dentition groups. This might be due to more or less similar environmental influences at different age groups. There was also a positive and high linear association ($P<0.01$) between body weight and body condition except in dentition three and in pooled data of Horro females. The high, positive and significant correlation between body weight and chest girth suggest that this variables could provide a good estimate for predicting live weight of these breeds.

Though the association of scrotal circumference with body weight affected by breed, physiological status, nutrition and management (Söderquist and Hulten, 2006), scrotal circumference also exhibited highly significant relationship ($P<0.01$) with live boy weight in Horro males ($r = 0.79$) and in Bonga males ($r = 0.35$). The observed highly significant correlation between body weight and scrotal circumference in this particular study suggest that selection for scrotal circumference would lead to males with high potential for sperm production. Looking at the values of correlation coefficients, in general, males showed higher tendency of relationship between body weight and linear body measurements. The higher correlation coefficient for males sheep in most cases indicate that on the basis of the dimension of the body weight could be predicted more accurately in males as compared to their female. This is in agreement with the findings of Hassan and Ciroma (1992). Since body measurements had high correlation with live body weight especially chest girth, this may be used as selection criteria in the upcoming breeding strategies.

4. 26. Multiple Regression Analysis

In order to predict body weight from linear measurements, stepwise multiple regressions was carried out where other body measurements were added, one at time, to chest girth. In estimation of body weight from body measurements in female and male Bonga sheep six and eight body measurements, respectively were utilized. Similarly, for Horro female and male seven and eight body measurements were considered. The independent parameters or regressors were body length, chest girth, wither height, chest width, pelvic width, and body condition. In addition to these variables scrotal circumference were considered for Horro and

Bonga male. Tail circumference was only omitted in Bonga female primarily due to the fact that most females were docked.

Table 30 and 31 shows the regression output and coefficient of determination for Bonga and Horro sheep breeds, respectively at different dentition and sex categories. In the prediction of body weight in Bonga female the multiple stepwise regressions found only three parameters to be significant ($P< 0.05$) for dentition two and three groups with R^2 values of 75% and 76% , respectively. Where as four and five parameters were found to be significant ($P< 0.05$) for animals of the same breed in dentition one and four, with R^2 values of 67% and 74%, respectively. Four regressors (CG, BCS, BL and PW) were found to have significant association ($P<0.05$) with body weight when all data pooled for the female with R^2 value of 77%. Only chest width was removed as its association with body weight was found non significant ($P>0.05$). In the males of the same breed using the pooled data from all dentition groups, the same parameters contributed significantly ($P< 0.05$) to the model and depicted an R^2 value of 85%.

Table 30. Prediction equations at different sex and age groups in Bonga sheep

Female Age group	Equations	Intercept	β_1	β_2	β_3	β_4	β_5	R^2	R^2 Change
1PPI	CG	-17. 24	0. 65					0. 45	0.00
	CG + BCS	-8. 70	0. 46	2. 26				0. 59	0.14
	CG + BCS + WH	-24. 66	0. 33	2. 09	0. 38			0. 65	0.06
	CG + BCS+ WH + PW	-30. 65	0. 36	1. 86	0. 35	0. 31		0. 67	0.02
2PPI	CG	-37.02	0.94					0.66	0.00
	CG + BCS	-24.90	0. 71	2.05				0.73	0.07
	CG + BCS+ WH	-34.66	0.59	2.33	0.26			0.75	0.02
3PPI	CG	-38.52	0.97					0.60	0.00
	CG + BCS	-30.46	0.77	2.60				0.70	0. 10
	CG + BCS + BL	-45.90	0.68	2.10	0.34			0.76	0.06
4PPI	CG	-25.68	0.80					0.52	0.00
	CG + BCS	-14.05	0.56	2.70				0.66	0.14
	CG + BCS + BL	-30.62	0.46	2.39	0.33			0.72	0.06
	CG + BCS + BL + PW	-33.66	0.49	2.36	0.27	0.50		0.73	0.01
	CG + BC S+ BL + PW + WH	-38.19	0.42	2.35	0.234	0.34	0.16	0.74	0.01
Male Age group 1PPI	CG	-30.92	0.85					0.69	0.00
	CG + WH	-40.53	0.69	0.31				0.74	0.05
	CG + WH + TC	-37.44	0.57	0.33	0.21			0.77	0.03
	CG + WH + TC + +BCS	-33.94	0.49	0.31	0.19	1.17		0.79	0.02
	CG + WH + TC+BCS + BL	-39.23	0.44	0.27	0.20	1.18	0.18	0.80	0.01
Female Age group 1- 4 PPI	CG	-33.34	0.90					0.62	0.00
	CG + BCS	-24.49	0.69	2.39				0.71	0.09
	CG +BCS + BL	-38.93	0.57	2.05	0.35			0.76	0.05
	CG+ BCS + BL+ PW	-41.18	0.562	1.99	0.31	0.28		0.77	0.01
Male Age group 0- 4 PPI	CG	-40.95	0.99					0.77	0.00
	CG +BL	49.88	0.83	0.31				0.81	0.04
	CG +BL +PW	-49.02	0.67	0.31	0.56			0.84	0.03
	CG +BL +PW +BCS	-43.79	0.58	0.29	0.48	1.26		0.85	0.01

CG= Chest Girth; BL=Body Length; WH= Wither height; PW = Pelvic Width; TC = Tail circumference; BCS= Body Condition Score; 1 PPI = 1 Pair of Permanent Incisors; 2 PPI = 2 Pairs of Permanent Incisors; 3 PPI = 3 Pairs of Permanent Incisors; 4 PPI = 4 Pair Permanent Incisors

Regression equation was developed for Horro male only from the pooled data for all age groups due to the low proportion animals at each dentition classes. As shown in Table 31 for dentition one of female Horro sheep only chest girth and tail circumference were significantly ($P< 0.05$) contributed to the model and together yielded an R^2 of 61%. In dentition two of the same breed and sex inclusion of chest girth, body length, tail circumference, body condition and wither height at first, second, third, fourth and fifth steps, respectively raised the prediction equation to 63%.

For Horro female at dentition classes three (3PPI) further addition of wither height, tail circumference and body length to the chest girth in that order improved the prediction accuracy by 9%, 5% and 2%, respectively. A further prediction analysis was carried out using pooled data for females and male of Horro sheep. Five regressors with significant contribution to the prediction model which include chest girth, tail circumference, body length, body condition, and pelvic width were fitted in first, second, third, forth and fifth steps and they explained 69% of the total variability in the dependent variable of the female sheep. In all age groups of males of Horro sheep body length alone accounted for a bout 80% of the variation in body weight. Further inclusion of chest girth improved the prediction accuracy to 81%.

The coefficient of determination (R^2) indicated that with the exception of Horro male chest girth succeeded in describing more variation in body weight than other body measurements in both Horro and Bonga sheep. It was more reliable in predicting body weight than other linear body measurements. Hence, in both of the breeds, live body weight at various growth stages could be fairly estimated from chest girth measurements. In Bonga female, second to chest girth, body condition score was more precisely predict body weight. The better association of body weight with chest girth was possibly due to relatively larger contribution to body weight of chest girth which consists of bones, muscles and viscera (Thiruvenkadan, 2005).

Table 31. Prediction equations at different sex and age groups in Horro sheep

Female Age group	Equations	Intercept	β_1	β_2	β_3	β_4	β_5	R^2	R^2 Change
1PPI	CG	- 41.26	0.93					0. 50	0.00
	CG + TC	-28.15	0.62	0.61				0. 61	0.11
2PPI	CG	-21.20	0.65					0.49	0.01
	CG + BL	-30.05	0.48	0.32				0.55	0.06
	CG + BL + TC	-25.84	0.38	0.30	0.29			0.60	0.05
	CG + BL + TC + BCS	-24.70	0.35	0.30	0.23	0.89		0.61	0.01
	CG + BL + TC+ BCS + WH	-28.95	0.28	0.25	0.20	1.10		0.63	0.02
3PPI	CG	-34.07	0.84					0.51	0.00
	CG + WH	-49.56	0.67	0.40				0.60	0.09
	CG + WH + TC	-47.06	0.57	0.40	0.34			0.65	0.05
	CG + WH + TC + BL	-50.50	0.52	0.30	0.36	0.20		0.67	0.02
4PPI	CG	-36.62	0.87					0.54	0.00
	CG + BCS	-36.02	0.82	1.69				0.60	0.06
	CG + BCS + BL	-49.77	0.67	1.63	0.36			0.66	0.06
	CG + BCS + BL + TC	-47.30	0.60	1.11	0.36	0.26		0.68	0.02
	CG + BCS + BL + TC + TL	-48.69	0.59	1.10	0.35	0.25	0.08	0.69	0.01
Female age groups 1- 4PPI	CG	-36.13	0.86					0.54	0.00
	CG + TC	-33.63	0.75	0.38				0.61	0.07
	CG + TC + BL	-46.62	0.59	0.38	0.36			0.66	0.05
	CG + TC + BL +BCS	-47.62	0.59	0.25	0.36	1.03		0.68	0.02
	CG +TC + BL +BCS + PW	-50.22	0.59	0.25	0.35	0.99	0.25	0.69	0.01
Male age groups 0- 4PPI	BL	-39.96	1.03					0.81	0.00
	BL+CG	-51.49	0.59	0.55				0.82	0.01

CG= Chest Girth; BL=Body Length; WH= Wither height; PW = Pelvic Width; TC = Tail Circumference; TL = Tail Length; BCS= Body Condition Score; 1 PPI = 1 Pair of Permanent Incisors; 2 PPI = 2 Pairs of Permanent Incisors; 3 PPI = 3 Pairs of Permanent Incisors; 4 PPI = 4 Pair of Permanent

It was noted that the variation in body weight due to body measurements vary between breeds and sex groups. The R^2 values computed for the body measurements were generally higher for Bonga than Horro sheep. On the same manner, it was observed that, the coefficient of determination is higher for males than their counterpart females. This indicates that linear measurements could predict more accurately males as compared to females.

Parameter estimates in multiple linear regression model showed that higher R^2 was observed when more than one body dimensions were used in the multiple regression equation. The addition of other measurements to chest girth would result in significant improvements in accuracy of prediction even though the extra gain was little. This suggests that body weight could more accurately be predicted accurately by combinations of two or more measurements than chest girth alone in Bonga and Horro sheep breeds. However, under farmers conditions, live weight estimation using chest girth alone would be preferable to combinations with other measurements because of difficulty of proper animal restraint during measurement and ease measurements. This thus reduces the practical usefulness of using other body measurements in conjunction with chest girth.

Based upon their contribution for variation in body weight, parameters such as chest girth, tail circumference and body length are the most important body measurements required for selection and breeding in Horro female sheep. Similarly for female Bonga sheep chest girth and body length could be used for the same purpose. In males of Bonga breed, chest girth and body length could be targeted for growth related improvement through selection.

5. SUMMARY AND CONCLUSIONS

5.1. Summary

Detailed understanding of production systems and characterization of the existing genetic resources are a pre-requisite for designing of sustainable breeding strategies and management of animal genetic resources. This study was conducted in Adiyo Kaka and Horro districts of the natural breeding tract of Bonga and Horro sheep breeds, respectively in response to characterize the breeds and production systems as the first step to design community based breeding strategies.

The mean numbers of sheep in Adiyo Kaka and Horro, per household, were 11.3 ± 1.27 and 8.2 ± 2.05, respectively. Sheep play multi-functional roles in both production systems. Most farmers in both of the sites keep sheep primarily for source of income. Mating was predominantly uncontrolled. About 56.3% and 29.6% of the respondents kept their own breeding males in Adiyo Kaka and Horro, respectively. Size, color and tail conformation were rated as the most important traits in selecting breeding ewes and rams in both production systems. The different feed resources reported in the area were natural pasture, fallow land, crop residues, and crop after math.

Average reported age at puberty for both breeds were 8.5 ± 2.5 and 7.2 ± 2.4 months for females and males, respectively. Ages at first lambing were 14.9 ± 3.1 and 13.3 ± 1.7 months for Bonga and Horro ewes, respectively. The average lambing intervals for Bonga and Horro sheep were 8.9 ± 2.1 and 9.2 ± 2.4 months, respectively. In Adiyo Kaka, pasteurellosis, coenuruses, diarrhea and lung worm in that order were the most common diseases of sheep. Whereas in Horro lungworm, liver fluke and coenuruses were ranked as first, second and third important diseases of sheep. Disease, feed shortage, and predators were the most pertinent constraints for sheep production in that order for farmers in Horro. In Adiyo Kaka, disease, labor shortage, predators were ranked as first, second and third based upon their significant influence on sheep productivity.

The most common coat color was brown among the Horro (56.2%) and Bonga 46.9% sheep breeds, respectively. The quantitative traits recorded from linear surface body measurements of the Bonga female population averaged 31.87 ± 0.19kg, 69.16 ± 0.15 cm, 72.92 ± 0.17cm, 68.12 ± 0.14cm, 15.92 ± 0.30 cm and 32.07 ± 0.37 cm for body weight, body length, chest girth, wither height, tail circumference and tail length, respectively. The corresponding values for male were 29.70 ± 1.17kg, 68.27 ± 0.89cm, 70.0 ± 1.026cm, 66.53 ± 0.85cm, 20.85 ± 0.97cm and 35.40 ± 0.96cm, respectively. The least squares means of body weight, body length, chest girth, wither height, tail circumference and tail length in female Horro were 27.65 ± 0.21 kg, 67.40 ± 0.164cm, 69.30 ± 0.94cm, 73.81 ± 0.19cm, 69.43 ± 0.16cm, 23.46 ± 0.97cm and 37.52 ± 0.95, respectively. The corresponding values for male of the same breed was 31.66 ±1.23kg, 69.30 ± 0.94cm, 76.12 ±1.08cm and 71.66 ± 0.90cm for body weight, body length, chest girth and wither height. Mean scrotal circumferences in Bonga and Horro rams were 23.02 ± 0.47cm and 27.17 ± 0.48cm, respectively.

Horro female had greater values for chest girth, wither height, and tail length than Bonga female. However, Bonga ewe's had higher values than Horro in body weight, body length, chest width, pelvic width, and ear length. Similarly, Horro male had greater values ($P < 0.01$) for chest girth; wither height and scrotal circumference than their counterpart Bonga males. The highest relationship between chest girth and body weight were observed in Bonga female of dentition one (81%) and in male for the pooled data (88%). Similarly in Horro, the highest correlation coefficient between the dependent variable body weight and the independent variable chest girth were established in females from pooled data (77%) and in male (85%). Correlation between body weights and body measurements in pooled data from 1 to 4 dentition class were higher than those at different dentition groups

5.2. Conclusions

Breeding strategies targeted at genetic improvement of Bonga and Horro sheep breeds need to incorporate the multi-functional roles that sheep play in these systems and focus on those functional traits identified as important by the owners of the animals themselves. Horro and Bonga sheep keepers practice selection for breeding male and female. Body size, tail conformation and color are given due emphasis in selecting breeding animals across the two production systems. For setting up sustainable community-based breeding strategies, the present survey revealed several pertinent constraints which should be well addressed. These include: generally flock sizes are very small with only a few breeding males; uncontrolled mating is predominant, absence of structured breeding seasons, rarely animals are separated by sex; communal grazing in wet season and free roaming during dry season makes controlled breeding or mating difficult.

The flock structures, obtained were generally similar to other parts in Ethiopia and females out numbered males. As compared to other sheep breeds of Ethiopia, Horro and Bonga sheep breeds are heavier in weight, large sized and prolific. Hence they do have potential for meat production under the existing limiting environmental factors (disease and feed shortage). The present study revealed that body weight and body measurements like chest girth, body length and wither height influenced by breed and age. An increase in body weight, body length chest girth and wither height with age trends to demonstrate that these breeds are late maturing. Body size and infertility are the main reasons for culling female sheep in Horro and Adiyo Kaka, respectively.

The positive and significant relation ship between body weight and linear measurements indicated that fairly good knowledge of live weight of Horro and Bonga sheep could be estimated from chest girth measurements. In all of the equations developed the best regressor of the response variable after a stepwise regression analysis was chest girth. Based upon their contribution for variation in body weight, parameters such as chest girth, tail circumference, body length, and pelvic width are the most important body measurements required for selection and breeding in Horro sheep. Similarly, for Bonga sheep chest girth, body length, pelvic width and wither height are considered for the same purpose.

Selection on chest girth could result in improved live weight in these breeds. Since scrotal circumference measurement has high correlation with body weight, they may also be used as selection criteria.

5.3. Recommendations

The following sets of recommendations were forwarded from the results of the study:

- A system by which breeding rams cloud be regularly exchanged between farmers should be created and strengthened to minimize the level of inbreeding and enhance efficient utilization of better breeding males.
- To avoid early disposal of breeding males strong extension service is required to convince the farmers and to develop interest about the benefits of better genotypes or incentives might be provided for those keeping their best males for breeding purposes.
- To reduce loss due to disease there should be an urgent attention by development actors and partners to strengthen veterinary services including training, credit facilities, and formation of farmers cooperative to facilitate drugs supply and distribution.
- To give curative treatments the proposed diseases should be confirmed through identification and diagnosis.
- Affordable and simple techniques for feed conservation and strategic supplementation schemes should be sought and made available to the farmers. In line with introduction of improved forages, inventory of the available local feed resources and utilization should be carried out for their efficient utilization and improvement.
- Efficient utilization of crop residues, introduction of adapted improved forages to the prevailing production system will potentially alleviate the existing feed shortage.
- Setting up of small scale fattening schemes to absorb unwanted males or culled males and females could potentially contribute to better success of the breeding strategies.
- Facilitation of access to credit is important for the farmers to support the breeding strategies with the necessary inputs like veterinary services, treatment, forage seeds, and fattening technologies.

- The on-farm assessment made on the reproductive and productive performance of the indigenous sheep in the study area is preliminary in its nature and needs to be further investigated. It is suggested that it is important to under take well planned on station study to predict the genetic potential of Bonga sheep for meat production.
- The fattening potential and meat quality of Bonga sheep recognized by the owners need further performance and carcass evaluation under feed lot condition.

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7. APPENDIX

Appendix Table 1. The questionnaire

General information and socio economic aspects

1.Interviewee________ 2. Household head ________Sex _______ Age ________

3. Position in household *(Tick one box)*
a. Household head ☐
b. Spouse of head ☐
c. Relative ☐
d. Son ☐
e. Daughter ☐
Others (specify) ________________

4. Age (yrs) ☐
a. <31 ☐
b. 31–40 ☐
c. 41–50 ☐
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 and reading ☐
c. Grade ☐

8. Religion ________________

9. Number of people living in the house by age and sex

		No			No
10. Children	a. Males ≤ 15 yrs	_______	11. Adult	a. Males >15	______
	b. Females ≤ 15yrs	_______		b. Females >15	_____

12. Land holding (in ha)

	Own	Rented
a. Crops (including fallow land)	_________	________
b. Fallow land	_________	________
c. Grazing	_________	________
d. Others (specify) ________________		

13. Trend in land holding
a. Decreasing ☐ b. Increasing ☐ c. Stable ☐

14.Reason: ____

15. 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						

** (Tick one or more boxes in the first half of the box in each column. Then rank top three in second half of box, according to their importance; 1 for most important , etc.)*

16. What is your major farming activity?*(Tick one box)*
a. Livestock production ☐
b. Crop production ☐
c. Both ☐

17. On which do you depend more for?
a. Food ____________________________
b. Income source ____________________

18. Numbers of livestock kept

	Number		Number
a. Cattle		f. Donkeys	
b. Sheep		g. Mules	
c. Goats		h. Camels	
d. Chickens		i. Horses	
e. Pigs			

19. Population trend in major livestock species

	Increasing	Decreasing	Stable	Reason
a. Sheep				
b. Cattle				
c. Goat				

20. Sheep Number by age group

	Number
a. Male 6 months to 1 year	____________
b. Female 6 months to 1 year	____________
c. Male > 1 year (Intact)	____________
d. Female > 1 year	____________
e. < 6 months male lambs	____________
f. < 6 months female lambs	____________
g. Castrated male	____________

21. Major crop grown

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

	During long rain ('Meher')	During short rain ('Belg')
22. List three most important crops	1. ____________________	____________________
	2. ____________________	____________________
	3. ____________________	____________________

PRODUCTION AND MANAGEMENT SYSTEM

1. General

1.1. Purpose of keeping sheep

		Rank			Rank
a. Meat			f. Manure		
b. Milk			g. Blood		
c. Wool/hair			h. Skin		
d. Tail fat			i. Savings		
e. Ceremonies			j. Dowry		

Others (specify) ________________________________

Do you intend to expand your sheep flock?

a. Yes ☐ b. No ☐

If not, reason ________________________________

If yes, reason ________________________________

____

1.2. Members of household who own sheep *(Tick one or more boxes)*

a. Head		d. Sons	
b. Spouse		e. Daughters	
c. Head/spouse together		f. The whole family	

Others (specify)

1.3. 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				Hired labour			
	(>=15y)		(>=15y)		(<15y)		(<15y)	
	M	F	M	F	M	F	M	F
a. Purchasing sheep								
b. Selling sheep								
c. Herding								
d. Breeding								
e. Caring for sick animals								
f. Feeding								
g. Milking								
h. Shearing								
i. Making dairy products								
j. Selling dairy products								

Others (specify)

k. ________________

1.4. Do you give your sheep for someone else as ribi'?

a. Yes ☐ b. No ☐

1.5. If yes, why do you give as 'ribi'?

	Reasons	Rank
a. Shortage of labor		
b. Feed shortage		
c. Large flock size		
d. Others (specify)		

2. Feeding and Grazing

2.1. Feed source *(Tick one or more boxes in each column and rank the top 3 in 2nd column*

	Wet season	Rank	Dry season	Rank
a. Natural pasture				
b. Established pasture				
c. Hay				
d. Crop residues				
e. Fallow land				
f. Concentrate				

2.2. Grazing method

	Dry season	Wet season
a. Free grazing		
b. Herded		
c. Paddock		
d. Tethered		
e. Zero-grazing		
Others (specify)		

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

Morning from ______________to _________ hours.
Afternoon ________________to__________ hours.
The whole day ____________hours.

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

Morning from____________ to __________ hours.
Afternoon from___________ to___________ hours.
The whole day ____________hours.

2.5. Do you use communal grazing?

a. Yes ☐ b. No ☐

2.6. Specify the area of your communal grazing land

_______________ hectares for ______________ households

2.7. Trend in communal grazing areas?
a. Decreasing ☐ b. Increasing ☐ c. Stable ☐
2.8.Reason ____

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

a. Male and female are separated ☐
b. Lambs are separated ☐

2.10. Sheep flock is herded
a. Together with cattle ☐
b. Together with goat ☐

2.7. 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) ____________________
2.8. If the answer is b, how many household mix their sheep together __________
2.9. Crop residues used for sheep

	Wet season	Dry season
a. Wheat	☐	☐
b. Barley	☐	☐
c. Sorghum	☐	☐
d. Maize	☐	☐
e. Bean	☐	☐
f. Pea	☐	☐
g. Lentil	☐	☐
h. Chick pea	☐	☐
Others (Specify) ______________	☐	

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

	Wet season	Dry season
1.	__________________	___________________
2.	__________________	___________________
3.	__________________	___________________

2.11. Concentrates used for sheep

	Rank		Type
a. Home made grain	☐	☐	______________________________
b. Oil seed cakes	☐	☐	______________________________
c. Local brewery by-products	☐	☐	______________________________
d. Flour by-products	☐	☐	______________________________

2.12. Is there seasonal fluctuation in feed supply?
a. Yes ☐
b. No ☐
2.13. At which season of the year do you experience feed shortage?
2.14. What is your copping mechanism?____

2.15. Supplementation regime
(Tick one or more boxes in each column)

	Dry season	Wet season
a. Roughage	☐	☐
b Minerals (salts)/vitamins	☐	☐

2.16. Which animals are supplemented?
(Tick one or more boxes)
a. Adult male animals (>1 yr) ☐☐
b. Adult female animals (>1 yr) ☐☐

c. Concentrates ☐ ☐ c. Young animals (<1 yr) ☐☐
d. None ☐ ☐

2.17. Do you practice fattening of sheep?

a. Yes ☐ b. No ☐

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

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

Rank the top 3 in the second column

2.19. Can you tell us the type of feed resources you use to fatten sheep?
a. Naturel Pasture ☐ Concentrate ☐
b. Crop residues ☐ Others (specify)

2.20. At which periods of the year do you commonly fatten sheep ? ____________

Season	Fattening duration	Reason
1. ______________	________________	____________________________________
2. ______________	________________	____________________________________
3. ______________	________________	____________________________________

2.21. Source of water
(Tick one or more boxes in each column)

	Dry season	Wet season
a. Borehole/water well	☐	☐
b. Dam/pond	☐	☐
c. River	☐	☐
d. Spring	☐	☐
e. Pipe water	☐	☐
f. Rain water	☐	☐
Others (specify)		
g. ______________	☐	☐

2.22. Distance to nearest watering point
(Tick one box in each column)

	Dry season	Wet season
a. Watered at home	☐	☐
b. <1km	☐	☐
c. 1–5 km	☐	☐
d. 6–10 km	☐	☐
e. >10 km	☐	☐

2.23. Are lambs watered with the adults?
a. Yes ☐ b. No ☐

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

2.25. Frequency of watering for adult animals

	Dry season	Wet season
a. Freely available	☐	☐
b Once a day	☐	☐
c. Once in 2 days	☐	☐
d. Once in 3 days	☐	☐
Others (specify)		
e. ____________	☐	☐

2.26. Water quality

	Dry season	Wet season
a. Clean	☐	☐
b. Muddy	☐	☐
c. Salty	☐	☐
d. Smelly	☐	☐

3. Housing

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

With roof

- a. In family house ☐
- b. Separate house ☐
- c. Yard ☐
- d. None ☐

Others (specify)

3.2. Type of housing materials

(Tick one or more boxes in each column)

	Roof	Wall	Floor
b. Grass/Bushes	☐	☐	☐
c Wood	☐	☐	☐
d Stone/bricks	☐	☐	☐
e. Earth/mud	☐	☐	☐
f. Concrete	☐	☐	☐
Others (specify)			
g. ______________	☐	☐	☐

3.3. Are sheep housed together with cattle? a. Yes ☐ b. No ☐

Type of disease	Symptom	Season of occurrence	Susceptible age group

4.2. Specify traditional treatments______________________________________

4.3. Access to veterinary services

(Tick one or more boxes)

- a. Government veterinarian ☐
- b. Private veterinarian ☐
- c. Shop or market ☐

Others (specify)

4.4. Distance to nearest veterinary services

(Tick one box)

- a. < 1km ☐
- b. 1–5 km ☐
- c. 6–10 km ☐

4.5. Mortality in the last 12 months (Enter numbers)

	Young <1 yr	Adults ≥1 yrs
a. Male		
b. Female		

4.6. Reasons for death

(Tick one or more boxes, then rank top 3)

a. Predators		
b. Disease		
c. Accident		
d. Poisoning		
f. Unknown		

BREEDING

(Tick one or more boxes)

1. Do you have ram by your own a. Yes ☐ b. No ☐

2. If yes,

2.1. How many? ________

2.2. Source of ram/s ____________

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

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

5. If yes, specify type of management________________________________

6. Purpose of keeping ram

a. Mating ☐
b. Socio-cultural ☐
c. For fattening ☐
Others (specify)
d. ______________ ☐

10. Source of ram (s)

a. Born in the flock ☐
b. Purchased, private ☐
c. Purchased in partner ☐
d. Rent ☐

7. If you do not have breeding ram, how do you mate your Ewe?

a. Neighbouring ram ☐
b. Unknown ☐
Others (Specify) ___________ ☐

8. Do you practice selection for?

Breeding male a. Yes ☐ b. No ☐

Breeding female a. Yes ☐ b. No ☐

Breeding male _____ months ☐ Breeding female _____ Months

10. Selection criteria for breeding ram?

a. Appearance/conformation		
b. Colour		
c. Horns		
d. Character		
e. Availability (no choice)		
f. Adaptability		
g. Growth		
h. Prolificacy		
i. Wool/hair		
j. Age		
k. Libido		
l. Ability to walk long distance		
m. Tail type/length		
n. Pedigree		
Others (specify) ___________		

** Tick any reason for choice considered in first half of box; one or more boxes to be ticked. Then rank top three by writing in second half of box, 1 for primary reason, 2 for second and 3 for third. List the top 3 in rank*

List the top 3 preferred color

1. ____
2. ____
3. ____

Unwanted color

1. ____
2. ____
3. ____

11. Selection criteria for breeding ewe

a. Size/appearance		
b. Colour		
c. Mothering character		
d. Lamb survival		
e. Lamb growth		
f. Age at first sexual maturity		
g. Lambing interval		
h. Twining ability		
i. Longevity		
j. Adaptability		
k. Milk yield		
l. Ability to walk long distance		
m. Tail type/length		
n. Wool/hair		
Others (Specify) _______________		

12. Breeding/mating

a. Controlled ☐

b. Uncontrolled ☐

13. If uncontrolled, what is the reason? ☐

a. Sheep graze together

b. Lack of awareness

c. Lack/insufficient number of ram

d. Others (specify) ______________

14. Type of mating used

a. controlled ☐ b. uncontrolled ☐

15. Could you able to identify the sire of a lamb?

a. Yes ☐ b. No ☐

16. If yes, specify the criteria used to identify

____

17. Do you allow a ram to mate his

	Yes	No	Reason
a. Mother			______________
b. Daughter			______________
c. Sister			______________

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

		Reason
a. Yes		______________
b. No		______________

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

		Reason
a. Yes		______________
b. No		______________

20. What is that attribute for female?

a. Able to give multiple birth repeatedly ☐
b. Known for growing their lamb in good condition ☐
c. Having exceptionally large size ☐
d. Show better adaptive behaviour ☐
e. Longevity ☐
f. Having shorter lambing interval ☐
Others (specify)
g. ______________ ☐

21. What is that attribute for male?

a. Produce fast growing lambs ☐
b. Able to produce lambs with attractive appearance ☐
c. Better sexual ability ☐
d. Able to produce females with better breeding ability ☐
e. Known for better wool yield and quality ☐
Others (specify)
f. ______________ ☐

CASTRATION AND CULLING

1. Do you castrate?

a. Yes ☐
b. No ☐

2. If yes, reasons for castration

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

3. If no, give reason

____
____

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 ________________

5. Do you give supplementary feed for castrated sheep
a. Yes ☐ b. No

6. If yes, type of supplementary feed
a. ____________________
b. ____________________
c. ____________________

7. For how long do you supplement castrated sheep?

8. Castration method
a. Modern ☐ b. Traditional ☐
Specify traditional method ________________________________

9.Numbers of animals added to the herd in the last 12 months
(Enter numbers)

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

Others (specify)

10. Numbers of animals reduced from the herd in the last 12 months
(Enter numbers)

	Males	Females
a. Sold		
b. Slaughtered		
c. Exchanged		
d. Died		
e. Predator		
f. Donated/gift		
g. 'Rebi'		
i. Share of 'rebi'		
k. Lost		

11. Reasons for selling
a. Cash needed ☐ b. Disposal/culling ☐

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

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

13. If reason is for disposal what are the criteria for disposal?

	Males		Females	
a. Size				
b. Unwanted colour				
c. Character				
d. Health				
e. Poor body condition				
f. Inferior production performance				
g. Old age				
h. Delayed puberty				
i. Sterile				
j. Delayed lambing interval				
k. Repeated abortion				
l. Mechanical injury				
Others (specify)	_____		_____	

** Tick any reason for choice considered in first half of box; one or more boxes to be ticked. Then rank top three by writing in second half of box, 1 for primary reason for choice, 2 for second and 3 for third.*

14. Would sheep ever be exchanged for cattle?

a. Yes ☐ b. No ☐

15. If yes, how many sheep for a: *(Enter numbers)*:

a. Bull ☐
b. Cow ☐
c. Calf ☐

16. Average market age in months Male _____ Female ________
Male _____ Female ________
17. Average culling age due to old age
18. Is your sheep number increasing in the last 10 years?
a. Increased ☐ b. Decreased ☐ c. stable ☐
19. What is the trend compared with other livestock?

	Increased	Decreased	c. Same	Reason
a. Compared with cattle	☐	☐	☐	________________
b. Compared with goat	☐	☐	☐	________________
c. Compared with camel	☐	☐	☐	________________

PRODUCTION CHARACTERISTICS

1. Average age at sexual maturity			2. Age at first lambing			3. Lambing interval		
a. Male	___	Months	Average	____	Months	Average	____	Months
b. Female	___	Months	Maximum	____	Months	Maximum	____	Months
			Minimum	____	Months	Minimum	____	Months

4. Do you fix age at first mating for the females? a. Yes ☐ b. No ☐

5. Do you fix age at first mating for the males? a. Yes ☐ b. No ☐

6. Average reproductive lifetime of ewe (in years) ____________
7. Average number of lambing per ewes life time _________________________

8. Lambing pattern, occurrence of most births
(Tick one or more boxes then rank top three in second half of box)

Month			Month		
January			July		
February			August		
March			September		
April			October		
May			November		
June			December		

9. Occurrences of multiple birth per 100 ewe ________

CONSTRAINTS FOR SHEEP PRODUCTION

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

Constraints Rank the top three

a. Genotype
b. Feed shortage
c. Water shortage
d. Disease
e. Drought
f. Market
g. Lack of superior genotypes
h. Predator
i. Labor
Others (specify) ____________

1. Do you practice docking?
a. Yes b. No
Reason(s) for docking____________________________________

EXTENSION SERVICE

1. Do you have any access to sheep extension services?
a. Yes ☐ b. No ☐

2. If yes, would you describe the services you have got so far?
a. Livestock credit scheme ☐
b. Extension advisory service ☐
c. Veterinary service ☐
Others (specify)

3. If for livestock credit scheme, describe purpose of credit
a. Restocking ☐
b. Establishing sheep husbandry ☐
c. Fattening ☐

4. If for extension advisory service

a. On feeding and grazing management ☐
b. About sheep health ☐
c. Breeding and management ☐
d. Marketing ☐
e. Others (specify) _____________

5. If for veterinary service

a. Advice on health management ☐
b. Vaccination ☐
d. Treatment ☐

Appendix Table 2. Points govern the focal group discussion session

1. History of the breed
2. How sheep herded across different seasons
3. Communal land utilization and management
4. Trend in grazing land
5. Major loss of livestock specifically sheep in the past
6. Occurrence and frequency of disease, drought, conflict, flood, and other disasters
7. Major feed resources during different seasons
8. Indigenous knowledge in managing the breed
    8.1. How do you describe your sheep breed (identification of the breed?
    8.2. What are the special qualities of the breed?
9. Major sheep production constraints (pair wise ranking)
10. The most common sheep disease in areas and any measures taken
11. Type of services is in place in sheep husbandry?
12. Sheep population trend in the last 10 years? _________________
13. Quality of traits perceived by owner for the breed
14. Any practice of ram sharing within the community (s)

Appendix Table 3. Checklist for collection of secondary data

1. Human population in each district_______________
2. Livestock population ___________________
3. Average land holding per household (in ha)___________________
4. Seasons of the year
1. Rainy season from ____________to __________
2. Dry season from _____________to __________
5. Topography of the zone (%):
Plain___________Mountain___________Plateau___________Other_______
6. Climatic data (distribution and amount)
Annual average temperature__________________
Maximum______________Minimium____________
Annual average rain fall___________
Maximum______________Minimium____________
Humidity (%)
Annual average humidity____________________
Maximum______________Minimium____________
7. Agro ecological zone of each district (%)
Lowland (500-1500) __________________
Intermediate (1500-2300) _______________
Highland (>2300) ______________________
8. Land use pattern (in hectare or in percent)

9. Production system /Farming system in percent
10. Vegetation cover___________________
11. Major soil types 1.____________
2.____________
12. Opinion on relative importance of sheep in the farmers' livelihood (Income contribution of the a activity in percent)

13. Major sheep production constraints in each district?

14. Organization/institutions actively involved in the area and their role in sheep production

15. Name of sheep breed, origin, distribution and the status of the breed at present? (Increasing, decreasing or stable and reasons for the trend)

16. Major sheep disease, occurrence, mortality, and treatment

17. Any efforts on-gonging in areas of sheep market (cooperatives, linking producers with traders, infrastructure development and market routes)

Appendix Table 4. Description of qualitative trait and respective code

1. Sex of the animal: 1= Female 2= Male 3 = Castrate

2. Coat color pattern: 1= plain 2= Patchy 3= Spotted

3. Coat color type: 1 = White, 2= Brown, 3 = Black, 4= Grey, 5 = Creamy white

4. Head profile: 1 = Straight 2 = slightly convex

5. Horn: 1= Present 2= Absent 3= Rudimentary

6. Ear Type: 1= Semi-pendulous 2 = Horizontal

7. Wattle: 1= Present 2= Absent

8. Ruff: 1= Present 2= Absent

9. Tail conformation: 1 = Straight and tip down ward 2 = Straight and twisted end

10. Source of animal: 1 = Born 2 = Purchased 3 = Ribi 4 = Gift 5 = Inherited

11. Body condition: 1 = Very thin 2 = Thin 3 = Average 4 = Fat 5= Obese

12. Dentition classes:

0PPI = with milk teeth

1PPI = with erupted ad growing 1st pair of permanent incisors

2PPI = with erupted ad growing 2st pair of permanent incisors

3PPI = with erupted ad growing 3st pair of permanent incisors

4PPI = with erupted ad growing 4st pair of permanent incisors

Appendix Table 5. Quantitative traits recorded for each sample animal

Body weight (Kg): Taken using spring balance using to the nearest 100 kg.

Body length (BL): The horizontal distance from the point of shoulder to the pin bone to the nearest centimeter.

Chest girth (CG): The height from the bottom of the front foot to the highest point of the shoulder between the withers to the nearest centimeter.

Height at wither (WH): The distance around the animal measured directly behind the front leg to the nearest centimeter.

Chest width (CW): The width of the chest between the briskets to the nearest centimeter.

Pelvic width (PW): The distance between the pelvic bones, across dorsum to the nearest centimeter.

Tail length (TL): The length of tail from the base to the tip to the nearest centimeter.

Tail circumference (TC): The circumference of the tail at its widest part to the nearest centimeter.

Ear length (EL): The length of the ear on its exterior side from its root at the poll to the tip to the nearest centimeter.

Scrotal circumference (SC): The circumference of the testis at the widest part to the nearest centimeter.

Appendix Table 6. Description of body condition score

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

Appendix Table 7. Means square for body weight and linear measurements for Bonga and Horro female sheep

	Mean squares		
Source of variation	Breed	Dentition	Breed x Dentition
DF	1	3	3
Body weight	4280.070**	2138.655**	16.209Ns
Body length	740.695**	1180.047**	7.569Ns
Chest girth	192.142**	1843.575**	39.269Ns
Wither height	412.413**	533.923**	64.088**
Chest width	132.095**	68.287**	1.861Ns
Pelvic width	32.599**	32.083**	4.567Ns
Body condition score	1.208Ns	0.181Ns	3.429**
Tail length	858.077**	8.796Ns	0.208Ns
Tail circumference	2.408Ns	11.201Ns	19.397Ns
Ear length	4.381*	1.897Ns	0.578Ns

Ns = Non-significant (P>0.05); * P< 0.05; ** P < 0.01; DF = Degree freedom

Appendix Table 8. Means square for body weight and linear measurements for Bonga and Horro males sheep

	Mean squares		
Source of variation	Breed	Dentition	Breed x Dentition
DF	1	1	1
Body weight	51.745Ns	441.549**	7.519Ns
Body length	14.38Ns	363.108Ns	0.648*
Chest girth	505.777**	254.761**	16.176Ns
Wither height	355.572**	247.446**	46.056Ns
Chest width	24.528**	0.011Ns	10.045Ns
Pelvic width	10.669Ns	20.736Ns	8.794Ns
Body condition score	3.662*	1.179Ns	0.016Ns
Tail length	57.313Ns	228.674**	1.935Ns
Tail circumference	87.146Ns	36.841Ns	0.401Ns
Ear length	6.1264**	0.08Ns	0.706Ns
Scrotal circumference	149.903**	17.378*	0.569Ns

Ns = Non-significant (P>0.05); * P< 0.05; ** P < 0.01; DF = Degree freedom