ON-FARM PHENOTYPIC CHARACTERIZATION OF CATTLE AND THEIR PRODUCTION SYSTEM IN JIMMA ZONE, SOUTHWESTERN ETHIOPIA

M Sc Thesis

Oumer Sheriff

October 2011

Jimma University

ON-FARM PHENOTYPIC CHARACTERIZATION OF CATTLE AND THEIR PRODUCTION SYSTEM IN JIMMA ZONE, SOUTHWESTERN ETHIOPIA

A Thesis Submitted to the

Department of Animal Science, School of Graduate Studies

COLLEGE OF AGRICULTURE AND VETERINARY MEDICINE

JIMMA UNIVERSITY

In Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

(ANIMAL PRODUCTION)

By

Oumer Sheriff

October 2011

Jimma University

SCHOOL OF GRADUATE STUDIES

JIMMA UNIVERSITY

As Thesis Research Advisor, I hereby certify that I have read and evaluated this thesis prepared, under my guidance, by Oumer Sheriff, entitled: **"On-farm Phenotypic Characterization of Cattle and Their Production System in Jimma Zone, Southwestern Ethiopia"** and I recommend that it can be submitted as fulfilling the Thesis requirement.

(Dr.) Berhanu Belay ___________________ _________________
Major Advisor Signature Date

(Dr.) Aynalem Haile ___________________ _________________
Co-advisor Signature Date

As member of the Board of Examiners of the MSc Thesis Open Defense Examination, We certify that we have read, evaluated the Thesis prepared by **Oumer Sheriff**, and examined the candidate. We recommend that the Thesis be accepted as fulfilling the Thesis requirement for the Degree of Master of Science in Agriculture (**Animal Production**).

(Professor) Solomon Demeke ---------------------- -------------------------
Name of Chairman Signature Date

(Dr.) Berhanu Belay ---------------------- -------------------------
Name of Major Advisor Signature Date

(Dr.) Aynalem Haile ---------------------- -------------------------
Name of Co-advisor Signature Date

(Dr.) Taye Tolemariam ---------------------- -------------------------
Name of Internal Examiner Signature Date

(Dr.) Solomon Abegaz ---------------------- -------------------------
Name of External Examiner Signature Date

DEDICATION

This work is dedicated to my beloved mother Alima Adem, who stood by me in all situations and felt my pain as hers, who inspired and propelled me to great heights of achievements, who would never allow me to quit without trying, who dared me to hope for the best and whose unconditional love lifted me.

STATEMENT OF AUTHOR

First, I declare that this thesis is my bona fide work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree at Jimma University College of Agriculture and Veterinary Medicine and is deposited at the University Library to be made available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgment of the source is made. Requests for permission for extended quotation form or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the School of Graduate Studies when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

Name: Oumer Sheriff Signature: ------------------

Place: Jimma University, Jimma

Date of submission: October 2011

BIOGRAPHICAL SKETCH

The author, Mr Oumer Sheriff, was born on 5 January 1984 in East Gojjam Zone Enemay Woreda from his father Sheriff Mohammed and his mother Alima Adem. He completed his elementary School in Edeget, Enemay and Hailuyosedek primary schools from 1990-1992, 1993-1995 and 1996-1998, respectively and he completed his secondary school in Belay Zeleke Senior Secondary School from 1999-2002. He successfully passed the Ethiopian School Leaving Certificate Examination of grade 12 in 2002 and joined the then Alemaya University, now Haramaya University in 2003, and graduated with B.Sc. degree in Animal Production and Health in 2006. After his graduation he was employed by the Amhara Regional Agricultural Development Office in Womberma woreda as a team leader in Agricultural inputs and loan supply and distribution and worked there for one year and six months. Then he joined the School of Graduate Studies at Jimma University College of Agriculture and Veterinary Medicine in September 2008 to pursue a study leading to M.Sc. degree in Animal Production.

ACKNOWLEDGEMENTS

First of all the author would like to praise The Higher Most Almighty God for His mercy, for the good health, mental stability, physical strength and the gift of life and support in this success, without Whose supernatural help nothing is possible. Great Thanks.

The author would like also to extend his appreciation and due acknowledgments to Womberma woreda Agriculture and Rural Development Office for their kindness for work leave permission and award of the scholarship.

His most profound appreciation and sincere thanks are due to Dr. Berhanu Belay of Jimma University College of Agriculture and Veterinary Medicine, advisor of the thesis research, for his meticulous and painstaking effort in the initiation, design, implementation and report writing of this thesis research. Sincere thanks are also due to the author's co-advisor, Dr. Aynalem Haile of ICARDA-Syria for his encouragement, tireless support, constructive comments and appraisal of the final thesis manuscript. He also provided constant flow of valuable suggestions and a lot of solace when everything seemed to work upside down.

I am indebted to my family members for their patience, financial and moral support all along my academic tenure. I owe a special debt of gratitude to my wife Hania Negash for her patience and consistent support throughout all phases of the study.

Even though it may not be possible to mention all of them here, the author would like to express his gratitude to many individuals and organizations that have supported this study by providing reference materials in the form of hard and soft copies are highly appreciated.

His sincere thanks are also extended to his friends, Tibebu Bekele (MOARD) and Shemeles Mesganaw and Shazeruan Kemal (JUCAVM) for facilitating and supporting this study. Graduate students Biruk Kebede, Yonatan Kassu, Belay Chufamo, Muhedin

Endris, Chala Kinate, Getenet Abate, Seifu Berhanu and Meseret Molla also take his friendly appreciation for their friendliness and kindness.

His appreciation is also extended to staff of Jimma Zone Statistics Office and Agriculture and Rural Development Main Department as well as Gera, Sigimo and Dedo districts Agriculture and Rural Development offices for their full cooperation. Eyob Getahun, Wondemu Jembere, Awoke Gebremariam, Mohammedamin Bediru, Abedelkadir and Daniel as enumerators take his due appreciation.

He would like also to express his sincere appreciation to the study communities who have participated in the interviews, focus group discussions, key informant discussions and informal talks and responded liberally to share their indigenous knowledge.

Finally, he wishes to express his appreciation to the Animal Science Department and School of Graduate Studies of Jimma University College of Agriculture and Veterinary Medicine for having given him the opportunity for this graduate study.

LIST OF ABBREVIATIONS

AEZ	Agro Ecological Zone
AnGR	Animal Genetic Resource
ANOVA	Analysis of Variance
CACC	Central Agricultural Census Commission
Cm	Centimeter
CSA	Central Statistical Authority
DA	Development Agent
DAD-IS	Domestic Animal Diversity Information System
DAGRIS	Domestic Animal Genetic Resource Information System
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agricultural Organization of the United Nation
GDP	Gross Domestic Product
GLM	Generalized Linear Model
IBC	Institute of Biodiversity Conservation
ICARDA	International Center for Agricultural Research in the Dry Areas
IGAD	Intergovernmental Authority on Development
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
ICRA	International Center for Development Oriented Research in Agriculture
Km	Kilometer
LSD	Least Significant Difference
LSM	Least Square Mean
Mm	Millimeter
MOARD	Ministry of Agriculture and Rural Development Office
NA	Not Available
NS	Non-Significant
OADB	Oromiya Agricultural and Rural Development Bureau
PA	Peasant Association
PCA	Principal Component Analysis
PSPDOR	Physical and Socio-economic Profile of 180 Districts in Oromiya Region
SAHN	Single-linkage Agglomerative Higherarchial and Non-overlapping
SAS	Statistical Analysis System
SE	Standard Error
SNNPR	Southern Nations, Nationalities and Peoples Region
SPSS	Statistical Package for Social Sciences

TABLE OF CONTENTS

Contents **Page**

TABLE OF CONTENTS (Continued)

Contents **Page**

LIST OF TABLES IN THE TEXT

Table **Page**

LIST OF TABLES IN THE TEXT (*Continued*)

Table **Page**

LIST OF FIGURES

Figures **Page**

LIST OF TABLES IN THE APPENDIX

Appendix Table **Page**

ON-FARM PHENOTYPIC CHARACTERIZATION OF CATTLE AND THEIR PRODUCTION SYSTEM IN JIMMA ZONE, SOUTHWESTERN ETHIOPIA

ABSTRACT

In the framework of designing community-based breeding strategies for indigenous cattle breeds of smallholders in Ethiopia, a survey of production system and on-farm phenotypic characterization of Jimma cattle types, was undertaken in the Gera, Sigimo and Dedo districts of Jimma zone. Multi stage stratified purposive and random sampling was employed as sampling technique. Detailed structure questionnaire, focus group discussions, field observations of animals, linear body measurements, and secondary data collection were employed to produce the data. One hundred eighty sample cattle owners with different herd sizes were interviewed on their cattle husbandry practices. Six quantitative measurements and thirteen qualitative records were taken and observed from 540 mature cattle and subjected to multivariate analysis of variance. For the analyses of quantitative data, the main effects of district and age of cattle were fitted to the final model. Cluster analysis on quantitative variables was employed to identify homogenous cattle populations that may represent cattle types. The clustering technique was single-linkage, agglomerative, hierarchical and non-overlapping (SAHN). Cattle have multi-purpose roles in all of the three districts. Among the reasons for keeping cattle, draught performance in male cattle and milk production in female cattle were ranked highest. The results showed significant ($p<0.01$) differences in quantitative traits between districts for both male and female populations. The analyses of variance to ascertain the difference between age group 1 (18-30 months), 2 (31-41 months) and 3 (≥ 42 months) for males and females showed a significant ($p<0.01$) effect. The results also revealed that, there was significant ($p<0.01$) difference between districts for milk production and lactation length. The overall average age at sexual maturity for males and females was 37.46±0.44 and 36.16±0.34 months, respectively. The overall average age at first calving and calving interval was 42.49±0.66 and 13.49±0.23 months, respectively. Based on results of cluster analysis, it is revealed that, morphologically, at least three distinct cattle types were found in the area, namely the Gera cattle type (comprising of cattle from Gera-Naso and Genji-

Chala sites), the Sigimo cattle type (Alia and Seriti sites) and the Dedo cattle type (Waro-Kolobo and Ofolle-Dawe sites). The Gera cattle type has the longest horn measurement, while the Sigimo cattle type has the shortest ear and horn length. On the other hand, the Dedo cattle type has big body frame and the longest ears. The characterization should be followed by community based genetic improvement scheme.

Keywords: Indigenous breeds, Jimma Zone, Phenotypic Characterization

1. INTRODUCTION

Ethiopia's cattle population is estimated at 49.3 million (CSA, 2009). The genetic diversity among indigenous cattle breeds of Ethiopia is also high as evidenced from recognized breeds described in literature (DAGRIS, 2006). To date, 32 recognized indigenous cattle breeds are known to exist in Ethiopia, dispersed over a diverse range of ecological zones (DAGRIS, 2007). This diversity is mainly due to Ethiopia's geographical location near to the historical entry point of many livestock populations from Asia, the large size and diversity of agro-ecological zones, the different cultural conditions, the huge cattle population size, the wide range of production systems and different management systems (Girma, 2004; Workneh *et al.*, 2004).

This variability has contributed to the evolution of different agricultural production systems (Azage and Crawford, 2000) and wealth of genetic diversity, which further resulted in huge livestock resources and species mix-up. However, today, many of these diverse breeds are being lost at an alarming rate (Azage and Crawford, 2000). The native Boran cattle breed in Southern Ethiopia is a living example of indigenous breed types disappearing gradually unnoticed from their original habitat (Azage and Crawford, 2000). As cited by Takele (2005), the Food and Agriculture Organization of the United Nations (FAO) estimates that globally 30 percent of livestock breeds are at risk of extinction (the total number of breeding females is less than or equal to hundred or the total number of breeding males is less than or equal to five; or the overall population size is less than or equal to 120 and decreasing) (FA0, 2000) and that about six breeds are lost every month, most of them in developing countries (ILRI, 1998).

Cattle production in Ethiopia is an integral part of almost all farming systems and being a major occupation in the lowlands and playing a decisive and catalytic role in crop production in the highlands. The role of livestock in general and cattle in particular in the national economy is more significant than what the official production figures would suggest when their contributions for farm traction, farm fertilization and fuel (through manure) are considered and valued (Workneh and Rowlands, 2004).

The livestock sector in Ethiopia contributes 45% of the Agricultural GDP (IGAD, 2010). Despite this significant contribution, little attention has been given to the sector. However, Keeping with FAO's mandate, research-oriented institutions such as International Livestock Research Institute (ILRI), Institute of Biodiversity Conservation (IBC), Ethiopian Institute of Agricultural Research (EIAR) and Haramaya University have prioritized and setup their own research programs on characterization of indigenous livestock of Ethiopia (Hegde, 2005), even though, the documentation of breed types is still far from complete. In line with this agenda, the importance of identification and characterization of livestock genetic resources and their production environment for long-term genetic improvement and sustained use of available resources should be realized (FAO, 2009).

For the development of appropriate breeding strategies and sustainable use of the genetic diversity, it is essential to characterize the phenotype and genotype of the various cattle breed types. Whether for reasons of long term genetic improvement of indigenous livestock or for sustained use of available resources, an essential initial step for countries like Ethiopia is identification of the breed types, estimation and documentation of their population size, their common uses and description of the management system in which they are maintained (IBC, 2004).

In sub-Saharan Africa, there are tendencies for breed improvement programs to focus on single, market driven traits such as milk or meat production in isolation of environmental constraints and broader livestock system functions which cattle assume in developing countries (Rege, 2003). This potentially leads to genotypes that are not well adapted to the environment and not capable of performing the multiple roles that cattle assume in cattle production systems of developing countries. In developing countries, many important functions of livestock are embedded in non-tradable traits that are neither captured in economic analysis nor considered in livestock improvement programs (Ouma *et al.*, 2002). Farmers' preference for cattle traits are influenced by various factors including cultural practices, production system characteristics and environmental conditions, especially in relation to disease prevalence and availability of cattle feeds (Ouma *et al.*, 2002).

The cattle breed in Jimma zone is one of the unidentified indigenous cattle breeds in Ethiopia. Little is known about the diversity and genetic resources of the breed, its production environment, management system, performance, disease tolerance and adaptation to local conditions. This is because genetic resource characterization, evaluation and improvement of cattle and characterization of the production system of farmers conducted so far were limited.

The first comprehensive attempt in this area was a survey done by the Oromiya Agricultural and Rural Development Bureau (OADB) and International Livestock Research Institute (ILRI) in 2004 which provided a wide range of baseline data on livestock production, mainly on cattle, sheep and goats (primary species) and on chickens, donkeys, horses, mules and camels (secondary species) (Workneh and Rowlands, 2004). The survey has taken many procedures to characterize livestock production systems and other related issues like crop production, land ownership and household characteristics in the twelve zones of Oromiya Regional State of Ethiopia. Despite its successful documentation and promising results, the survey used the multivariate cluster analysis, to identify the type and number of cattle breeds, only on a subset of data (cattle from Borana Zone) (Workneh and Rowlands, 2004). Hence, it did not lead to a straightforward identification and characterization of different cattle breeds in Jimma zone.

Therefore, this paper tried to fill this gap by identifying and characterizing the type of cattle breeds in the study area and updating the previous results that need routine inventories and on-going monitoring. Thus, the outcome of this study may serve as baseline information to the national effort to identify, characterize and conserve the different indigenous cattle breeds.

The survey was conducted between December, 2009 and April, 2010 in Jimma zone with the following operational objectives:

- To describe the production system of cattle in the study area;
- To undertake on-farm phenotypic characterization of cattle types in the study area in their natural habitat; and
- To identify the trait preference of the cattle owners and suggest a breed improvement strategy.

2. LITERATURE REVIEW

2.1. Origin and Domestication of African Cattle

The family of animals that includes all types of domestic cattle is known as Bovidae. It is the dominant family of hoofed mammals and one of the most recent to evolve. Within the sub-family Bovidae are found all the varied types of cattle that have been domesticated. The African cattle population derives from three major introductions from Asia (Epstein, 1957; Faulkner and Epstein, 1957; Williamson and Payne, 1977; Oliver, 1983). The first cattle introduced into Africa, the hump less Hamitic longhorn (*Bos taurus longifrons*), arrived about 5000 BC. They were followed by the humpless shorthorn (*Bos taurus brachyceros*) about 2500 years later and the humped zebu (*Bos indicus*) in about 1500 B C. Most cattle followed the Nile Valley through Egypt or came through the Horn of Africa. Further migrations resulted in a heavy concentration of cattle in the highlands of Ethiopia and Kenya, regarded today as one of the original sites of Africa's indigenous cattle. Interbreeding among these three types resulted in the Sanga, a so-called intermediate type because of the length of its horns and the location of its hump (Mason and Maule, 1960).

This was opposed by the genetic evidence from Hanotte *et al.* (2002), which indicated the earliest cattle indeed originated within the African continent and were domesticated from local strains of the wild ox, the Auroch, some 7000 to 9000 years ago. They further suggested that the earliest domestications occurred in today's Egypt-Sudan border. A similar study made by Bradley *et al*. (1996) also reported that the earliest domesticates were humpless, or *Bos taurus*, in morphology and may have shared a common origin with the ancestors of European cattle in the Near East. Alternatively, people in either continent may have adopted local strains of the wild ox, the Aurochs, either before or after cultural influence from the Levant. This latter study examined mitochondrial DNA displacement loop sequence variation in 90 extant bovines drawn from Africa, Europe, and India. Phylogeny estimation and analysis of molecular variance verify that sequences cluster significantly into continental groups.

2.2. Origin and Classification of Ethiopian Cattle Breeds

Given its diversified ecology, its huge livestock size and cattle types which have evolved over time in the various production systems, and its geographic location on the route to major livestock migrations across Africa, Ethiopia can be considered as a center of diversity for animal genetic resources. It is also home to the most important cattle breeds for Eastern and Southern Africa (Beyene and Bruke, 1992; Workneh *et al.,* 2004). The indigenous breed as explained by Epstein (1957), is originated from the migration of Hamitic Longhorn and Shorthorn from Egypt along the Nile Valley and the humped Zebu from India through the horn of Africa. The present day Ethiopian cattle are classified in to four main breed groups: the Humpless, Zebu, Sanga, and Zebu-Sanga (intermediate) (Beyene and Bruke, 1992; Workneh *et al.,* 2004). Besides, the Red Bororo or Fellata are also confirmed for their presence (Zewudu, 2004). Sometimes the Humpless cattle are divided in to Shorthorn Humpless and Longhorn Humpless (Alberro and Hailemariam 1982a, b; Beyene and Bruke, 1992). The diversification of Ethiopian cattle breeds (Table 1) is relevant in terms of specific adaptation to the various agro-ecological zones where the breeds exist, for instance for attributes like heat tolerance, disease resistance and drought tolerance. These characters help the breeds to survive and produce under prevailing environmental challenges of the different agro-ecological zones of the country.

Moreover, indigenous cattle are vital to subsistence and economic development in Ethiopia accounting for 97% of the country's annual milk production (Tedla *et al.,* 1991). Cattle are also used to generate critical cash in times of scarcity, provide collateral for local informal credit and serve other socio-cultural functions in Ethiopia (Ulfina *et al.,* 2005). Therefore it is very important to characterize and evaluate these valuable resources to know their potential for further uses and conserve them.

Table 1: *Classification of identified cattle breeds in Ethiopia*

Group	Name	Synonyms	Distribution	Population estimate	Status
SMALL EAST AFRICAN ZEBU	Adwa	NA	Central Zone of the Tigray Region and Adwa	NA	Unknown
	Ambo	NA	Western Shoa (Ambo, Addis Alem, Holetta)	NA	Unknown
	Bale	NA	Bale highlands	73,8000	Unknown
	Goffa	NA	North Omo (Goffa, Sawla)	NA	Unknown
	Guraghe	NA	Guraghe and Hadiya areas, close to the tsetse infested valleys	NA	Unknown
	Hammer	NA	South Omo Zone	NA	Unknown
	Harar	NA	Highlands of Eastern and Western Hararghe	NA	Unknown
	Jem-Jem	Black Highland	Highlands of Jem-Jem, Sidamo and Bale	43,4000	Not at risk
SMALL EAST AFRICAN ZEBU	Jijiga	NA	Somali Region, Jijiga area	10,0000	Not at risk
	Mursi	NA	South Omo Zone	NA	Unknown
	Ogaden Zebu	Lowland Zebu	Somali Region and Ogaden area	NA	Unknown
	Smada	NA	South Gondar Zone (Gayint, Smada) and parts of North Wello	NA	Unknown
	Anuak	Abigar	Gambella Region and adjoining areas in south-western Ethiopia	548,600	Not at risk
	Danakil	Adal, Afar and Kereyu,	Northeastern Ethiopia (Tigray, Wollo), and parts of Djibouti &Eritrea.	NA	Not at risk
LARGE EAST AFRICAN ZEBU	Raya-Azebo	Galla-Azebo	Parts of Tigray and Wello east of Lake Ashenge	NA	Not at risk
	Arsi	Arusi	Arsi, Shewa, Bale, Sidamo and Hararghe	2,012,000	Not at risk
	Ethiopian Boran	Borana	In the southern rangelands with the Borana pastoralists	1,896,000	Not at risk
	Murle	NA	Eastern Gambella, on the border with the Sudan	NA	Unknown
ZENGA	Arado	NA	Northern Tigray (Shire, Adwa, Agame) and the highlands of Eritrea	NA	Not at risk
	Fogera	NA	The Fogera plains around Lake Tana in South Gondar and at the adjoining areas of West Gojjam.	800,000	Not at risk
	Horro	NA	Highlands of western Ethiopia (East Wollega, West Shoa, Illubabor	NA	Not at risk
HUMP LESS SHORT HORNS	Sheko	Shewa-Ghimira, Goda, Mitzan	Bench Zone in southwestern Ethiopia, originally with the Sheko people	31,000	Endangered

Source: Workneh et al., (2004)

2.3. Livestock Production Systems in Ethiopia

Livestock production is an integral part of the country's agricultural production system. The country, with its extreme variations in agro-climatic conditions, possesses one of the largest and the most diverse plant and animal genetic resources in the world. As an essential component of the overall farming system, livestock serves as a source of draught power for the rural farming population, supplies farm families with milk, meat and manure, source of cash income, and plays a significant role in the social and cultural values of the society. In pastoral areas, the livelihood of the population depends on livestock. Despite the importance of livestock to the farming and pastoral population and to the national economy at large, the sector has remained underdeveloped and underutilized.

Livestock production system in Ethiopia can be broadly categorized into (MOA, 1998):

- ❖ Crop-livestock mixed system where animals provide inputs like draught power, transport and manure to other parts of the farm system and generate consumable or saleable outputs like milk, manure, meat, hides and skins, wool, hair and eggs.

- ❖ Pastoral and agro-pastoral. In the pastoral livestock production system, animals are kept by pastoralists but they do not provide inputs for crop production instead they are the very backbone of life for their owners, providing all of the consumable saleable outputs listed above and, in addition, representing a living bank account and form of insurance against adversity. The Agro-patoral system is characterized by high degree of reliance on pastoral activities for household revenue, but rain fed cultivation by, or on behalf of, the household also contributes an important share (up to 50 percent). Agropastoralism includes village-based herders, who make a substantial commitment to farming.

- ❖ Urban and peri-urban production system where animals are mainly held by state farms, co-operatives and some private individuals and produce milk and eggs for local sale and meat for export.

2.4. Socio-Economic Importance of Cattle

Livestock production plays an important role in Ethiopia's economy. However, expansion was constrained by inadequate nutrition, disease, lack of support services such as extension services, insufficient data with which to plan improved services, and inadequate information on how to improve animal breeding, marketing, and processing. Socio-economic, rather than genetic, reasons seem to determine the genotype raised by the smallholder farmers, hence the breeding decisions for those genotypes should be made to benefit the cattle owners. From the study by Nakhumwa *et al*. (2000), some of the reasons why smallholder farmers choose to raise particular livestock species are profitability (39.5 %), ease of management (23.7 %) and the dual-purpose use of some livestock (5.3 %).

.

Smallholder cattle farmers in developing countries have multiple goals for their cattle enterprise. The roles that cattle play in these systems are manifold. Apart from meat and milk production, livestock are closely linked to the social and cultural lives of millions of resource poor farmers for whom animal ownership ensures varying degrees of sustainable farming and economic stability (Rege, 2003). These values vary from society to society and largely determine the strategies, interventions, and demand and development opportunities for livestock. Livestock acts as security assets influencing access to informal credits and loans. They are also considered as a common means of demonstrating wealth, cementing relationships through bride price payments and as social links and are important in crises. In many smallholder systems of developing countries, manure is considered as important as milk, meat or draught power (ILRI, 1998).

Livestock assets feature as living “savings” for future planned expected needs and perform financing roles in a context where banking is not developed or households are not fully integrated into credit markets, they also perform insurance roles because the capital invested in the herd forms a guarantee for meeting future unexpected requirements (Ouma *et al.,* 2002).

2.5. Animal Genetic Diversity and 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 agricultural production (FAO, 2003).

Phenotypic characterization can involve either of the following two approaches, depending on the type of background information available (FAO, 2011):

Exploratory approach – undertaken in situations in which no reliable background information on the existence of recognized breeds in the study area is available; in such circumstances, the objective of phenotypic characterization is to investigate the existence of distinct breeds in the study area.

Confirmatory approach – undertaken in situations in which some basic information on breed identity and distribution is available; in such circumstances, the objective of phenotypic characterization is to validate breed identity and provide systematic descriptions of the breeds.

Characterization of AnGR encompasses all activities associated with the identification, quantitative and qualitative description, and documentation of breed populations and the natural habitats and production systems to which they are or are not adapted. The aim is to obtain better knowledge of AnGR, of their present and potential future uses for food and agriculture in defined environments and their current state as distinct breed populations (FAO, 1984; Rege, 1992). National-level Characterization comprises the identification of the country's AnGR and the surveying of these resources. The process also includes the systematic documentation of the information gathered so as to allow easy access. Characterization activities should contribute the reliable prediction to the performance of the animal in defined environments, so as to allow a comparison of potential performance within the various major production systems found in a country or region (Rege, 1992). It is, therefore, more than the mere accumulation of existing reports.

The information provided through the characterization process enables a range of interest groups, including farmers, national governments and regional as well as global bodies to make informed decisions on priorities for the management of AnGR (FAO, 1992). Such policy decisions aim to promote further development of AnGR while ensuring that these resources are conserved for the needs of present and future generations. The following lists of seven broad categories of breed descriptors selected are from a longer catalogue used in compiling the FAO Global Data Bank. This subset is regarded as an essential assembly of information for the initial characterization of a breed (Rege, 1992).

Priority elements include the following general identification (Rege, 1992).

- Country, species, breed or population and location where the breed is found.
- Population size during the reporting year.
- Physical characteristics including coat color, horns shape and size (by sex).
- Linear measures of adult size and weight including wither height, live weight, body length (for each sex) with indication of precision.
- Current uses (purposes) as indicated by producers and ranked by priority. Possession of special or unique adaptive traits such as resistance to major diseases and to climate.
- Qualitative description of predominant management system (stationary, transhumant, nomadic, housing, feeding, etc.).
- Biological performance

2.6. Animal Genetic Resource and the Production Environment

According to FAO (2000), a production environment encompasses all input-output relationships, over time, at a particular location. The relationships will include biological, climatic, economical, social, cultural, and political factors, which are combined to determine the productive potential of a particular livestock enterprise. Animal uses, genetic variance, and abundance of genetic diversity change across production systems should also be included. As different production systems are evolved, varying pressures are placed upon the existing breeds (FAO, 2004). Marked differences between production systems, such as product need and price, disease occurrence, spread and controlling 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 production environment also encompasses the people who keep them, the reasons why they keep them, and the extent of genetic diversity among and between various animal populations, breeds and strains within each species at molecular and functional genomics levels (Rege, 2003). Phenotypic characterization of traditional breeding practices involves a broad range of exploratory research outcomes. These include the description of the origin of breeds, mating systems, castration, culling, pedigree recording, population size, structure, typical features and phenotypic performances of these resources in defined management and climatic environments (Okeyo and Ayalew, 2004).

The traditional well established community organizations are seen suitable candidates to handle breeding schemes, provided that a sound market-oriented research and technical assistance that integrates management, nutrition, health and transformation are also delivered (Kahi *et al.,* 2005). An open nucleus appears to fit community organizations and the integrated improvement approach better. Within this framework, community producers have also been considered for in situ germplasm conservation. This is true to the extent that new production alternatives or inappropriate programs could eventually lead to erosion of genetic resources. Village breeding programs are predominant in the tropics and are defined as those breeding programs carried out by communities of smallholder farmers (villagers), often at the subsistence level (Sölkner *et al.*, 1998). With regard to animal breeding, local knowledge has mostly been ignored for whatever reasons (Köhler-Rollefson, 2003). Further on, herders have to be willing to genetically improve their animals and take an active part in the development and implementation of any measure from the very beginning. Experiences show that the success or failure of breeding projects in the tropics is largely determined by the producers, i.e., whether they were involved and considered in the design and running of the project or not (Fall, 2000;

Philipsson, 2000; Tewolde, 2000; Kosgey *et al.*, 2006a). In addition, a stable organization is needed for the co-ordination and provision of basic services.

Genetic characterization of livestock reveals importance information regarding phenotypic and genetic variability. Blood groups and protein polymorphisms have been used widely to determine genetic diversity (Ndamukong, 1995; Misohou *et al.,* 1999; Deza *et al.*, 2000; Mwacharo *et al.*, 2002). Such an exercise identifies quantitative trait loci (QTLs) for traits such as adaptation to heat/ drought and disease tolerance that are expensive to measure using conventional methods or have low heritability but are essential in the low-input production systems (Rege and Gibson, 2003). Microsatellite markers are considered a marker of choice to characterize breeds for diversity assessment (FAO, 2007). Their short length makes them amenable to amplification by polymerase chain reaction (Weber & May, 1989; Wang *et al.,* 1998). Microsatellites have been effectively exploited to evaluate genetic diversity and relationships among cattle populations (Ashwell *et al.,* 2004; Sun *et al.,* 2007). Microsatellite analysis using fluorescently labeled primers and capillary fractionation is the pre-eminent method for the genetic analysis of eukaryotic organisms (Fatima, 2007). The importance of phenotypic and genetic characterization of livestock and the utilization of the information that arise from characterization are many and have been well articulated by Drucker and Gibson (2003). This includes identification of representative samples of breeds or strains that should be a priority for conservation on the account of the unique genes that they posses (Rege and Gibson, 2003).

Traditional breeding efforts and techniques are important, but more information is needed regarding the breeding population that exists in the system. This background information should precede any major interventions (Cunningham, 1992). Characterization and utilization of local indigenous breeds as stated by Hall (1992) should be considered whenever development of animal production system is discussed. Indigenous genotypes may well be adequate and able to respond sufficiently to the reasonable economic improvements in the low-input smallholder production system (Workneh *et al.,* 2003). Over many generations indigenous breeds have evolved to perform various functions under local conditions. Unfortunately, inadequate attention has been given to evaluating these resources or to setting up realistic and optimum breeding goals for their improvement. As a result some of the animal genetic resources of Africa are endangered and, unless urgent concerted efforts are taken to characterize and conserve, these resources may be lost even before they are described and documented (Rege and Lipner, 1992).

2.7. Livestock Breeding Program and its Constraints

Breeding strategies contribute significantly to improve livestock production efficiency by enhancing the productive and reproductive performance of livestock (Wollny, 2003). Ethiopia is yet to develop and enact a binding livestock breeding policy (IBC, 2004). The limitations in skilled manpower and facilities are also paramount bottlenecks for the aspired development in the livestock breeding sector. However, the relative importance and level of threat to the maintenance of animal genetic diversity in Ethiopia is not precisely known. Encouraging but far from sufficient, effort has been made to comprehensively document the AnGR diversity in the country. In addition to their conclusiveness, previous research and development efforts generally ignored the importance of adapted indigenous farm AnGR due to a general belief that they are not adequately productive and incapable of contributing to increase agricultural production (IBC, 2004). The past and present neglect of local knowledge regarding AnGR and traditional breeding practices causes major difficulties to develop and implement appropriate participatory strategies at national and local level (Wollny, 2003).

There are many important circumstances that determine the scope of opportunities and constraints of the breeding program. According to Kosgey *et al.* (2006), determinants of success in breeding program includes: agricultural policy and market, environmental conditions, characteristics of animal populations and infrastructure availability. Similarly, 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 program 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.,* 2006a).

2.8. Designing Sustainable Community-based Breeding Strategies

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 program 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). Community based breeding strategies basically needs detailed understanding of the community's indigenous knowledge of farm animals regarding breeding practices and breeding objectives, considering the production system holistically and involves the local community at every stage starting from the planning and operation of the breeding program (Baker and Gray, 2003).

2.9. Indigenous Knowledge in Managing Cattle Breed

Indigenous knowledge on animal breeding is a valuable resource about the existence of breeds and their adaptive traits. It can be a source of information about scientifically undocumented breeds and traits (Kohler-Rollefson and McCorcle, 2000). Indigenous knowledge on animal breeding is made up of various concepts and practices used by livestock owners to influence the genetic composition of their herd. Indigenous knowledge includes cultural concepts about how to use an animal, local preference for certain characteristics: such as color, size, and behavioral patterns, disease and drought tolerance, selection practices for certain qualities (culling and offspring testing), pedigree-keeping, social restriction on selling animals and leading closed gene pools (Kohler-Rollefson, 2000).

The importance of indigenous or local knowledge in animal husbandry has been recognized by many researchers (Kohler-Rollefson and Wanyama, 2003). In the past, the focus was on gathering information about indigenous knowledge related to animal nutrition, fodder evaluation and pasture management (Morrison *et al*., 1996; Rodriguez and Preston, 1997; Walker *et al*., 1999; Roothart and Franzel, 2001), as well as ethnoveterinary medicine (Leeftanq, 1993; Adekunle *et al*., 2002; Samal *et al*., 2002). However, more recently, attention has been paid to the importance of local knowledge related to breeding, not only in cattle but also in other livestock species (Adams *et al*., 2002; Ouma *et al*., 2004; Mwacharo and Drucker, 2005; Wurzinger *et al.,* 2006). In some studies, preferences between different breeds are compared, largely with the aim of carrying out a comparative analysis of local and exotic breeds with a view to supporting sustainable breeding programmes in the future (Bebe *et al*., 2003; Lemke *et al.,* 2005; Mwacharo and Drucker, 2005). Other studies concentrate on selection criteria within one breed (Perezgrovas *et al*., 1992 and Jaitner *et al*., 2003) but that of Wurzinger *et al.,* 2006 study concentrate on comparing selection criteria within a breed but in different regions and production systems.

2.10. Productivity of Indigenous Cattle Breeds

Despite the huge number of indigenous cattle and their economic importance, the productivity is low due to the constraints of disease, nutrition, poor management and poor performance of indigenous breeds. These constraints result in poor reproductive performance of dairy cattle. Among the major problems that have direct impact on reproductive performance of dairy cows are abortion, dystocia, Retained Fetal Membrane (RFM), metritis, prolapse (uterine and vaginal), anoestrus and repeat breeder. These could be classified as prepartum and postpartum reproductive problems (Shiferaw *et al*., 2005; Lobago *et al*., 2006).

The productivity of cattle depends largely on their reproductive performance (Arthur *et al.*, 1989). Among the reproductive traits, age at first service (AFS), number of services per conception (NSC), days open (DO) and calving interval (CI) are the bases for a profitable dairy farming (Enyew *et al.*, 1999). The heritabilities of these traits are low, so that environmental factors, including management conditions, play a significant role in the variability of the traits (Olori *et al.*, 2002).

Table 2: *Reproductive and milk production performance of some indigenous cattle breeds*

Breeds	AFC (months)	CI (days)	DMY (liters)	LMY (liters)	LL (days)
Boran, Ethiopia	42.8	447	1.7	507	240
Horro	53	527	-	550	173
Begait	60	458	-	645	184
Fogera	53.4	525	2.32	270	698
Sheko	54.1	468	-	-	297

AFC=Age at first calving, CI=Calving interval, DMY=Daily milk yield, LMY=Lactation milk yield and LL=Lactation length

Sources: Trail et al. (1984); Ouda et al. (2001); DAGRIS (2006).

2.11. Linear Body Measurements of Cattle

Linear body measurements (LBM) can be used in assessing growth rate, feed utilization and carcass characteristics in farm animals (Brown *et al*., 1973). Linear body measurements are divided into skeletal and tissue measurements (Essien & Adesope, 2003). The height at wither is part of skeletal measurement where as the heart girth is part of tissue measurement (Blackmore *et al*., 1958). Bulls with a large scrotal circumference (as a reflection of large testicles) produce more semen, have a higher prevalence of normal sperm, and have greater sperm motility than bulls with small scrotal circumference. In cattle, there is a high correlation between scrotal circumference measurements in bulls and the age at which female progeny reach puberty. Females from sires with above average testicle size reach puberty at an earlier age. Selection based on scrotal circumference offers another opportunity to improve fertility in herds (Brad and Michael, 2007). Venter *et al*. (1984) proposed that minimum scrotal circumference standards at certain ages should be known for individual breeds.

2.12. Numerical Taxonomy as a tool in Breed Identification

As reviewed by Workeneh (1992), Lauvergne, 1982 and Wilson, 1991 argue that in the African context where the majority of livestock population is non-standardized or traditional that it is perhaps erroneous to talk of livestock 'breeds'; however, it is evident that identifiable types do exist which have developed through natural selection in adaptation to stressful environments. The Collin's English Dictionary (1986) gives a more elaborate definition of a breed as a group of organisms within a species, especially domestic animals, having clearly defined characteristics. In the taxonomic sense, Johansson and Rendel (1968) defined a breed as a population of animals of sufficiently large size inhabiting a certain area and share common morphological and physiological characteristics. It differs from other populations within the same species with respect to definite genetically determined traits, which can be qualitative (coat color, hair type, horns, etc.) or quantitative (body size, milk yield, etc.). However, a number of breeds of farm animals can have similar external features. Quantitative traits may also show continuous variation and no clear dividing line can be drawn between breeds (Workeneh, 1992).

Known livestock breeds or breed types are distinguishable by marked differences in morphological characteristics. They can be identified by qualitative as well as quantitative description of their appearance and dimensions. By implication, breed types in traditional populations can be explored through evaluation of aggregate morphological differences between groups of animals in exactly the same way taxonomists classify organisms into hierarchical groupings Johansson and Rendel (1968). These animal groups are expected to share a characteristic genetic constitution and definite area of distribution. In theory, the ideal means to identify genetically different animal populations would be examination of the nucleotide sequence of the genome, but there are both technical and operational constraints to even the latest technologies in the field. Kemp (1992) has reviewed the current state of knowledge on DNA biotechnology as a tool in breed type characterization, and remarked that a cost-effective and efficient DNA sequencing strategy is yet to be developed.

The rapidly advancing technology in deciphering the genome has made it possible to quantify in relative terms with the base sequence divergence as a measure of genetic distance between identified groups or breeds. Breed specific gene markers can be identified and compared without high cost using the latest technologies based on the Polymerase Chain Reaction (PCR), such as the use of Random Amplified Polymorphic DNA (RAPD) (Williams *et al*., 1990 and Michelmorte *et al*., 1991). However, it has not been possible to explore taxonomically distinct animal populations using this technology alone. As it stands it is more of a supportive tool to the conventional breed description procedure (Workneh, 1992).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

Jimma Zone, found in Southwestern Ethiopia, lies between 36^0 10´ E longitude and 7^0 40´ N latitude at an elevation ranging from 880 to 3360 meters above sea level (Dechassa, 2000). Currently Jimma Zone is divided in to 18 Woredas/districts (PSPDOR, 2009) hosting a total human population of over 2.7 million (CSA, 2005) with an agro-ecological setting of highlands (15%), midlands (67%) and lowlands (18%) (Dechassa, 2000). The zone is one of the major coffee growing areas of Southwestern Ethiopia; accommodating cultivated and wild coffee as a main cash crop.

Jimma zone is endowed with natural resources contributing significantly to the national economy. Major crops grown other than coffee are: maize, teff (*Eragrostis tef*), sorghum, barley, pulses (beans and peas), root crops (enset-false banana and potato), chat and fruits. Tef and honey production are another sources of cash after coffee. Enset (*Ensete ventricosum*) is a strategic crop substantially contributing to food security of the zone and this crop is mainly important in highland woredas of Jimma zone, Setema and Sigimo (CSA, 2005). The climate of Jimma zone is humid tropical with bimodal heavy annual rain fall, ranging from 1200 to 2800 mm (Jimma Zone Metrology Station Report, 2004). In normal years, the rainy season extends from February to early October. The thirteen years mean annual minimum and maximum temperature of the area was 11.3 ^oC and 26.2 ^oC, respectively.

3.2. Sampling Procedures

The sampling procedure followed in this survey was multi stage stratified purposive random sampling. Out of 18 woredas in Jimma zone (PSPDOR, 2009), 3 woredas were selected to represent Dega/Highland (between 1500 and 3000 meters above sea level), Weinadega/Mid-highland (between 1000 and 1500 meters above sea level) and Kolla/Lowland (below 1000 meters above sea level) (MOA, 2000) that bound the highest coverage of AEZ of the woreda. In each of the selected woredas, two PAs falling in the same agro-ecology were selected randomly. Then, thirty households (in each of the selected peasant associations) possessing cattle were selected at random. Finally, three matured cattle per household were measured for qualitative and quantitative characteristics.

Linear body measurements (Appendix Table 4) like: Body Length, Ear Length, Horn Length, Heart Girth, Height at Wither and Pelvic Width were measured on 253 matured males (144 oxen and 109 bulls) and 287 breeding females (181 cows and 106 heifers) using plastic measuring tape. In terms of district distribution 81, 94 and 78 matured males and 99, 86, and 102 breeding females were examined from Dedo, Gera and Sigimo districts, respectively (Table 4). Measurements were carried out at homestead, in kraals, at watering points and at communal grazing lands. These places were chosen as they are strategic gathering points. In terms of age and sex category, 60 of the male cattle were in between 18-30 months of age, 89 of them being at the age of 31-41 months and 104 of the males were ≥ 42 months. Similar to males, 64 females were in between 18-30 months, 103 of them at the age of 31-41 months and 120 of the female cattle were≥ 42 months age. Here collecting data from different age categories was important to know the average values for each trait.

Simultaneously, qualitative characters like: coat color pattern, hair type, facial profile, back profile, rump slope, hump position, dewlap size, horn orientation, horn shape, tail length, udder size, teat size, ear orientation and testis size were also observed on a total of 253 matured males and 287 breeding females. With regard to qualitative measurements, the standard breed descriptor list of FAO (1986 b) was adapted. Qualitative variables on the shape and appearance of the animals were recorded in pre-coded format. Photographs of some cattle were also depicted (Figure 2, 3, 4, 5, 7, 8 and 9).

Body conditions: To determine the body condition of an animal, methods developed by ILCA (Nicholson and Butterworth, 1986) was used. The body condition scores developed by ILCA were for zebu cattle. The scoring levels were from 1-9, body scoring one is given for very thin animals and nine is given for very fatty animals.

3.3. Methods of Data Collection

To produce the data, a modified questionnaire were prepared (Appendix Table 1) by adopting a questionnaire set by ILRI (International Livestock Research Institute)-OADB (Oromiya Agricultural and Rural Development Bureau) for survey of livestock breeds in Oromiya Regional state (Workneh and Rowlands, 2004). The questionnaire addressed description of cattle and their production system. The first part of the questionnaire dealt with household general information. Part two was entirely devoted to cattle production system. Part three dealt with cattle health. Part four dealt with breeding and purpose of keeping cattle. Part five dealt with breed specific information. Part six dealt with reproduction characteristics and part seven dealt with phenotypic description of cattle types in the study area.

The questionnaire was pre-tested around Jetu PA in Dedo district before administration and some re-arrangement, reframing and correction in accordance with respondents' perception was done. The pre-tested semi-structured questionnaire was administered to (60) randomly selected households' heads (cattle owners) or representatives in each of the three districts by two enumerators (DAs) per district that were recruited and trained for this specific purpose with close supervision by the researcher.

To substantiate the information collected from individual farmer interviewee, focus group discussions (Figure 1) were held in 8 different sites, namely: Chala, Gure-Genji and Haro in Gera district, Waro-Kolobo, Jetu and Siba in Dedo district and Alia and Serity in Sigimo district. Each group consisted of elderly farmers, village leaders, women cattle owners, youngsters, development agents and socially respected individuals who are known to have better knowledge on the present and past social and economic status of the study area. Nomination of discussants was made together with the local MOARD staff and peasant association administrators. On average 6 people (ranging from 4 to 12) were participated in the discussion.

Fig 1: *Focus group discussion held at Waro Kolobo kebele in Dedo woreda*

The discussion (Appendix Table 2) was focused on the history of development of the breed, communal land utilization and management, trend in grazing land, major feed resources during different seasons, how cattle are herded in different seasons, cattle population trend in the last 10 years, any practice of bull sharing within the community, the most common cattle diseases and measures taken, traits perceived by cattle owners and types of services in cattle husbandry. Secondary data on climate, topography, human and livestock population, land use pattern, and soil type of the areas was collected from the respective zonal and district agricultural and rural development offices using a prepared checklist (Appendix Table 3).

Table 3: *Summary of sampled households, focus group discussions, peasant associations and the number of cattle by district*

Description	HH (N)	Focus group discussion (N)	PAs (N)	Phenotypic description of cattle		
				Male	Female	Total
District						
Dedo	60	3	2	81	99	180
Gera	60	3	2	94	86	180
Sigimo	60	2	2	78	102	180
Total	180	8	6	253	287	540

3.4. Data Management and Analysis

Data collected through questionnaire were described by descriptive statistics using Statistical Package for Social Sciences (SPSS for window, release 16.0, 2006). Qualitative data obtained from male and female cattle were subjected to Chi-square test using the FREQ Procedure of SAS (SAS, 2002). The General Linear Model (GLM) procedures of the SAS (Statistical Analysis System) software (SAS, 2002) were employed to analyze the quantitative data and to detect statistically significant quantitative variation in body size between the sample cattle population. The analysis was done separately for male and female population as the breed characterization needs to be sex specific. Taking district and age as main fixed effects, the following model was used to analyze the data.

$$Yijk = \mu + ai + bj + eijk$$

Where Y_{ijk} = is the observed value of trait of interest (body length, ear length, horn length, height at wither, heart girth and pelvic width)

μ = the overall mean

a_i = fixed effect of i^{th} district (Gera or Sigimo or Dedo)

b_j = fixed effect of j^{th} age class (1…3); where 1…3 represents eruption of the first and second, third (lateral) and fourth (corner) incisors representing the age at 18-30, 31- 41 and ≥42 months of age, respectively.

e_{ijk}= random residual effect. Since none of the interaction components was significant, they were dropped from the final model.

Multivariate cluster analysis was also employed to identify distinct, relatively highly similar cattle groups from the traditional cattle population. The clustering technique was single-linkage, agglomerative, hierarchical and non-overlapping (SAHN) (Sneath and Sokal, 1973).

The working hypothesis was that the cattle types in the study area are distinct enough in external morphology and that each of the types has sufficient homogeneity to be identified from the other types. Principal components analysis was used to transform the selected morphological variables into fewer standardized components.

Effective population size for a randomly mated population was calculated as:
Ne = (4 Nm Nf) / (Nm + Nf) Where, Ne = effective population size, Nm = number of breeding males and Nf = number of breeding females. The rate of inbreeding coefficient (ΔF) was calculated from Ne as $\Delta F = 1/(2Ne)$ (Falconer and Mackay, 1996).

The Coefficient of Unlikeability was used to measure the variability of qualitative characters within the cluster. Unlikeability is defined to mean how often observations differ from one another. As described by Kader and Perry (2007), coefficient of unlikeability (u_2) was calculated using the formula:

$u_2 = 1 - \Sigma\, pi^2$, where *pi* is the proportion of each response within a category.

4. RESULTS AND DISCUSSION

4.1. Household General Information

The survey revealed that the majority (96.6%) of the households in the study area were headed by males which accounted for 98.3% in Gera, 93.3% in Sigimo and 98.3% in Dedo. The remaining proportion of the households was headed by females. Female headed households in this study would indicate either the husband has died or they are divorced. In contrast to this report, higher proportion of households headed by males (100%) was reported in West Showa (Jiregna, 2007). However, the present result was in agreement with the result of Tsedeke (2007) who has revealed (96%) of male headed households. The present study was higher than the report of Belete (2009) in Goma district who has reported the male headed house hold of (94.4%). As shown in (Table 4), 72% of the households in the study area were headed by members with age classes between 31 and 50 years. In all districts, there was a sharp drop in the proportion of household heads with ages below 31 and above 60 years.

Table 4: *Age of households' heads by districts*

	Districts							
	Gera		Sigimo		Dedo		Overall	
Age in years	N	%	N	%	N	%	N	%
	60		60		60		180	
< 30	1	1.7	5	8.3	8	13.3	14	8
31–40	24	40	20	33.3	21	35	65	36
41–50	25	41.7	24	40	15	25	64	36
51–60	8	13.3	10	16.7	15	25	33	18
61–70	2	3.3	1	1.7	1	1.7	4	2
>71	0		0		0		0	

The average family size in the study households (6.5) (Table 5) was comparable with average family size estimate (6.7 persons) of Alaba (Tsedeke, 2007). Figures for all districts obtained in this survey were higher than the average values in the region (5.0) (CACC, 2008), the report of Tesfaye (2009) in Metema (5.6) and it was also higher than the report of Belete (2009) in Goma district (5.5). However, the present result was lower than the findings of Daniel (2008) who has reported the household size of (8.0) in Borena zone. The present study was also lower than the result of Workneh (1992) who reported an average family size of (9.1) and (13.1) persons, for highland and mainly growing perennial crops in Sidama and for agro-pastoral production systems in SNNPR, respectively.

Table 5: *The average number of people living in the house by age and sex by districts*

District		Category				
		Male children (<15 yrs)	Female children (<15 yrs)	Male adults (>15yrs)	Female adults (>15yrs)	Overall
Gera	N	55	51	60	60	60
	Minimum	1	1	1	1	2
	Maximum	5	4	5	3	14
	Mean	1.91	1.80	1.57	1.57	6.42
	SD	1.005	0.825	0.909	0.593	2.204
Sigimo	N	55	57	58	60	60
	Minimum	1	1	1	1	3
	Maximum	5	5	4	3	16
	Mean	2.05	2.32	1.52	1.52	7.07
	SD	1.061	1.152	0.822	0.624	2.476
Dedo	N	53	48	59	59	60
	Minimum	1	1	1	1	2
	Maximum	5	5	4	4	12
	Mean	1.79	1.73	1.64	1.49	6.05
	SD	0.863	0.792	0.804	0.774	2.004

4.2. Farming Activities and Land Holding

The major farming activity reported by the sampled households across the three districts was both crop and livestock production. Most of the households reported that they own the land used for crop and livestock production. The mean ± standard deviation of land holding per family in the study area was 1.93±0.787, 1.76±0.932 and 1.26±0.768 hectares for crop production and 0.44±0.399, 0.82±0.404 and 0.54±0.509 hectares for grazing in Gera, Sigimo and Dedo areas, respectively (Table 6), most of which was rain-fed although small number of farmers have access to irrigation. This survey result illustrates that, crop production was allocated larger proportion of land than livestock rearing. The overall average land holding (2.25 ha meant for crop and livestock production) was greater than the value reported for Debark district (1.66 ha) (Sisay, 2006), Goma district (1.93) (Belete, 2009) and Yerer district (1 to 1.5ha) (Samuel, 2005) but comparable with Layarmacho (2.03 ha) of Gondar (Sisay, 2006). However, it was smaller than total land holding in Metama (6.17) (Sisay, 2006). The feed resource base in the study area is diversified to meet the nutritional requirements. Cattle are reared on natural pastures, grazing on fallow lands, wetlands, forests and bushes, and boundaries of farms under a continuous grazing system. Cattle are also freely grazing on crop land after crop harvest and grazing on river bank sides and road sides. Similar report was made by Takele (2005) in Bench Maji zone.

Table 6: *Land holding of the districts for crop and livestock production (in ha)*

Land holding (in ha)	District			
	Gera Mean ± SD	Sigimo Mean ± SD	Dedo Mean ± SD	Overall Mean ± SD
For crop production	1.93±0.787	1.76±0.932	1.26±0.768	1.65±0.841
For livestock production	0.44±0.399	0.82±0.404	0.54±0.509	0.60±0.564
Overall	2.37±1.120	2.58±1.603	1.80±0.768	2.25±1.009

4.3. Cattle Husbandry Practices

4.3.1. Livestock Management

Based on the level of care provided to livestock around homestead, livestock management in sample households was classified as extensive, semi-intensive and intensive. Overall, 59.4% of the respondents adopt extensive livestock management, 37.2% of them adopt semi-intensive care while 3.4% provide intensive care (Table 7). Comparable proportion of semi-intensive care of livestock management (38%) and intensive care (3%) and lower extensive care (50%) was reported by Workneh and Rowlands (2004). Moreover, all of the sampled households in the study area across the three districts practice sedentary livestock management.

Table 7: *Levels of livestock management by districts*

	Districts							
	Dedo		Gera		Sigimo		Overall	
Categories	N	%	N	%	N	%	N	%
	60		60		60		180	
Extensive	35	58.3	32	53.3	40	66.7	107	59.4
Semi-intensive	20	33.3	25	41.7	22	36.7	67	37.2
Intensive	3	5.0	2	3.3	1.7		6	3.4

4.3.2. Grazing / Feeding Practices

Irrespective of districts, both communal and private natural pasture grazing were by far the most common sources of feed during dry and wet season. In the study area, 74.5% of the sampled households depend on communal grazing land as a feed source, while 25.5% of the respondents reported that cattle graze on privately owned land. The present study concurs well with the study conducted in developing countries (ILRI, 1998). In Dedo and Gera, permanent communal grazing lands comprised mostly of the tree covered and bush/shrub grass lands. During the focus group discussion session, most of the discussants (key informants) stated that the trend in grazing land was decreasing due to an increasing human population from time to time and expanded use of communal grazing lands for crop production. Thus, keeping small number of better performing cattle than keeping large number of unproductive one's was a solution forwarded by the discussants. Key informants also proposed privatizing the existing communal lands or practicing tethering as a solution. However, the former does not always need to be the best alternative because individual tenure could deny farmers for access to extensive grazing lands. As cited by Zewdu (2008), Verbeek *et al*., 2007 explained that 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.

During the focus group discussion and secondary data collection, key informants and livestock experts of the districts also stated that cattle are provided with non-conventional feed sources such as chat left over, home left over, fruit left over, salt, enset and banana parts, weeds and crop tillers of maize and sorghum differently for different cattle categories. Similar finding was also reported by Takele (2005) in Bench Maji zone, Belete (2009) in Goma district and Yeshitila (2007) in Alaba, where the utilization of non-conventional feeds as a feed supplement (chat left over, brewer's recipes and fruit leftovers) was practiced. A preferential feeding was practiced and draft oxen, milking cows and very young calves were provided some of these supplements. The reason of supplementing draft oxen was to increase draft power performances. Milking cows were supplemented to increase milk and butter yield. In addition to suckling their dams, very young calves were supplemented to increase growth rate of the calf. Other cattle categories such as dry cows, heifers and bulls did not get feed supplements. The study revealed farmers' preference to supplement draft oxen, milking cows and young calves indicated the importance of traction, milk and growth performance of calves in this production system. The practice of preferential feeding to vulnerable and productive category of livestock could create the opportunity to introduce strategic feeding in the districts.

Higher number of farmers in Dedo (23.3%) and Sigimo (33.3%) districts practiced tethered feeding than farmers in Gera (1.7%). Tethering is usually practiced in areas where the grazing land was encroached by crop farming and when herding labor was scarce. The main reasons of households for practicing tethering were: to avoid crop damage, to secure the herd against theft and to protect it from predation or extreme weather, to reduce aggressiveness in case of male animals and to use the limited grazing land properly. More than three-fourth of the farmers in Gera (93.3%) used herding as a grazing method, while more than half of the sampled households in Dedo (70%) and Sigimo (60%) used herding to fed their cattle. The rest of the households in each district used zero grazing (Table 8). Tsedeke (2007) and Belete (2009) also reported the importance of tethering animals mainly to avoid crop damage and to save labor. 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 herd and sufficient grazing land and labor. The limitations of tethering with regard to animal performance and grazing land condition warrant further investigations. The practice of tethering in the livestock feeding system will create a venue to introduce cut and carry feeding system to use the grazing land effectively and play a role in land resource management.

Table 8: *Frequency and percentage of feeding practices of households by districts*

Type of feeding	Districts							
	Gera		Sigimo		Dedo		Overall	
	N	%	N	%	N	%	N	%
	60		60		60		180	
Herding	56	93.3	36	60	42	70	134	74.4
Tethering	1	1.7	20	33.3	14	23.3	35	19.4
Zero grazing	3	5	4	6.7	4	6.7	11	6.2

Fig 2: *Dedo calf tethered at fallow land (left*) **Fig 3:** *Dedo herd grazing in communal grazing land (right)*

4.3.3. Housing System

Adequate housing protects animals from extreme temperature (rain, cold, excessive heat and wind), predators and theft. It further provides opportunities for intensive feeding and controlled breeding. In the study area, different types of housing systems were reported that varies between districts (Table 9). In households of Dedo area, 33.3% of farmers reported that cattle were housed in family house and 61.7% of farmers housed their cattle in a separate house. The majority of the farmers across the study area house their cattle during the night and early hours of the morning. Cattle are sheltered for protection from theft and extreme temperature in most rural communities such as: Bench Maji Zone (Takele, 2005), Danno district (Jiregna, 2007) and Gambella region of Southwestern Ethiopia (Abebe, 2009). However, places of sheltering and type of house vary among the districts. The farmers in Dedo, whose herd sizes were relatively small (Table 15), used either a separate sector of family home or a house built on its own to keep adult cattle (≥ 3 years) and young calves (1-3 years) inside, where as farmers in Gera and Sigimo were keeping both adult cattle and young calves in a kraal. Farmers in Dedo share the main family house with cattle because of the fear of theft and predators. In the study area, calves of age less than one year were housed under roofed houses during dry and wet seasons mixed with goats and sheep (Figure 6) but in isolation from adult cattle to protect them from suckling their dam, trampling, predators, wind, rain and draft and joined only during the morning and evening hours during or soon after milking.

Table 9: *Types of housing for cattle by districts*

Districts	House holds	Type of Housing									
		Family house		Separate house		Veranda		Kraal		Yard	
	N	N	%	N	%	N	%	N	%	N	%
Dedo	60	20	33.3	37	61.7	0	0	0	0	3	5
Gera	60	0	0	0	0	4	6.7	56	93.3	0	0
Sigimo	60	0	0	0	0	3	5	57	95	0	0
Overall	180	20	11.1	37	20.6	7	3.9	113	62.8	3	1.7

Fig 4: *Cattle housing system in Gera: Kraal (Left)*

Fig 5: *A separate house for cattle in Dedo (Right)*

Fig 6: *A calf housed with goats in Gera (Left)* **Fig 7:** *Cattle housing system in Sigimo:kraal (Right)*

In households that keep their cattle under a separate house, wood covered with grass was primarily used for roofing (63.3% of the households); in 21.7% of the respondents, wood was used for roofing while 15% of the households stated that corrugated iron sheet nailed with wood was used for roofing. In such a house, the wall was constructed from wood with no any other building material (53.3%); wood covered with mud (43.3%) and in a few cases wood covered with stone (3.4%) was used. Similarly, for the few households that constructed floor from materials other than earth, wood was the primary material used almost entirely. Similarly, households that keep their cattle in a family house, the roof was made of grass and wood followed by wood and iron sheet, while the wall in most cases is constructed from wood and mud. The use of wood, mud, iron sheet, grass and stone to construct cattle house is also reported in Oromiya region (Workneh and Rowlands, 2004).

4.3.4. Sources of water

According to the respondents in the three districts, river was the major water source both in dry and wet seasons. River serving as main source of water for cattle was also reported by a number of workers that have studied the traditional livestock production system (Abebe, 2009; Jiregna, 2007 and Workneh and Rowlands, 2004). River accounts for 88.3% and 51.7% of the total water source in Gera, 55% and 91.7% in Sigimo and 98.3% and 50% in Dedo during dry and wet season, respectively. During the dry season, spring was also used as source of water in 11.7% of the households in Gera, 45% in Sigimo and 1.7% in Dedo. Moreover, during wet season, water well, dam/pond and rain water were used as source of water in 48.3% of the households in Gera, 8.3% in Sigimo and 50% in Dedo (Table 10). Generally, water supply was not a constraint in all of the areas. The present study concurs well with the study conducted by Takele (2005) in Bench Maji zone where shortage of water is not reported as a production constraint, but it did not concur with other studies in the lowlands. The report by Abule (1998) and Daniel (2008) indicated that, water is a limiting factor in livestock production for Kereyu and Borena pastoralists, respectively.

As shown in (Table 10), the distance to the nearest watering point for adult cattle during dry season was less than a kilometer as reported by 77.7% of the households. Twenty two percent of the households reported that the nearest watering point is 1-5 kilometer, while 0.6 % of the households watered their cattle at home. Similarly, during wet season 61.7% of the households watered their cattle at a distance of less than a kilometer, 10.6% of them at 1-5 km and 15.6% of the sampled households watered cattle at home. During wet season, there were also households that watered cattle both at home and at a watering distance of less than a kilometer. The proportion of these households accounted for 12.2%. During dry season, relatively more households trek their cattle longer distance in search of water than during wet season. Similar result was reported by Workeneh and Rowlands (2004).

Across the three districts, sampled households did not report the distance to the nearest watering point in dry and wet season longer than six kilometer and provision of water at home is not common especially during the dry season. Furthermore, 45% of the sampled households in Dedo district and almost all households in Sigimo district reported that calves were watered with adult cattle. However, 55% of the sampled households in Dedo and all households in Gera stated that calves were watered at home twice a day.

During dry season, clean water is fully accessible to cattle in Gera and Dedo, while in Sigimo (98.3%) of cattle had access to clean water and the rest used muddy water. However, during wet season, (85%) of cattle in Gera, (50%) of cattle in Sigimo and

(61.7%) of cattle in Dedo had access to muddy water. There was also a report on the use of smelly water (5%) in Dedo (Table 10). The use of muddy and smelly water is also reported by Workneh and Rowlands (2004) in Oromiya region and Grum (2010) in Dire Dawa.

The frequency of watering across the study districts varied among seasons. During dry season, three fourth of the households reported that the frequency of watering their cattle was twice per day. However, during wet season, 95.6% of the sampled households watered their cattle once per day. Watering cattle once per day during dry season and twice per day during wet season is also reported by Takele (2005), and Abebe (2009). Farmers took animals to watering points during day time. As stated by most respondents, time of watering is noon 12:00 A.M. and 3:00 P.M. According to farmers, reasons of providing water to cattle were: to increase feed intake, to satisfy thirst, to protect cattle from diseases and constipation, to make the hair smooth, to increase milk yield of cows and to facilitate digestion.

Table 10: *Sources of water and distance to watering point during dry and wet season by districts*

Particulars	District						Overall	
	Gera		Sigimo		Dedo			
	N	%	N	%	N	%	N	%
1. *Sources of water*								
Dry Season	60		60		60		180	
River	53	88.3	33	55	59	98.3	145	80.6
Spring	7	11.7	27	45	1	1.7	35	19.4
Wet Season	60		60		60		180	
River	31	51.7	55	91.7	30	50	116	64.4
Water well + dam + rain water	29	48.3	5	8.3	30	50	64	35.6
2. *Distance to the nearest watering point*								
Dry Season	60		60		60		180	
Watered at home	0		0		1	1.7	1	0.6
<1km	58	96.7	30	50	52	86.7	140	77.7
1–5 km	2	3.3	30	50	7	11.7	39	21.7
6–10 km	0		0		0		0	
>10 km	0		0		0		0	
Wet Season	60		60		60		180	
Watered at home	0		26	43.3	2	3.3	28	15.6
<1km	59	98.3	0		52	86.7	111	61.7
1–5 km	1	1.7	12	20	6	10	19	10.6
6–10 km	0		0		0		0	
>10 km	0		0		0		0	
Watered at home + at less than a kilometer	0		22	36.7	0		22	12.1
3. *Clean water accessibility*								
Dry season	60		60		60		180	
Clean water	60	100	59	98.3	60	100	179	99.4
Muddy water	0	0	1	1.7	0	0	1	0.6
Wet season	60		60		60		180	
Clean water	9	15	30	50	20	33.3	29	16.1
Muddy water	51	85	30	50	37	61.7	148	82.2
4. *Frequency of watering*								
Dry season	60		60		60		180	
Once a day	18	30	2	3.3	22	36.7	42	23.3
Twice per day	42	70	58	96.7	33	55	133	73.9
Three times/day	0	0	0	0	3	5	3	1.7
Ad lib	0	0	0	0	2	3.3	2	1.1
Wet season	60		60		60		180	
Once a day	56	93.3	60	100	56	93.3	172	95.6
Twice per day	4	6.7	0	0	0	0	4	2.2

4.3.5. Type of Mating and Sources of Bull/s for Breeding

Cattle owners in the study area usually have limited control over breeding practice of their cattle. This is because they allot fractions of their time and resources in controlling breeding practices. Therefore, most often mating is natural and uncontrolled and this would result in non-descript herd structure. The use of natural mating by the sampled households was also reported (Workneh and Rowlands, 2004). In all the districts, control of mating was exercised as a means not to use unwanted males and females, to obtain big sized calves with attractive color as demanded by the market. Poorly reproducing females and extra males were culled by direct selling in the market. Slaughtering and castration were also taken as measures in males. Reasons for uncontrolled mating in all areas were because of communal grazing land and watering point where all herds intermingle and existing bulls mate freely. In general, 128 (71.1%) of the households practice uncontrolled mating, while 52 (28.9%) of the households practice controlled mating. Similar report was made by Workneh and Rowlands (2004) on the use of uncontrolled mating (70%) in the region. In Bench Maji zone, controlled mating is practiced by half of the households (Takele, 2005). As reported by the sampled households across the districts, the sources of bull/s used for breeding within the previous 12 months were neighbor's bull (63%), own bull breed at home (27%), own bull purchased from the market (9%), bull borrowed from relatives far from their destiny for breeding purpose (< 1%) and unknown bull that serves their cow (< 1%) (Table 11).

Table 11: *Controlled and uncontrolled mating and sources of bulls by districts*

	Districts							
	Gera		Sigimo		Dedo		Overall	
Particulars	N 60	%	N 60	%	N 60	%	N 180	%
1. Type of mating								
Controlled	1	1.7	41	68.3	10	16.7	52	28.9
Uncontrolled	59	98.3	19	31.7	50	83.3	128	71.1
2. Sources of bull/s								
Own bull (bred)	24	40	11	18	14	22	49	27
Own bull (bought)	13	22	2	4	1	2	16	9
Bull borrowed	0	0	0	0	1	2	1	<1
Neighbor's bull	23	38	47	78	43	72	113	63
Unknown bull	0	0	0	0	1	2	1	<1

4.3.6. Weaning Practices

Weaning is a crucial period in the management of cows and calves. It is the practice of removing calves from the milk diet provided by the cow. Early weaning allows cows to return to breeding condition earlier and have accelerated calving but creates stress to calves and cows. None of the respondents reported purposive weaning. Calves were naturally weaned when they could not get milk from their dam. The minimum (five months) and maximum (9 months) weaning age was reported by the sampled households. The reported average weaning age of calves was almost similar in the three districts with Mean ± SD (7.98±0.45) months for Gera and (7.44±0.47) months for Dedo, while farmers in Sigimo district reported the average age of calves up to weaning was 8 months. This is in agreement to the result of Workneh and Rowlands (2004) that reported the average weaning age of calves, was greater than 6 months in over 85% of the households. Early weaning (60 and 75 days old) (Galli *et al*., 1995) of the calves is one management tool used by farmers to overcome the suckling effect without compromising reproduction, nor health of the calves (Galina *et al.,* 2001). Early weaning is a management practice which tends to improve the reproductive performance, generating larger forage availability for the cow, because nursing is suppressed and the calves receive artificial feeding (Arias *et al*., 1996) and this improves the body condition score of the cow. There is strong negative correlation between body condition score and calving interval. Increasing body condition score significantly decreases calving intervals (Obese *et al*., 1999). Higher pregnancy rates were observed in cows approaching or maintaining average body condition from parturition to conception than for cows moving away from moderate body condition (Houghton *et al*., 1990). As a disadvantage, it is reported that early weaning produces a great stress (Galli *et al*., 1995). Though calves separated at the later age gained more live weight (Arias *et al.,* 1996, Flower and Weary 2001), the response to stress separation by both cows and calves increased when calves were separated at later (6 to 8 months) (Galli *et al*., 1995). In late weaning, cows made significantly more movements in the grazing land, called at much higher rates and spent more time standing, than cows separated soon after birth (Weary and Chua, 2000).

4.4. Cattle Trait Preferences

Traits like draught performance, body size, color and growth rate were all considered as important traits across the study area and given due emphasis in selecting breeding bulls. The trait preference of farmers will dictate the breeding objectives in keeping cattle. The data were collected for male and female cattle to ascertain the purpose of keeping cattle. High draught output, large body size, color in favor of red or brown coat color and fast growing ability were the most preferred traits of male cattle by most of the farmers. Horn type, fertility, temperament, longevity and meat quality were given relatively little emphasis in selecting breeding animals. Milk production, large body size, color, and growth rate were also the most highly rated traits in selecting breeding females in the study area. The preference of draught power in males might be a result of the use of oxen in all agricultural operations and milk is processed to a form of different by-products, consumed in the household and marketed (Rege *et al.,* 2001). Milk yield and draught performance as primarily preferable traits of farmers in female and male cattle, respectively was also reported in the traditional livestock production system in Bench Maji zone (Takele, 2005), Dano district (Jiregna, 2007) and Gambela region (Abebe, 2009). The preference for milk yield is common in many traditional African cattle owners (De Leeuw and Wilson, 1987).

In general, the survey revealed that there was multi-functional role of cattle in the study area. Furthermore, it is also revealed that the production objectives of farmers in crop-livestock production system were not only focusing on marketable products such as milk and generation of income from sale of live animals and animal products but also non-marketable functions such as traction, reproduction, trashing crops and socio-cultural services. In addition, the result showed that the purposes of keeping male and female cattle were different, which indicates each cattle category of farmers has different functions. The present result is in agreement with the result of a study conducted in Western Wollega by ICRA (1998), Jiregna (2007) and Laval and Assegid (2002) which indicated the multi-purpose functions of cattle. The use of indigenous zebu cattle as multipurpose animals in Ethiopia was also reported by Mukasa-Mugerwa (1981) and van Dorland *et al.* (2004), also in Kenya (Mosi *et al.,* 1996; Rege *et al.,* 2001) and in Sudan

(Musa *et al.*, 2005). In Zambia, Steglich (2006) studied the production objectives of agro-pastoralists and reported that cattle have primarily saving functions. However, milk production is important, but so are manure and traction power. In crop-livestock production system as reported by Peters (1991) the targets of breed improvement programs should not be focused on few traits such as lactation yield but on overall performance including reproduction efficiency to obtain a suitable performance.

Multiple functions are particularly important in low and medium input production environments. Different studies recognized 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 and Zewdu *et al.,* 2006). These broad and multiple uses of cattle genetic resources are widely recognized (Rege and Bester, 1998). This has arisen from the need to extract more than just milk and meat, in the quest to maximize output from these animals that can survive and reproduce under the harsh environmental conditions of the tropics. Rege *et al.* (2001) mentioned that the development of specialized single purpose breeds, for the exclusive production of either beef or milk, is not an appropriate option for areas such as the study areas or for other areas where indigenous cattle are the most important livestock species. Further, the bio-energetic efficiency of multipurpose livestock production would be overlooked by such developments giving rise to misplaced objectives.

In a simulation study to compare different breeding objectives and schemes, Kahi (2000) reported higher profits in breeding programs with dual-purpose objectives than in those with a single purpose objective (beef). The functions required of zebu cattle influence the traits desired by farmers from the viewpoint of genetic improvement. Therefore, the component traits need to be identified carefully before deciding what breeding or livestock development objectives should be adopted. Furthermore, the relative importance of each of these uses is relevant for research and development on cattle genetic resources of the study area, because they provide the basis for setting the current and future objectives of sustainable use and genetic improvement of cattle genetic resources.

All in all, breeding programs should be geared towards functional traits that are top ranked. The management practices such as better feeding and health should go in line with genetic improvement programs. The coat color of the animal was one of the preferred traits. Thus, this survey further confirmed the importance of considering traits like coat color in designing sustainable breeding strategies in the rural livestock production setting. The identification and inclusion of the traits preferred by farmers (draft performance, size and color in male cattle and milk yield, color and size in female cattle) in the breeding program ensures the effectiveness of community based genetic improvement.

Table 12: *Trait preference of farmers for matured males and breeding females (%)*

Character	Males				Females			
	Rank 1	Rank 2	Rank 3	Index	Rank 1	Rank 2	Rank 3	Index
Color	16.7	20	20	0.184	18.3	25	20	0.208
Draft performance	43.3	36.7	26.7	0.383	0	0	0	0
Fertility	3.3	3.3	5	0.036	15	10	11.7	0.128
Growth rate	6.7	8.3	11.7	0.081	10	13.3	8.3	0.108
Horn	0	5	8.3	0.031	0	0	0	0
Longevity	0	0	3.3	0.006	3.3	8.3	6.7	0.055
Meat quality	0	1.7	5	0.014	0	0	0	0
Milk yield	0	0	0	0	28.3	23.3	21.7	0.255
Size	30	21.7	13.3	0.245	20	16.7	23.3	0.205
Temperament	0	3.3	6.7	0.022	5	3.3	8.3	0.042

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

4.5. Ownership of cattle and different activities

4.5.1. Ownership of cattle by family members

The ownership pattern of cattle by each of the family members is shown (Table 13). Cattle are owned either by the head of the household or jointly with other members of the family, including spouses, sons, daughters and other members. However, across districts, the most frequent pattern is the joint ownership between the head of household and the spouse. Similar report was made by Abebe (2009) and Workneh and Rowlands (2004).

Table 13: *Ownership of cattle by family members by districts*

	Districts							
	Dedo		Gera		Sigimo		Overall	
Family members	N	%	N	%	N	%	N	%
	60		60		60		180	
Head	4	6.7	0	0	0	0	4	2.2
Spouse of head	1	1.7	0	0	0	0	1	0.6
Head & spouse	49	81.7	60	100	37	61.7	146	81.1
Sons	0	0	0	0	0	0	0	0
Daughters	0	0	0	0	0	0	0	0
The whole family	6	10	0	0	23	38.3	29	16.1

4.5.2. Responsibility in Cattle Management Activities of Family by Age and Gender

Details of the responsibilities of family members in cattle management activities categorized by age and gender are shown (Table 14). Farming communities of Jimma zone, according to this study, have better chance of benefiting from the opportunities that could be derived from readily available family labor. The selling and buying of cattle was mostly the responsibility of males above 15 years of age. This group was also responsible for breeding, health care and feeding activities whereas their female counterparts are responsible for milking, making and selling dairy products, health care and feeding of cattle staying at home. These results are in line with Mwacharo and Drucker (2005) and Wurzinger *et al.* (2006), who reported that women play an important role in cattle husbandry and the processing of milk is carried out exclusively by female household members in Kenyan and Ugandan cattle keeping rural communities. 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. However, women were less frequently involved in activities related to breeding management (selection, castration, culling and mating) in the study area. Children below 15 years of age often provide the bulk of labor in cattle management. For example, boys under 15 years of age were given responsibilities mainly for herding, health care, feeding and in some cases selling dairy products. In herding of cattle, suckling calves were separately kept at home, to prevent them from suckling their dams. The rest of the animals are herded in either communal or private grazing lands in groups. Young girls under 15 years were also involved in herding, feeding, helping older women in dairying activities and sometimes caring for sick animals. Boys take the higher share of herding than girls.

Use of hired labor (adult male) to herd, feed, milk, herd care and making and selling dairy products was reported mainly in Dedo. The use of hired labor (male children) to herd and fed cattle was reported both in Dedo and Gera. Household labor is an essential resource that influences management practices, enterprise combinations, labor hiring/sharing strategies and overall levels of technical and economic performance (ILCA, 1990). The amount of household labor available and the manner of labor allocation are critical to effectively carry out farm operation and influence livestock management techniques and adoption of improved technologies (ILCA, 1990; Addisu *et al.,* 1998).

The share of each household member in cattle husbandry primarily depends upon the number and 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 cattle ownership in the survey areas depict relatively gender imbalance which is a product of strong cultural background biased against women.

Table 14: *Division of cattle raising activities among age and gender groups in the districts*

Particulars	Districts							
	Dedo		Gera		Sigimo		Overall	
	N	%	N	%	N	%	N	%
1. Adult male								
purchase cattle	17	28	22	37	13	22	52	29
Sell cattle	15	25	20	33	13	22	48	27
Bred cattle	2	3	1	2	12	20	15	8
care for health of cattle	14	23	11	18	11	18	36	20
fed cattle	12	20	6	10	11	18	29	16
2. Adult female								
care for health of cattle	12	20	10	17	9	15	31	17
fed cattle	7	12	0	0	7	12	14	8
milk cattle	15	25	17	28	16	27	48	27
make dairy products	13	22	17	28	15	25	45	25
sell dairy products	13	22	16	27	13	22	42	23
3. Boys								
herd cattle	28	46.7	27	45.0	26	43.3	81	45.0
care for health of cattle	6	10.0	5	8.3	8	13.3	19	10.6
fed cattle	26	43.3	26	43.3	24	40.0	76	42.2
sell dairy products	0	0	2	3.3	2	3.3	4	2.2
4. Girls								
Herd cattle	0	0	60	100	0	0	60	33.3
care for health of cattle	0	0	0	0	6	10.0	6	3.3
fed cattle	19	31.7	0	0	7	11.7	26	14.4
milk cattle	8	13.3	0	0	13	21.7	21	11.7
make dairy products	27	45.0	0	0	19	31.7	46	25.6
sell dairy products	6	10.0	0	0	15	25.0	21	11.7
5. Hired labor (adult male)								
herd cattle	14	23.3	0	0	0	0	14	23.3
care for health of cattle	14	23.3	0	0	0	0	14	23.3
fed cattle	6	10.0	0	0	0	0	6	10.0
milk cattle	6	10.0	0	0	0	0	6	10.0
make dairy products	10	16.7	0	0	0	0	10	16.7
sell dairy products	10	16.7	0	0	0	0	10	16.7
6. Hired labor (Boys)								
herd cattle	60	100	35	58.3	0	0	95	79.2
fed cattle	0	0	25	41.7	0	0	25	20.8

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

- An adult for male and female is ≥ 15 years.
- Children for male and female is <15 years

4.6. Herd characteristics

There is a relationship between functions of zebu cattle and sex structure of the herd (Rege *et al*., 2001). Therefore, it is important to study the herd structure and herd size of the study area.

4.6.1. Herd size

The overall average herd size in the study area was 7.87±3.02 (Table 15). As compared to Gera (7.47±5.16) and Dedo (5.92±1.81) heads, the average cattle herd size of sampled households was higher in Sigimo (10.13±4.09). The cattle herd size was in the range of 3 to 35, 4 to 23 and 3 to 12 in Gera, Sigimo and Dedo districts, respectively. The highest average herd size was recorded in Sigimo and the lowest was recorded in Dedo. This could be due to the availability of large grazing land in Sigimo and less grazing land in Dedo (Table 6). The average cattle herd size of the sampled households in this study is above the report in Bench Maji zone that has been reported (5.2) (Takele, 2005). However, the present study was below the observations in Danno district of West Showa zone which has been reported the herd size of (12.1) (Jiregna, 2007) and the herd size of 10.5 heads of cattle in Boji district, west Wollega Zone (Laval *et al*., 2002). The average herd sizes are small indicating that scope for within herd selection amongst replacement cattle is small. Consequently, organization of an efficient breeding program using individual herd is limited and this may call a community based selection program that has participated the herd of small scale farmers to widen the genetic base for selection.

4.6.2. Age and sex structures of the herd

Table 15 shows the age and sex structure of cattle. Females accounted for about 48%, 56% and 57% of the total herd in Gera, Sigimo and Dedo districts, respectively, while male animals made up of 52%, 44% and 43% in Gera, Sigimo and Dedo, respectively. The higher proportion of females in Sigimo and Dedo may be attributed to the prevalent practice of retaining females for breeding while males are either castrated in order to fetch higher price or sold when they reach market age. The higher proportion of females as compared to males at national level in large ruminant was also reported (CSA, 2008). The high proportion of males in Gera herds may be due to fattening which was practiced by most of the sampled households in Gera.

Male to female ratio of 43:57 in Dedo and 44:56 in Sigimo districts was similar to the result of Jiregna (2007) who reported male to female ratio of 43:57 in Danno Shanan PA and 44:56 in Sayyo Gamballa PA, while male to female ratio of 52:48 in Gera district in this survey was different from 46:54 in Gidda Abbu PA (Jiregna, 2007). Similarly, the present result was different from the reports in pastoral and agro-pastoral production system of Kenya (Rege *et al.,* 2001), where they found male to female ratio of 35:65. A similar report was found in Sudan (Wilson and Clarke, 1975) and Nigeria (Pullan, 1979). The proportion of males in the traditional sector such as this study is high as compared to the commercial dairy farmers. In support of this investigation, Wilson (1986) noted the higher proportion of males in the traditional systems and this indicates the fact that, the objectives of cattle keeping is to ensure traction or meat production. This has also been noted in other agro-pastoral systems of Africa such as in Mali (De Leeuw and Wilson, 1987), Ethiopia (Mukasa-Mugerwa, 1981) and Kenya (Rege *et al.,* 2001).

The average herd size in the sampled households of Gera cattle was 1.39 young castrated males (males of age < 3 years), 2.1 young intact males (males of age < 3 years), 2.67 young females (females of age < 3 years), 1.63 adult castrated males (males of age $\geq$ 3 years), 2.02 breeding males (intact males of age $\geq$ 3 years) and 2.17 breeding females (females of age $\geq$ 3 years). The corresponding values for Sigimo were 1.46, 2.11, 3.63, 1.65, 1.69 and 2.40, respectively. For Dedo the values were 1.64, 1.11, 1.78, 1.71, 1.10 and 1.81 in that order (Table 15).

The breeding females (adult females) take a major portion (26.3%) in Gera followed by young females (21.6%) and breeding males (adult intact males) (20.9%). Similarly, in Dedo breeding females were dominant (29.5%) followed by young females (27.5%) and adult castrated males (19.7%). Breeding males in Dedo was accounted for (6.5%). However, young females take the higher portion (33.6%) in Sigimo followed by breeding females (22.2%), young intact males (18.2%) and breeding males (10.7%). Larger proportion of breeding females in Gera and Dedo would imply the production of larger number of calves which in turn might contribute to increase the intensity of selection or replacement.

In Gera and Dedo, the proportion of adult cattle (both male and female cattle of age ≥3 years) was greater than those of young cattle (calves of age < 3 years), while the opposite is true in Sigimo (Table 15). This showed that, in Gera and Dedo, the herd was dominated by adult animals. This is in consistent with the findings of studies carried out elsewhere in East and South Africa (Doran *et al.*, 1979) and (CSA, 2009) that showed a considerable proportion of cattle over 3 years of age in relation to the total constitute of all herds.

In Dedo, the proportion of castrated males (both young and adult) (24.7%) was higher than intact (both adult and young) males (18.3%). This can be explained by the availability of attractive urban markets for castrated males in the vicinity (Jimma town). On the contrary, the number of castrated males in Gera (16.6%) and Sigimo (15.3%) was lower than the number of intact males (35.5%) in Gera and (28.9%) in Sigimo. The proportion of adult castrated males (11%) in Gera and (19.7%) in Dedo was higher than young castrated males (5.6%) in Gera and (5.1%) in Dedo. This would imply that male cattle in Gera and Dedo were castrated at their older age than males in Sigimo, where the proportion of adult castrated males (7%) was lower than young castrated males (8.3%). Key informants from Gera and Dedo, during the focus group discussion, also stated that males are castrated after they are used for several years as source of draught.

Cows (33.5%) were the dominant cattle categories in all districts and oxen (26.7%) were the second dominant cattle categories. Higher proportion of cows was also reported (CSA, 2009). Bulls (20.2%) and heifers (19.6%) were the third and fourth dominant cattle categories in all districts, respectively. The dominance of milking cows shows the importance of milk production and reproduction in crop-livestock production system. The high number of oxen shows the importance of oxen for traction in this production system.

Table 15: *Age and sex structures of cattle by sampled households*

Districts	Categories	Total cattle in the household	Cattle types					
			Young castrated male	Young intact male	Young female	Adult castrated male	Adult intact male	Adult female
Gera	N of households	60	18	31	36	30	46	54
	N of cattle	445	25	65	96	49	93	117
	Mean±SD	7.47±5.16	1.39±0.61	2.1±1.6	2.67±2.9	1.63±0.67	2.02±1.06	2.17±1.48
	Range	3-35	1-3	1-8	1-16	1-4	1-5	1-10
	% of total herd	100	5.6	14.6	21.6	11	20.9	26.3
Sigimo	N of households	60	35	53	57	26	39	57
	N of cattle	616	51	112	207	43	66	137
	Mean±SD	10.13±4.09	1.46±0.85	2.11±1.22	3.63±1.98	1.65±0.75	1.69±0.80	2.40±1.033
	Range	1-4	1-8	1-9	1-3	1-3	1-5	1-23
	% of total herd	100	8.3	18.2	33.6	7	10.7	22.2
Dedo	N of households	60	11	38	55	41	21	58
	N of cattle	356	18	42	98	70	23	105
	Mean±SD	5.92±1.81	1.64±0.51	1.11±0.31	1.78±0.79	1.71±0.51	1.10±0.30	1.81±0.76
	Range	3-12	1-2	1-2	1-4	1-3	1-2	1-4
	% of total herd	100	5	11.8	27.5	19.7	6.5	29.5
Overall	N of households	180	64	122	148	97	106	169
	N of cattle	1417	94	219	401	162	182	359
	Mean±SD	7.87±3.02	1.47±0.61	1.80±0.72	2.71±1.77	1.67±0.63	1.72±0.81	2.12±1.24
	Range	1-35	1-8	1-9	1-16	1-4	1-5	1-23
	% of total herd	100	6.6	15.5	28.3	11.4	12.8	25.3

4.6.3. Effective Population Size and Level of Inbreeding

Utilization of breeding bull/s born within the flock, uncontrolled mating and small herd size may lead to accumulation of inbreeding and decreased genetic diversity (Falconer and MacKay, 1996; Jaitner *et al*., 2001 and Kosgey, 2004). However, communal herding practiced by many of the cattle owners and borrowing bull for breeding purpose in the study area allow breeding females to mix with males from other herds and this can minimize the risk of inbreeding (Jaitner *et al*., 2001) by increasing the effective population size.

Based on the information of age and sex structure of the population, the effective population size (Ne) and the rate of inbreeding coefficient (ΔF) calculated for Gera, Sigimo and Dedo cattle herd considering the existing herd size and herding practice are presented (Table 16). Under random mating and when cattle herds of households were not mixed, Ne and ΔF for Gera cattle were 4.18 and 0.120, respectively. Ne for Sigimo

(3.97) and Dedo (2.74) was lower and ΔF was higher for these two sites (0.126 for Sigimo and 0.182 for Dedo). In all of the three cases, the level of inbreeding was higher than the maximum acceptable level of 0.063 (Armstrong, 2006). Based on the information obtained from key informants during the focus group discussion, counting the number of cattle on the communal grazing land and consulting the herds men on the cattle they kept, many of the cattle herds of households (on average 34, 20 and 26 in Gera, Sigimo and Dedo areas, respectively) were mixed together. When herds were mixed the ΔF was reduced to (0.0035) in Gera, (0.0063) in Sigimo and (0.0070) in Dedo cattle herds.

Table 16: *Effective population size and level of inbreeding for Gera, Sigimo and Dedo Cattle herds*

District	When herds are not mixed				When herds are mixed			
	Nm	Nf	Ne	ΔF	Nm	Nf	Ne	ΔF
Gera	2.02	2.17	4.18	0.120	68.68	73.78	142.28	0.0035
Sigimo	1.69	2.40	3.97	0.126	33.8	48	79.35	0.0063
Dedo	1.10	1.81	2.74	0.182	28.6	47.06	71.16	0.0070

N_e = effective population size; ΔF = coefficient of inbreeding; N_m = number of breeding male and N_f = number of breeding female.

4.7. The Trend in Cattle Population and Reasons for the Population Trend

The majority of the farmers in Gera (86.6%), Sigimo (93.3%) and Dedo (78.3%) reported an increasing trend in cattle population. Respondents associated the increasing trend of cattle population to the increasing interest of farmers for cattle (58.3%, 30% and 46.7% in Gera, Sigimo and Dedo districts, respectively) due to adaptability of the breed to the area, attractive market price obtained from sale of cattle, better awareness of cattle owners on the importance of livestock and improvement in farmers' income from sale of live animals and animal products. However, 13.3% of the farmers in Gera, 5% in Sigimo and 3.3% in Dedo reported that, the persistency (ability of an organism to remain in a particular setting of time after it is introduced) of the breed was the reason for the increasing trend of cattle population. Farmers of the study area stated that since the breed is readily available, it can reproduce and increase its number. More than half (60%) of the respondents in Sigimo, 25% in Gera and 5% in Dedo stated that the reasons for the increasing trend of the cattle population were both the increasing interest of the farmers and the availability of the breed in the place where the cattle owners live. Nearly half (45%) of the respondents in Dedo, 3.4% in Gera and 5% in Sigimo reported that the reason for the increasing trend of the population was unknown. However, few respondents showed a decreasing trend in the number of cattle. To mention, about 3.3% of the respondents in Gera, 1.7% of the respondents in Sigimo and 5% of the respondents in Dedo reported a decreasing trend in cattle population. These households reported that the reasons for the declining of cattle population in the last ten years were a decreased in the interest of farmers for cattle (56% of the respondents in Sigimo and 78% in Dedo) due to disease and feed shortage. Farmers of the study area also reported not only their interest but the rare availability of the breed (14% of the respondents in Sigimo and 9% in Dedo) and shortage of grazing land (30% of the respondents in Sigimo and 13% in Dedo) were also the reasons for the decrease in the cattle population. Moreover, 10% of the respondents in Gera, 5% in Sigimo and 16.7% in Dedo reported that the trend for the cattle population was not known (Table 17). An increasing trend of cattle population is also reported by Workneh and Rowlands (2004). The increasing tendency might be attributed to the access to market and lucrative price of cattle in the local and international market. However, DAD-IS (2000) and Takele (2005) stated the population trend profile as decreasing.

Table 17: C*attle population trend by districts*

Particulars	Districts							
	Gera		Sigimo		Dedo		Overall	
	N	%	N	%	N	%	N	%
Trend								
Increasing	52	86.6	56	93.3	47	78.3	155	86.1
Decreasing	2	3.3	1	1.7	3	5.0	6	3.3
Unknown	6	10.0	3	5.0	10	16.7	19	10.6
Reasons for increasing trend	60		60		60		180	
1. Increasing interest of the farmers	35	58.3	18	30	28	46.7	81	45
2. Breed availability (readily available)	8	13.3	3	5	2	3.3	13	7.2
3. Both	15	25	36	60	3	5	54	30
4. Unknown	2	3.4	3	5	27	45	32	17.8
Reasons for decreasing trend	0	0	60		60		120	
1. Decreasing interest of the farmers	0	0	34	56	47	78	81	67.5
2. Breed availability (shortage)	0	0	8	14	5	9	13	10.8
3. Feed shortage	0	0	18	30	8	13	26	21.7

4.8. Calving Pattern

Calving occurred at any time of the year. However, there was seasonal variation in calving pattern. Therefore, it would be interesting to determine the specific biological and environmental conditions which are favorable for the occurrence of most conceptions at the time of the year. Regular calving normally results in an increase in both the number of calves born and the amount of milk produced per cow per lifetime and, consequently, influences the rate of herd replacement and the extent of voluntary culling (Salisbury *et al.*, 1978). In the study area, significant numbers of calving was reported at every month of the year and the most frequent calving occurred in June, July and August (Table 18). The occurrence of peak calving in the main rainy season implies that most conceptions took place between September and December of the previous year. This is the period of the year when temperatures in the study area are relatively cool and natural grass for grazing is highly available from the preceding rainy season. Similar result was reported by Workneh and Rowlands (2004), Takele (2005) and Zewudu (2008). The second highest calving rate occurred during November upon which the conception took place between February and March when animals have access to crop residues after harvesting. The animals have therefore been adequately fed for a number of months, providing sufficient time to maintain their energy status. In previous studies, Knopf *et al.* (2000) with Ndama cattle in central Guinea Savannah and Madibela *et al.* (2001) working with Tswana and Simmental X Tswana crosses in Botswana reported a bimodal calving pattern during the year. However, a unimodal peak calving in a Tanzanian dairy herd has been reported previously by Kanuya *et al.* (1997). Kanuya *et al.* (2006) reported that seasonal pattern of conception and calving could be an adaptive physiological mechanism by the indigenous animals developed over many years so that calving occurs at a time of plentiful nutrition including easy availability of drinking water.

Table 18: *Calving pattern in Gera, Sigimo and Dedo districts*

	Districts											
	Gera				Sigimo				Dedo			
Season	Rank 1	Rank 2	Rank 3	Index	Rank 1	Rank 2	Rank 3	Index	Rank 1	Rank 2	Rank 3	Index
September	8	5	4	0.11	3	5	7	0.072	6	4	3	0.081
October	2	6	3	0.058	2	6	4	0.061	0	3	2	0.022
November	0	3	5	0.031	12	10	14	0.194	3	5	7	0.072
December	3	5	0	0.053	6	4	2	0.078	4	3	4	0.061
January	7	10	11	0.14	10	6	5	0.131	11	10	8	0.169
February	0	0	1	0.003	0	1	1	0.008	0	2	3	0.019
March	0	1	2	0.011	1	0	2	0.014	0	3	2	0.022
April	1	5	6	0.053	4	6	5	0.081	0	4	6	0.039
May	4	2	0	0.044	0	2	4	0.022	3	2	2	0.042
June	6	9	11	0.13	6	7	5	0.103	7	5	6	0.103
July	10	7	9	0.15	9	5	6	0.119	13	9	9	0.183
August	19	10	8	0.24	7	8	5	0.117	13	10	8	0.158

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular season of a year divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all seasons.

4.9. Cattle Health

4.9.1. Disease Prevalence and Health Management

Table 19 summarizes the range of prevalent animal diseases and disease conditions as reported by 180 respondents across the study area. The diseases were indicated based on the associated symptoms as recalled by the farmers. However, it was not possible to find out a clear seasonal pattern of disease incidence and mortality levels based on interviews. The major cattle diseases were anthrax, blackleg, diarrhea, pasteurellosis, lumpy skin disease and bloating. The occurrence of such diseases was also reported by a number of authors in smallholder dairy production systems (Workneh and Rowlands, 2004; Takele, 2005 and Jiregna, 2007). Diarrhea occurred most frequently in Gera. Lumpy skin disease and bloating were reported by a sizeable proportion of households only from Dedo district. Farmers treat sick animals by branding especially for black leg. The locals practice branding of the animal body with red hot metal utensils in an attempt to treat the disease. Branding is also reported to be used in many other cultures and countries such as the Fulani in Kenya (Ellen, 2001) They also put ground pepper "*berbere*" in hollow stems of bamboo plant and puff it to the branded place (in Sigimo area). The local farmers have also developed their own ethno-veterinary practices in the management of anthrax, which mainly focus on the control of the endemic. This include drenching the animal with *Apis Africans miaia* (*Tazemma mar*), a mixture of boiled milk, melted butter and garlic (*Allium sativum*) and leaves of the plants like "*Yetota ater*" and *Crotom macrusachys* (*Besana*). Other preparations such as water, table salt and chemicals (gasoline, cooking oil and sulfur ointment) were also reported for external application to treat external diseases and problems. Water boiled with table salt is applied on lesions and open wounds in cases of lumpy skin disease, predator bites and other mechanical injuries as a sort of antiseptic treatment of the lesions. Throughout this survey, farmers mentioned very few cattle diseases. This indicated that local cattle of the area did not have major health problems other than those listed above.

Table 19: *Reported prevalence of cattle diseases by districts*

	Districts							
	Dedo		Gera		Sigimo		Overall	
Households	N	%	N	%	N	%	N	%
Diseases/disease conditions	60		60		60		180	
Anthrax	7	11.7	22	36.7	21	35	50	27.7
Blackleg	8	13.3	15	25	19	31.7	42	23.3
Diarrhea	0	0	11	18.3	0	0	11	6.1
Pasterullosis	18	30	12	20	20	33.3	50	27.7
Lumpy Skin Disease	16	26.7	0	0	0	0	16	8.8
Bloating	11	18.3	0	0	0	0	11	6.1

4.9.2. Distance to the Nearest Veterinary Service

On average, 17% of the households in the study area trek their animals for 6-10 km to the nearest veterinary service, while 65% of the households trek their cattle for 1-5 km to reach the nearest veterinary service. No household reported trekking of cattle farther than 10 km to get the veterinary service (Table 20). The highest and lowest percentage of households trekking cattle for (< 1km) were reported from Dedo (45%) and Gera (3%), where as the highest and lowest percentage of households trekking cattle for (1-5km) were reported from Sigimo (95%) and Dedo (33%) and for 6-10 km the highest and lowest number were from Gera (30%) and Sigimo (none of the households), respectively. Almost all (99%) of the households in the study area used governmental veterinary services and only 1% used services from private veterinarians (Table 10). Except 3% of the households in Dedo district, all of the sampled households in the three districts had used governmental veterinary service. Governmental and private veterinary services are reported in Oromiya region as a service rendering institution (Workneh and Rowlands, 2004).

Table 20: *Distance to the nearest veterinary service and source of veterinary service by districts*

Districts	No. of households	Distance in km						Type of veterinary service			
		<1		1-5		6-10		Government veterinarian		Private veterinarian	
		N	%	N	%	N	%	N	%	N	%
Gera	60	2	3	40	67	18	30	60	100	0	0
Sigimo	60	3	5	57	95	0	0	60	100	0	0
Dedo	60	27	45	20	33	13	22	58	97	2	3
Overall	180	32	18	117	65	31	17	178	99	2	1

4.10. Reported Productive and Reproductive Performance by District

The productivity of cattle depends largely on their reproductive performance (Arthur *et al.*, 1989). The heritability of age at first service (AFS), number of services per conception (NSC), days open (DO) and calving interval (CI) is low, so that environmental factors, including management conditions, play a significant role in the variability of the traits (Olori *et al.*, 2002).

The overall average milk production/day per cow was (1.63±0.06 liters) and there was significant ($p<0.01$) difference across the three sites for milk production. The highest average milk production was reported in Dedo (1.92±0.09) compared to Gera (1.60±0.05) and Sigimo (1.57±0.04) (Table 21). The differences in performance can be explained in terms of climate, vegetation type, management practices, and phenotypic (and probably genetic) differences between Jimma cattle populations. This type of variation therefore, provides a solid base for genetic selection (Hegde, 2005). The result obtained in this survey showed a lower average milk yield as compared to the various reports, where Takele (2005) revealed an overall average of 2.3 liters per day per cow in Bench Maji zone and Abebe (2009), in Gambella region, reported the average daily milk yield per cow of 2.67±0.20 liters for Nuer cattle, 2.95±0.26 for Fellata and 2.12±0.22 for Sheko-Mezhenger with a range of milk yield (1.68-3.07). However, the present result is higher than the report of Jiregna (2007) he reported the daily milk yield per cow of 1.2 liters in Danno district. The level of milk production per day per cow in this survey is greater than the national average of 1.3 liters (CSA, 2009).

The overall average lactation length among the three districts was (8.29±0.15 months) and there was significant ($p<0.01$) difference in lactation length among sites (Table 21). This is in agreement with the findings of Workneh and Rowlands (2004) in Oromiya region who have got (8.9±0.3 months) of lactation length. However, the present result is greater than what has been reported as seven months in DAD-IS (2000), but lower than the report of Takele (2005) who reported 9.9 months for Sheko cows. The lactation length of a cow in Gera (8.43±0.18) months was longer than the lactation length of a cow in Sigimo (8.34±0.15) months and Dedo (7.31±0.31) months with values ranging from 6 to 11, 6 to 13 and 7 to 9.25 months for Gera, Sigimo and Dedo, respectively. The values on average lactation length and daily milk production then give total lactation milk production of 404.64 liters for Gera, 392.81 liters for Sigimo and 421.06 liters for Dedo. This is much better than the reported averages for Danno district cattle which lactate for 258 days, with an estimated annual milk yield of 366, 512.4 and 366 kg for Sayyo Gamballa, Gidda Abbu and Danno Shanan PAs (Jiregna, 2007). However, the present result is lower than the reported values on average lactation length and daily milk yield of about 698.3 liters (Takele, 2005). On station works at Holeta research center, resulted in yield of 550 liters and 173 days of lactation period which varies with parity (Alberro and Haile-Mariam, 1982 a, b). Mulugeta *et al.* (1993), working at Bako Agricultural research center reported an average lactation milk yield of 508±341kg (range 100 to 1155kg) per lactation with a daily average of 2.41kg per cow and lactation length of 229.8±74 days.

Age at sexual maturity obtained in this study (37.46±0.44 months for males and 36.16±0.34 months for females) is lower than what has been reported in Oromia region who have reported 39.6 and 39.9 months of age at sexual maturity for females and males, respectively (Workneh and Rowlands, 2004). The overall average reported age at first calving was 42.49±7.64 months and it varied from (42.40±0.65) months in Gera female cattle population (Range 30 to 54) to (42.02±0.53) months in Sigimo (Range 27 to 60) and (40.24±1.08) months in Dedo (Range 39 to 57). This average is comparable with the earlier report made by Mekonnen (1987) who reported average age at first calving of 41.5 months for Boran cattle on station conditions. The age at first calving in the present study is higher than the report of Enyew (1992) and Mekonnen and Goshu (1987) who obtained age at first calving of 32.8 and 38.8 months for Arsi and Fogera cattle, respectively, under station management. However, the age at first calving in this study is shorter than earlier reports on indigenous cattle: Takele (2005), Kassa and Arnason (1986) reported average age at first calving of 54.1 and 45.2 months for Sheko cattle on their natural habitat and Boran cattle on station conditions, respectively. Both average age at sexual maturity and age at first calving in Jimma cattle were found to be less than what had been reported by Zewdu (2004) on Semien, Wogera Sanga and Foggera cattle in Northwestern Ethiopia. The differences in breeding efficiency are largely due to environment, although between breeds heredity plays some part in the variation of reproductive performance. Traits related to reproduction are mainly influenced by environmental factors such as feeding (Msanga *et al*., 1999). Poor feeding and management could have been the reason for highest age at first calving during this period since a majority of farmers at that time had no experience in dairy cattle management (Asimwe and Kifaro, 2007).

Although the overall average reported calving interval was 13.49±4.37, it varied from 14.43±0.35 (range 8 to 24) months in Gera to 13.84±0.29 (range 9 to 25) months in Sigimo and 12.87±0.59 (Range 8.5 to 10) months in Dedo. This result is lower than what had been described by Ababu (2002) for Boran cows at Abernossa ranch, Zewdu (2004) for Semien, Wogera Sanga and Foggera cattle, Alganesh *et al*. (2003) on indigenous cattle of west Wallaga and Takele (2005) in Bench Maji zone (15.6 months). Mismanagement practices like poor heat detection and feeding could be the cause for long calving intervals. Phipps (1974) associated long calving intervals to nutritional factors notably level of nutrition and mineral imbalances. Msanga *et al*. (1999) attributed long calving intervals to poor nutrition and /or failure to detect heat by farmers.

Table 21: *Least squares means ± standard errors of MP, LL, ASM, AFC and CI for the effects of districts*

		MP	LL	ASM		AFC	CI
Effects				Male	Female		
& level	N	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	180	1.63±0.06	8.29±0.15	37.46±0.44	36.16±0.34	42.49±0.66	13.49±0.23
C.V		23.44	16.47	7.22	11.17	11.37	19.47
R^2		10.60	21.15	89.15	84.79	60.85	64.64
District		**	**	**	NS	NS	NS
Gera	60	1.60±0.05[b]	8.43±0.18[a]	35.58±0.26[b]	35.41±0.56	42.40±0.65	14.43±0.35
Sigimo	60	1.57±0.04[c]	8.34±0.15[a]	37.52±0.46[a]	35.49±0.49	42.02±0.53	13.84±0.29
Dedo	60	1.92±0.09[a]	7.31±0.31[b]	35.39±0.94[b]	35.24±0.51	40.24±1.08	12.87±0.59

*Means with different superscripts within the same column are statistically different, NS=Non-significant;**significant at 0.01, MP=Milk production in liter; (LL=Lactation length; ASM=Age at sexual maturity; AFC=Age at first calving and CI=Calving interval) in months.*

Positive and moderate correlations among fertility traits were found. This is expected because fertility measures were closely related to each other (Kadarmideen *et al*., 2000). The correlation matrix for productive and reproductive traits in the female cattle population (Table 22) showed that the strongest and positive correlation (r =0.638783) was between ASM and AFC at significant probability level (p< 0.01). If correlation between the two traits is high, the selection for one trait would result in an improvement/deterioration for the other trait as a correlated response. This finding is also substantiated by that of Takele (2005), who reported strong and positive correlation (P<0.01) between ASM and AFC. Similarly CI showed a moderate and positive correlation with MP (P=0.1638) and LL (P=0.0521). Javed *et al.* (2004) reported that there was positive phenotypic correlation (0.39) between milk production and calving interval of Sahiwal cows. Mantysaari and Van Vleck (1989) also reported a positive phenotypic correlation of (0.30) between the two traits in Holstein cattle. However, CI has shown a negative correlation with ASM (P=0.1100). Lactation length (LL) also exhibited a moderate and positive correlation with both ASM (0.1693) and AFC (P<. 0001). AFC (P<0.01), ASM (P<0.01) and LL (P=0.4331) had a negative correlation with MP (Table 22). However, the correlation magnitude between AFC and CI (r=0.080757) was found to be the weakest and it was statistically insignificant (p=0.5616).

Table 22: *Correlation matrices of reported averages of productive and reproductive traits in the female population (n=287)*

	MP	*LL*	*ASM*	*AFC*	*CI*
MP		- 0.108909 0.4331	- 0.601672 (<.0001)	- 0.521314 (<.0001)	0.192228 0.1638
LL			0.189794 0.1693	0.515255 (<.0001)	0.265781 0.0521
ASM				0.638783 (<.0001)	- 0.219939 0.1100
AFC					0.080757 0.5616
CI					

4.11. Variability in the Sample Cattle Population

4.11.1. Qualitative Variation

The Chi-square test results showed highly significant difference ($p<0.0001$) between sample cattle populations in all qualitative variables except face profile ($p<0.05$) (Table 23). Generally, most of the variables had medium to high association values with the study sites. Coat pattern and face profile had respectively the maximum and minimum phi coefficient, contingency coefficient and Cramer's V values. Minimum phi coefficient and contingency coefficient for face profile was also reported by Dereje (2005) from South and North Wollo zones of Amhara region. Among the cattle owners in the study area, uniform coat pattern in favor of red or brown coat color is considered as a good selection criterion for breeding males (next to draught performance and size) and breeding females (next to milk production). Coat pattern had the highest association value or discriminating power in the present study. Therefore, breed improvement strategy in an area like the study area should take the coat color and its pattern in to account.

Table 23: *Chi-square tests and level of association between sites and categorical variables for both female and male sample populations (n=540)*

Variables	P-value	Phi coefficients	Contingency coefficients	Cramer's V
Coat pattern	<0.0001	0.85	0.65	0.60
Dewlap size	<0.0001	0.64	0.54	0.45
Hump size	<0.0001	0.45	0.41	0.32
Face profile	0.04	0.15	0.14	0.15
Ear orientation	<0.0001	0.51	0.45	0.36
Horn shape	<0.0001	0.40	0.37	0.28
Horn orientation	<0.0001	0.63	0.54	0.45
Tail length	<0.0001	0.59	0.51	0.42
Udder size for females	<0.0001	0.37	0.35	0.26
Teat size for females	<0.0001	0.46	0.42	0.32
Naval flap	<0.0001	0.42	0.39	0.30
Testis size for males	<0.0001	0.41	0.38	0.29
Perpetual sheath size for males	<0.0001	0.47	0.42	0.33

Cattle keepers of the study area have their own way of assessing each important qualitative trait. According to this result, farmers assess qualitative trait expression based on visual observation. As a result, they could not quantify their targeted trait expressions. This was due to the reason that farmers do not have graduated measuring materials for each trait. Example, the targeted expression of farmers for coat pattern was uniform coat color pattern and the way of assessing this trait was visual observation on coat color of the animal, while the targeted expression of dewlap was thick and large dewlap size and the way of assessing the trait was visual observation at dewlap of the animal. Similarly, the targeted expression of hump size and position was large hump and not tilted to one side and the way of assessing the trait expression was visual observation at the length of the hump from the base where it starts to the tip of the hump. Long tail was the targeted expression of most farmers in the study area and the way of assessing this trait was visual observation. When the tail of the animal was below the hock knee, the tail was considered to be long which was a good indicator of male and female reproduction as reported by farmers. The targeted trait expression for udder was big size. The way of assessing this trait was visual observation around the udder of the animal. Farmers say udder size of a cow large, medium and small but they can not quantify it. The targeted trait expression for teat was long and thick teat and the way of assessing the trait was visual observation at the length of the teat from the base of the udder down wards. The targeted expression for testes was large testes size and the way of assessing the trait expression was visual observation of testes of the animal. Cattle owners prefer male animals which have large testes size and such animals are considered very good for reproduction as recalled by farmers of the study area.

Across the three districts, four patterns of coat colors were recorded with 68.54% uniform, 9% pied, 12.13% spotty and 10.33% shaded (Table 24). Brown, light brown, dark brown, red, light red, dark red, white and white with brown dominant coat colors were the dominant colors both in the female and male cattle population, in that order. Black coat had the least preference among the wide ranges of coat colors and this was confirmed by small proportions of cattle exhibiting black coat color in the sampled population. Similar report was made by Jiregna (2007). Most of the time the head profile ranged from straight (57.79%) to concave (42.18%) appearance. Dewlap size was observed at frequencies of 33.48% for small dewlap, 53.70% for medium dewlap and 13.03% for large dewlap (Table 24). Half of the sampled cattle populations had small hump (50.45%), 39.49% having medium hump and 10.06% having large hump. Ear orientation varied between upright (9.64%), lateral (84.89%) and dropping (5.47%). Similarly, the frequency of occurrence of forward, lateral, upright and dropping horn orientation were 50.3%, 17.36%, 31.61% and 0.7%, respectively (Table 24).

Table 24: *Summary of the percentages of qualitative traits of cattle in the three districts*

Character	Attributes	District			Overall
		Gera	Sigimo	Dedo	
Coat color pattern	Uniform	62.98	78.20	64.40	68.54
	Pied	8.03	7.23	11.75	9.00
	Spotty	12.20	12.75	11.45	12.13
	Shaded	16.75	1.82	12.40	10.33
Dewlap size	Small	23.15	66.65	10.65	33.48
	Medium	50.02	21.73	89.35	53.50
	Large	26.82	12.28	0	13.02
Hump size	Small	23.17	71.68	56.50	50.45
	Medium	53.07	27.30	38.10	39.49
	Large	23.76	1.02	5.40	10.06
Face profile	Flat	51.08	54.55	67.75	57.79
	Concave	48.92	45.45	32.25	42.21
Ear orientation	Upright	24.05	4.88	0	9.64
	Lateral	59.53	95.12	100.00	84.89
	Dropping	16.42	0	0	5.47
Horn shape	Straight	48.4	48.90	43.70	47.00
	Curved	20.42	39.82	54.95	38.40
	Lyre-shaped	31.18	11.28	1.35	14.60
Horn orientation	Forward	83.58	12.83	54.50	50.30
	Lateral	3.02	41.65	7.40	17.36
	Upright	12.68	44.10	38.05	31.64
	Dropping	0.70	1.38	0	0.70
Tail length	Short	11.10	2.90	1.55	5.19
	Medium	56.82	3.65	61.38	40.62
	Long	32.08	93.45	37.07	54.19
Udder size	Small	38.60	34.80	78.30	50.57
	Medium	52.40	55.72	15.10	41.07
	Large	9.00	9.48	6.60	8.36
Teat size	Small	39.55	36.13	19.80	31.83
	Medium	55.40	32.05	24.55	37.33
	Large	5.05	31.82	55.65	30.84
Naval flap	Absent	8.10	34.15	0.95	14.00
	Small	73.60	28.50	36.80	45.30
	Medium	18.30	34.48	62.25	38.08
	Large	0	7.87	0	2.62

Table 24 *(continued)*

Character	Attributes	District			Overall
		Gera	Sigimo	Dedo	
Testis size	Small	51.65	80.50	50.00	60.70
	Medium	38.23	14.63	17.55	23.47
	Large	10.15	4.88	32.45	15.83
Perpetual sheath size	Small	29.60	77.45	71.65	59.57
	Medium	52.53	8.53	20.25	27.10
	Large	17.87	14.02	8.10	13.33

4.11.2. Quantitative Variation for the Male Cattle Population

The analysis of variance showed that district, which represents cattle population types, was highly significant ($p<0.01$) in the model for all the six quantitative variables except horn length ($p<0.05$). Between age categories of male cattle, all the six variables were also significantly different ($p<0.01$). Table 25 shows the level of significance of main fixed effects. The coefficient of variation for horn length was the highest followed by ear length and pelvic width, indicating the existence of high variations in the male cattle population for these traits. The discriminating power of horn length was also confirmed by Dereje (2005).

Results for Least square means ± SE of linear body measurements of male cattle revealed that the male population sampled from Dedo had larger values for heart girth, body length, height at wither, ear length and pelvic width than male cattle in Gera and Sigimo. However, Dedo male cattle population had medium horn length between Gera and Sigimo male cattle population (Table 25). Sigimo male cattle types on the other hand had the lowest measurement for heart girth, body length, height at wither, pelvic width, ear length and horn length. The male cattle population sampled from Gera had intermediate values for heart girth, body length, height at wither, ear length and pelvic width between Sigimo and Dedo male cattle population, but they had the longest horn length (20.28±0.90 cm) (Table 25).

Results for linear measurements of male cattle in age class 1, 2 and 3 revealed that male cattle in age class 3 (≥ 42 months of age) had higher values than those in age class 1 (18-30 months of age) and age class 2 (31-41 months of age categories) for all the six quantitative variables, while male cattle in age class 2 had intermediate linear body measurements between age class 1 and 3. Male animals in age class 1 on the other hand had the lowest value for heart girth, body length, height at wither, ear length, pelvic width and horn length. This showed that older cattle had higher values than younger cattle 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.

Table 25: *Least squares means ± standard errors of linear body measurements (cm) for the effects of district and age for male cattle*

Effects & level		Heart girth	Body length	Height at wither	Ear length	Pelvic width	Horn length
	N	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	253	151.83±1.01	112.33±0.30	109.94±0.56	17.16±0.24	31.80±0.a7	18.22±0.92
CV%	253	5.91	3.04	4.65	14.26	5.95	30.04
R^2	253	38.08	78.41	61.47	9.00	23.30	6.48
District		**	**	**	**	**	*
Gera	94	153.51±0.71[a]	112.76±0.27[b]	109.99±0.40[b]	17.06±0.19[b]	31.75±0.15[b]	20.28±0.90[a]
Sigimo	78	143.36±1.47[b]	110.96±0.56[c]	105.99±0.84[c]	16.35±0.43[c]	30.51±0.31[c]	17.58±0.43[c]
Dedo	81	153.88±1.59[a]	113.40±0.60[a]	115.11±0.90[a]	18.41±0.40[a]	33.32±0.34[a]	18.49±0.97[b]
Age group		**	**	**	**	**	**
1	60	143.32±1.19[c]	103.94±0.45[c]	103.59±0.68[c]	16.21±0.32[c]	31.20±0.25[a]	17.01±0.73[b]
2	89	151.05±1.00[b]	112.73±0.38[b]	110.82±0.57[b]	17.37±0.27[b]	32.08±0.21[b]	19.45±0.61[a]
3	104	156.38±1.21[a]	120.46±0.46[a]	116.68±0.69[a]	18.24±0.33[a]	32.30±0.26[a]	19.89±0.74[a]

*Means with different superscripts within the same column and class are statistically different. Ns = Non significant; *significant at 0.05 and **significant at 0.01. Age group 1=18-30 months of age; age group 2=31-41 months of age and age group 3=≥42 months of age.*

The correlation matrix for quantitative traits in the male cattle population (Table 26) showed that the strongest correlation (r =0.480171) was between body length and height at wither at significant probability level (p< 0.01). However, the correlation magnitude between body length and pelvic width (r=0.001125) was found to be the weakest and it was statistically insignificant (p=0.9859). Other insignificant correlations exist between heart girth and ear length, body length and pelvic width, body length and horn length, height at wither and ear length and ear length and pelvic width (r=0.7680, 0.9859, 0.2583, 0.1430 and 0.4784, respectively).

Table 26: *Pearson's correlation coefficients of quantitative traits (in cm) in the male population (n=253)*

	HG	BL	HW	EL	PW	HL
HG		0.170861 (0.0069)	0.260554 (<.0001)	0.018789 0.7680	0.285177 (<.0001)	0.244785 (<.0001)
BL			0.480171 (<.0001)	0.165731 (0.0088)	0.001125 0.9859	0.071914 0.2583
HW				0.093097 0.1430	0.329011 (<.0001)	0.184414 (0.0035)
EL					0.045125 0.4784	0.189468 (0.0027)
PL						0.367822 (<.0001)
HL						

HG= Heart girth, BL= Body length, HW= Height at wither, EL= Ear length, PW= Pelvic width and HL= Horn length

4.11.3. Quantitative Variation for the Female Cattle Population

As with the male cattle population, the quantitative data from the sampled female cattle population was analyzed by considering district and age of cattle as main fixed effects. Frequency distributions of quantitative variables for the female data set by district and age of cattle showed that the total female sample population was not homogenous with respect to the variables considered. Moreover, differences were observed between districts which justify further analysis of the data to find out distinct cattle groups which are more similar to each other. The analysis of variance showed highly significant differences ($p<0.01$) between age categories of female cattle for all variables (Table 27). Highly significant ($p<0.01$) difference was also noted between districts for body length, ear length, pelvic width and horn length measurements. Heart girth and height at wither did not vary significantly ($p>0.05$) between districts in the female cattle.

Similar to male cattle population, horn length had the highest coefficient of variation followed by ear length and pelvic width (Table 27). Hence, horn length had the highest variability between districts in the female cattle. Generally the coefficients of variation of variables on female cattle were higher than those of male cattle.

Results for linear measurements of female cattle revealed that the female cattle population sampled from Gera had the largest value for horn length, intermediate values for ear length and pelvic width and lowest value for body length measurements. Female cattle sampled from Sigimo on the other hand had the largest value for body length and the lowest values for ear length, pelvic width and horn length. However, the female cattle population sampled from Dedo had intermediate measurements between the Gera and Sigimo cattle types for body length and horn length but they had the highest values for ear length and pelvic width (Table 27).

Similar to male cattle, results for linear measurements of female cattle in age class 1, 2 and 3 revealed that female cattle in age group 3 (≥ 42 months of age) had higher values than those in age class 1 (18-30 months of age) and age class 2 (31-40 months of age categories) for all of the variables under consideration. Female cattle population in age class 2 on the other hand had intermediate values for heart girth, body length and height at wither and the lowest values for ear length, pelvic width and horn length. Female cattle population in age class 1 had intermediate values for ear length, pelvic width and horn length measurements and the lowest measurements of heart girth, body length and height at wither.

Table 27: *Least squares means ± standard errors of linear body measurements (cm) for the effects of district and age for female cattle*

Effects & level		Heart girth	Body length	Height at wither	Ear length	Pelvic width	Horn length
	N	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	287	148.27±1.02	109.72±0.92	106.05±0.81	17.36±0.20	31.39±0.23	18.26±0.67
CV%	287	6.52	5.82	6.54	14.31	6.56	32.66
R^2	287	3.80	13.88	10.68	17.75	7.94	10.54
Districts		NS	**	NS	**	**	**
Gera	86	145.18±1.52	107.32±0.70^{b}	105.62±0.76	16.36±0.27^{b}	31.54±0.22^{b}	19.47±0.55^{a}
Sigimo	102	147.72±0.89	110.58±0.59^{a}	105.30±0.64	15.44±0.39^{c}	30.73±0.19^{c}	14.65±0.94^{c}
Dedo	99	149.18±1.05	107.63±1.00^{b}	105.27±1.09	17.78±0.23^{a}	31.56±0.32^{a}	16.91±0.65^{b}
Age group		**	**	**	**	**	**
1	64	145.57±1.04^{c}	107.09±0.69^{c}	103.18±0.75^{a}	16.37±0.27^{b}	31.25±0.22^{b}	16.19±0.64^{b}
2	103	147.29±1.75^{b}	107.10±1.16^{b}	104.72±1.26^{b}	15.38±0.45^{c}	30.74±0.37^{c}	15.97±1.08^{c}
3	120	149.71±0.79^{a}	111.33±0.52^{a}	108.28±0.57^{c}	17.83±0.20^{a}	31.84±0.17^{a}	18.86±0.49^{a}

*Means with the different superscripts within the same column and class are statistically different. Ns = Non significant; **significant at 0.01. Age group 1=18-30 months of age; age group 2=31-41 months of age; age group 3=≥42 months of age.*

As in the male cattle populations, the correlation matrix of quantitative traits in the female population in this study showed that the strongest correlation (r =0.755115) was between body length and height at wither at high significant level (p< 0.01). However, the correlation between heart girth and ear length (r=0.123189) was found to be the weakest and it was statistically significant at (p<0.05) (Table 28).

Table 28: *Pearson's correlation coefficients of quantitative traits in the female population (N=287)*

	HG	BL	HW	EL	PW	HL
HG		0.483019 (<.0001)	0.393464 (<.0001)	0.123189 0.0384	0.185344 (0.0017)	0.392443 (<.0001)
BL			0.755115 (<.0001)	0.209660 (0.0004)	0.260136 (<.0001)	0.238106 (<.0001)
HW				0.305400 (<.0001)	0.373727 (<.0001)	0.177838 (0.0027)
EL					0.516671 (<.0001)	0.454001 (<.0001)
PW						0.433444 (<.0001)
HL						

HG= Heart girth, BL= Body length, HW= Height at wither, EL= Ear length, PW= Pelvic width and HL= Horn length

Comparing male and female cattle population within district, adult males have overall larger measurements than females for most of the quantitative variables which is generally expected for the species. This is consistent with what has been reported before for growth related traits in cattle (Saeed *et al*., 1987 and Mwandotto, 1985). Dereje (2005) in South and North Wollo zones of the Amhara region also reported that within site adult males have larger measurements than females for body length, height at withers and heart girth, but shorter horn and ear length. However, comparing male and female cattle population within the same age class, female cattle of age class 1 had superior linear body measurements (for heart girth, body length, ear length and pelvic width) except height at wither and horn length than male cattle of the same age group. This is because female cattle grow faster than male cattle at early age (Frandson and Elmer, 1981). This linear body measurement difference might be partly due to hormonal effect that is non-release of androgen, known to have growth and weight stimulating effect in male animals until the testes are well developed (Frandson and Elmer, 1981). Before the onset of puberty, female cattle have more body fat than male cattle. Male cattle of age class 2 and 3 on the contrary had overall larger measurements than female cattle of the same age group.

4.12. Body Condition Scores of Cattle in the Study Area

Body condition scoring (BCS) is a management technique used routinely to appraise the body fat reserves and energy status in cattle (Wildmann *et al*., 1982). Changes in BCS over time reflect both the body composition and energy balance, which in turn, are critical for metabolic stability, health and fertility (Coffey *et al*., 2001). Body condition of cattle has been reported to influence maintenance, growth, reproduction, milking ability, and productive lifespan (Wiltbank *et al.,* 1962; Klosterman *et al.,* 1968 and Dunn *et al.,* 1969). The influence of body condition on economically important traits indicates that a practical tool to measure condition in cattle is necessary for use in cattle management.

The overall mean body condition scores of male and female cattle populations at 18-30 months of age (4.2±1.2) was smaller than the body condition scores of cattle at 31-41 months of age (5.1±1.0) and cattle at ≥ 42 months of age (4.8±1.3) (Table 29). This showed that cattle with the third (lateral) incisor erupted (31-41 months) had highest average body condition scores than other cattle categories. Male cattle had slightly higher average body condition score than female cattle in all districts and age categories.

Cattle sampled from Dedo have relatively higher body condition scoring than cattle sampled from the other two districts. Dedo cattle type (both male and female cattle) also had the maximum heart girth measurements (Table 25 and 27). As cited by Nicholson and Butterworth (1986), there is a high correlation between body condition score and heart girth (Nicholson and Sayers, 1986b). Cattle sampled from Sigimo on the other hand had the minimum body condition scoring.

Table 29: *Body condition scores of different cattle categories by district and age of cattle*

District	Overall			Male			Female		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Gera	180	4.7	1.1	94	5.0	1.1	86	4.4	1.0
Sigimo	180	4.6	1.0	78	4.8	1.2	102	4.3	1.0
Dedo	180	4.9	1.0	81	5.1	1.0	99	4.6	1.1
Age category									
18-30 months BCS	224	4.2	1.2	104	4.2	1.1	120	4.1	1.0
31-41 months BCS	192	5.1	1.0	89	5.3	1.0	103	4.8	1.1
≥42 months BCS	124	4.8	1.3	60	5.1	1.2	64	4.5	0.7

4.13. Cluster Analysis to Characterize Cattle Population Types

This survey resulted in a number of breed names of cattle (Boke, Bora, Bure, Culo, Dale, Dedo, Gera, Jerso, Jeto, Megal, Nuno, Orome, Sendew and Sigimo) across the study areas. It was not known how many of these names describe distinctive cattle breeds. Different breed names for similar breed types may have been developed in different areas. For example, individual names of breeds were often closely related to the clan or ethnic group to which farmers belong or, alternatively, they may be derived from the location where the animals were raised. This means that, it was difficult to analyze the results to describe and compare different breed types. One possible solution was to use a statistical method known as 'cluster analysis' to use the phenotypic data collected in the survey to form different groups or clusters of cattle that can then be summarized and mapped.

The set of observations on 253 matured male and 287 breeding female cattle against 6 quantitative and 13 qualitative variables were considered for classification. The thirteen qualitative variables were first converted into percentage frequencies (Table 24) for sample cattle population from a study districts. Similarly, arithmetic means of the six quantitative variables for sample cattle population were considered. Then the mean values of observations were clustered by SAHN using SAS 9.2 (SAS, 2002). Finally the 19 correlated variables (both qualitative and quantitative) were first transformed into as many independent principal components.

Chatfield and Collins (1980) stated that when analyzing a correlation matrix where the sum of the Eigen values is equal to the number of variables; many social scientists use the rule that Eigen values less than 1 may be disregarded. This arbitrary policy is a useful rule of thumb but has no theoretical justification. It may be better to look at the pattern of Eigen values and see if there is a natural breakpoint in the Eigen values. Chatfield and Collins (1980) claimed that one serious drawback is that there is no objective way of deciding how many components to retain.

The first principal component explained about 23.25% of the total variance, the second principal component explained about 18.58%, and the third principal component explained about 14.77% of the variation. The six principal components that account for 86.47% of the total variance (on 19 correlated variables) were considered in the subsequent analysis. The six associated Eigen values for the six principal components were shown (Table 30).

Table 30: *Eigen values (latent roots) for the six principal components*

	Eigen values	Contribution to total variance
λ_1	7.20684695	23.25%
λ_2	5.76124851	18.58%
λ_3	4.57827947	14.77%
λ_4	3.63606144	11.73%
λ_5	3.10058936	10.00%
λ_6	2.52325708	8.14%
	26.80628281	86.47%

Correlations of the variables with the principal components indicate the significance of each variable to differentiate cattle groups. The first principal component (PC1) has negative correlations with uniform and pied coat color patterns, but positive correlation with spotty and shaded coat color patterns (Table 31). It has also low to medium positive correlations with the first six quantitative variables except horn length. Similarly, positive correlations were observed with medium to large dewlap and hump size, concave face, upright and dropping ear orientation, lateral horn orientation, straight and lyre-shaped horn, short and long tail, medium to large udder size, medium teat size, small naval flap, large testis and small to medium perpetual sheath. PC1 also had negative correlations with horn length, small dewlap and hump size, flat face, lateral ear orientation, forward, upright and dropping horn orientation, curved horn shape, medium tail, small udder size, small to large teat, medium to large naval flap, small to medium testis and large perpetual sheath. Therefore, this component can be viewed as one contrasting cattle population with uniform and pied coat pattern, upright and dropping ear orientation, short and long tail, medium to large udder and large testis on one side and those with spotty and shaded coat pattern, lateral ear orientation, medium tail, small udder and small and medium testis on the other.

The second principal component has comparatively strong positive correlations with pelvic width, pied coat pattern, medium dewlap and hump size, and curved horn, short to medium tail length, large teat, long naval flap, large testis and long perpetual sheath size (Table 31). However, PC2 had comparable negative correlations with ear length, spotty coat pattern, small dewlap and small hump size, straight horn, long tail, small teat, short naval flap and small testis size and medium perpetual sheath. This component is, therefore, a contrast of size on dewlap, hump, teat, naval flap, testis and perpetual sheath and horn shape.

The general feature of principal component 3 is that it has the highest positive and negative correlation with forward and lateral horn orientation and the lowest positive and negative correlation with flat and concave face, respectively. Similarly the fourth principal component gives much weight for the difference between flat and concave face.

Table 31: *Correlation of the classification variables with the principal component*

Variable	PC1	PC2	PC3	PC4	PC5	PC6
Heart girth	0.233200	0.125031	0.045896	0.275940	0.010327	-.097285
Body length	0.135760	-.029116	0.258562	0.271827	0.271317	-.063409
Height at wither	0.104999	0.128205	0.298575	0.084618	0.337849	0.045129
Ear length	0.078658	-.285774	0.171366	0.002534	0.149024	-.165482
Pelvic width	0.066917	0.324923	0.185501	-.061644	0.191343	0.032990
Horn length	-.070637	-.086369	-.077037	0.202224	0.326903	-.014805
Uniform coat pattern	-.190763	0.082886	-.167656	-.022382	0.308044	-.291903
Pied coat pattern	-.188020	0.109076	-.023846	-.101900	-.291639	0.325482
Spotty coat pattern	0.127940	-.269907	0.164291	0.002865	-.027046	0.060465
Shaded coat pattern	0.291009	-.038861	0.149893	0.085920	-.212362	0.155344
Small dewlap	-.233385	-.213915	-.221263	0.061784	0.143943	0.008735
Medium dewlap	0.074655	0.302907	0.212293	0.150727	-.131950	0.052840
Large dewlap	0.262232	-.086197	0.052616	-.320256	-.043127	-.110861
Small hump	-.324381	-.148815	0.036140	-.007447	-.093332	0.064798
Medium hump	0.207460	0.229681	-.128182	0.075206	0.120757	-.115598
Large hump	0.331909	-.019938	0.097661	-.082541	0.016945	0.028278
Flat face	-.097094	-.051184	0.006830	0.438417	-.031910	0.232313
Concave face	0.097101	0.051617	-.006514	-.438689	0.031805	-.232088
Upright ear orientation	0.046211	0.178883	-.288201	0.150035	0.240315	0.086016
Lateral ear orientation	-.133762	-.128430	0.181792	0.054735	-.294578	-.277300
Dropping ear orientation	0.144488	-.053961	0.126508	-.301136	0.119734	0.313552
Straight horn	0.036060	-.228329	0.062729	0.088341	0.059759	0.280414
Curved horn	-.165155	0.159967	0.108183	-.008600	-.088459	-.371477
Lyre-shaped horn	0.206586	0.072129	-.256716	-.111227	0.053649	0.183690
Forward horn orientation	-.163273	0.165679	0.321220	0.021272	-.055961	0.166665
Lateral horn orientation	0.203767	-.059334	-.327327	0.125121	-.139925	-.149356
Dropping horn orientation	-.164842	-.091614	-.101312	-.170976	0.247922	0.277799
Short tail length	0.109942	0.246692	-.285809	-.070709	-.059216	0.175922
Medium tail length	-.221606	0.292995	0.125248	-.053930	0.014693	-.000605
Long tail length	0.174893	-.352123	-.029574	0.072504	0.004712	-.053394
Small udder size	-.094767	-.016005	-.197412	-.223911	0.242511	0.00000
Medium udder size	0.094271	-.051645	0.136348	0.199248	-.313050	0.00000
Large udder size	0.046733	0.174602	0.245469	0.168378	0.057590	0.00000
Small teat size	-.204751	-.167029	-.106578	-.082631	-.127187	0.00000
Medium teat size	0.262479	0.049282	0.125893	0.072836	-.013113	0.00000
Large teat size	-.050571	0.238878	-.008084	0.036115	0.269404	0.00000
Small naval flap	0.252346	-.138603	-.016309	0.031386	0.083320	0.00000
Medium naval flap	-.271069	0.078845	0.065374	-.024944	-.070575	0.00000
Large naval flap	-.111043	0.266341	-.014803	-.106965	0.092870	0.00000
Small testis	-.086581	-.241849	-.170236	0.161937	0.009513	0.00000
Medium testis	-.056585	0.068909	-.125448	-.406698	0.143945	0.00000
Large testis	0.113383	0.195086	0.230744	0.060755	-.085199	0.00000
Small perpetual sheath	0.080235	0.083939	0.183093	0.306432	0.221849	0.00000
Medium perpetual sheath	0.115932	-.213670	-.151666	-.219486	0.058729	0.00000
Large perpetual sheath	-.207626	0.151352	-.014304	-.061581	-.284704	0.00000

4.14. Tree Diagram

The PCA was followed by a method of clustering known as Single-linkage Agglomerative Hierarchical and Non-overlapping (SAHN) that calculates average dissimilarities between the phenotypic observations using the method of 'Mahalanobis distance'. The 'strong linkage' approach was then used to aggregate individual animal into clusters. This was done by using a dendrogram or 'tree' diagram.

The TREE procedure produces a tree diagram, also known as a dendrogram or phenogram, from a data set created by the CLUSTER procedure that contains the results of hierarchical clustering as a tree structure. The TREE procedure uses the data set to produce a diagram of the tree structure in the style of Johnson (1967), with the root at the top. Alternatively, the diagram can be oriented horizontally, with the root at the left.

Figure 8 shows the hierarchical tree and it had three major branches with very wide relative differences. The first two sites from Gera (Gera-Naso and Genji-Chala) came out in one group or cluster. It will appear later that this group represents one of the cattle types identified (Gera). Their differences from all the rest were mainly due to horn orientation (84% had forward horn orientation), uniform coat color pattern (62%), large naval flap (27%), long and curved horn shape, medium tail length (56.82%) and lateral ear orientation (59.53%). Cattle with long tail (93%) from Sigimo (Alia and Seriti sites) segregated into one of the branches (cluster 2). This group differed from the remaining sites in short horn and ear and small naval flap (29%). This group is what later will come out as another cattle type (Sigimo). The remaining 2 sites (Waro-Kolobo and Ofolle-Dawe) from Dedo proved more similar to each other in those variables than they were to either of the two branches and it will represent the third cattle type (Dedo).

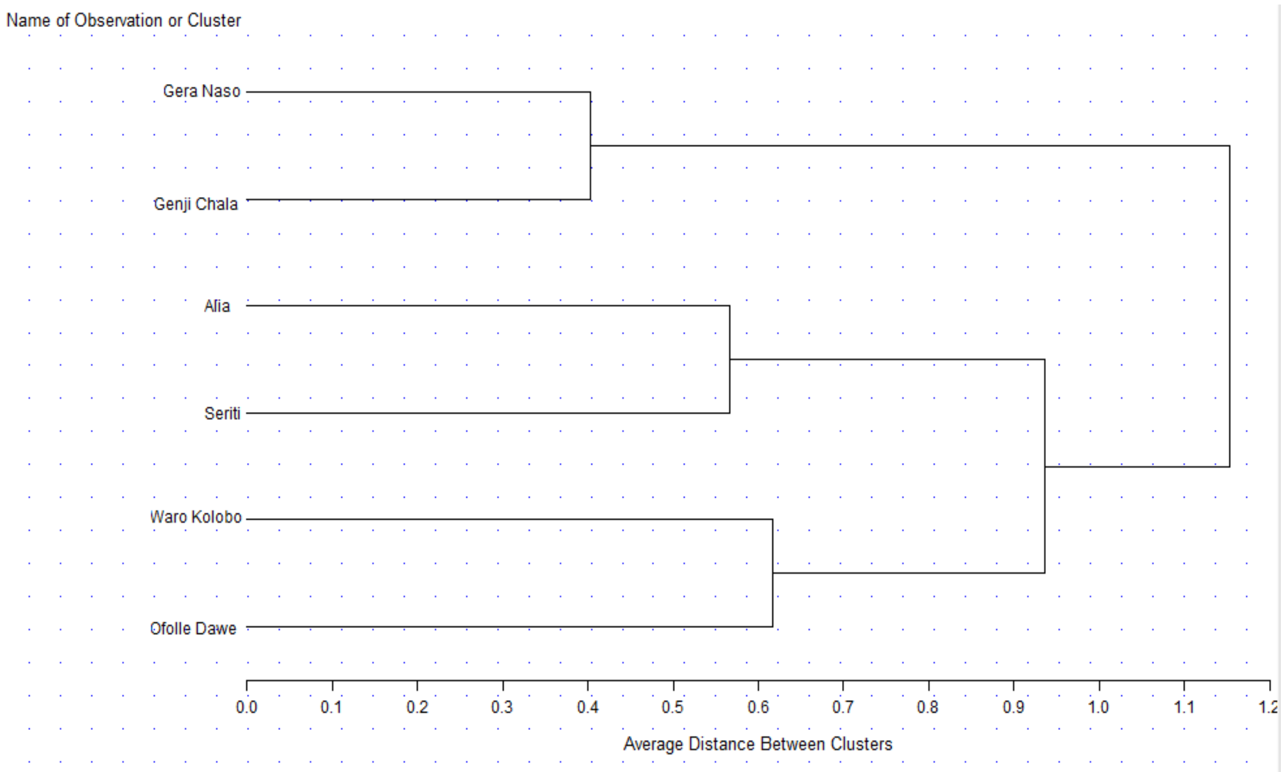

Fig 8: *Dendrogram for the sample cattle population by site*

4.15. Description of Cattle Types

4.15.1. Cluster 1: The Gera Cattle Type

This cluster consists of the cattle populations from Gera-Naso and Genji-Chala sites. The main production functions of these cattle are traction, milk production and meat. The coat color pattern varies between any of the four types with 62.98% uniform, 16.75% shaded, 12.2% spotty and 8.03% pied. The head profile is either straight (51.08%) or concave (48.92%) (Table 24).

The Gera cattle type is dominated by cattle with medium hump size (53.07%). Cattle with large hump size accounted for (23.75%) of the population and the rest (23.18%) had small hump. The size of the dewlap was large in 26.8%, medium in 50.02% and small in 23.15% of the cattle population.

More than fifty percent of cattle had a characteristic of medium tail length (56.82%) with tail just at the hocks. In some cases, the tail hangs above the hocks (11.1%) and it may reach below the hock knee of hind legs (32.08% of the population). The predominant ear form or orientation observed in about 59.53% of the sample population was semi-pendulous (lateral). Only 16.42% of cattle had dropping ear, while 24.05% of them carry upright ears (Table 24).

It was observed that 38.6% of adult female cattle had small udder size, 52.4% of the sampled female cattle had medium udder size, while 9% of females had large udder size. From male cattle, about 51.65% had small testis size, 38.2% medium testis size and 10.15% had large testis size.

Results for the least square means ± SE of linear body measurements revealed that the male cattle populations sampled from Gera had the highest value for horn length measurements (20.28±0.90 cm) and had intermediate values between Sigimo and Dedo cattle types for heart girth (153.51±0.71) cm, body length (112.76±0.27) cm, height at wither (109.99±0.40) cm, ear length (17.06±0.19) cm and pelvic width (31.75±0.15) cm (Table 25).

However, female population sampled from Gera had larger values for height at wither (105.62±0.76) cm and horn length (19.47±0.55) cm but intermediate values for ear length (16.36±0.27) cm and pelvic width (31.54±0.22) and lowest value for heart girth (145.18±1.52) cm and body length (107.32±0.70) cm than Sigimo and Dedo female cattle population (Table 27).

The Gera cattle type has an average daily milk production per cow (1.60±0.05) liter between the Sigimo and Dedo cattle types. However, they have the longest lactation length (8.43±0.18) months with a value ranging from 6 to 13 months and the highest calving interval (14.43±0.35) (range 8 to 24) months (Table 21).

Female Gera calves reach sexual maturity at earlier age than their counter parts in Sigimo, but not Dedo. However, the average age at sexual maturity in Gera male calves was the highest as compared to Sigimo and Dedo male calves. The average reported age at first calving was (42.40±0.65 months) in the female cattle population (Range 30 to 54) was the highest (Table 21).

Fig 9: *Picture of cattle in Gera woreda, belonging to cluster 1*

4.15.2. Cluster 2: The Sigimo Cattle Type

This cluster consists of the cattle populations from Alia and Seriti sites. The main production functions of these cattle are traction, milk production and meat. Male cattle are the shortest in height at wither (105.99±0.84) cm, body length (110.96±0.56) cm and horn length (17.58±0.43) of the cattle types in the study area. They also had the smallest measurements for chest girth (143.36±1.47) cm, pelvic width (30.51±0.31) cm and ear length (16.35±0.43) cm (Table 25).

Mature females of Sigimo cattle type are the longest in body length (110.58±0.59), but medium in heart girth (147.72±0.89) cm and height at wither (105.30±0.64) cm. They had the lowest measurements for pelvic width (30.73±0.19) cm, ear length (15.44±0.39) cm and horn length (14.65±0.94) cm (Table 27).

Facial profile varied between straight (55%) and concave (45%). The ear takes the form of semi-pendulous (95.13%) and dropping (4.88%). The dominant coat color patterns were uniform (78.2%), spotty (12.75%), pied (7.23%) and shaded (1.83%) (Table 24).

The Sigimo cattle type is dominated by small dewlap size (66.65%) with (12.28%) possessing large and (21.73%) having medium dewlap. Although short and medium tail length are also seen at low frequencies (altogether 6.55%), the dominant tail is mainly long (93.45%). The udder size is small in 46.4% of the female cattle population, medium in 40.97% and large in 12.63%. About half of the males have medium testis size (Table 24).

Sigimo females have the highest age at sexual maturity. But they are the lowest in daily milk production (1.57±0.04 liters). The lactation length (8.34±0.15 months), age at first calving (42.02±0.53 months) and calving interval (13.84±0.29 months) of a cow are smaller than Gera, but higher than Dedo cattle type (Table 21).

Fig 10: *Picture of cattle in Sigimo Woreda, belonging to cluster 2*

4.15.3. Cluster 3: The Dedo Cattle Type

This cluster consists of the cattle populations from Waro-Kolobo and Ofolle-Dawe sites. The main production functions of these cattle are traction, milk production and meat. The male cattle populations have big body frame with the longest ear length (18.41±0.40) cm but intermediate horn length (18.49±0.97) cm between Gera and Sigimo cattle types. They had also the highest measurements for heart girth (153.88±1.59) cm, body length (113.40±0.60) cm, height at wither (115.11±0.90) cm and pelvic width (33.32±0.34) cm (Table 25).

The female Dedo cattle population on the other hand had the lowest value for height at wither (105.27±1.09) cm, but the highest value for heart girth (149.18±1.05) cm, ear length (17.78±0.23) cm and pelvic width (31.56±0.32) cm. They had intermediate values for body length (107.63±1.00) cm and horn length (16.91±0.65) cm (Table 27).

More than half (64.4%) of the population have uniform coat color pattern, 12.4% being shaded, 11.75% are pied and 11.45% are spotty. The head profile is mainly straight (68%). Concave forms occur in (32%) of the cattle population. Both sexes have Semi-pendulous ears. More than three-fourth of the cattle populations have small dewlap (89%) and only 11% have medium dewlap size. The Dedo cattle type are also characterized by small hump size (56.5%). Only 5.4% of the population had large hump. The rest of the cattle population had medium hump size (38.1%) (Table 24).

The Dedo cattle type is dominated by medium tail length (61.38%). Cattle with long tail accounted for (37.03%) and a very small proportion (1.55%) had short tail. It was observed that 56.6% of the female cattle population had small udder, 30.2% of them having medium udder, while 13.2% of females had large udder size. A higher proportion of males (64.9%) had large testis size (Table 24). Several authors have established that males with larger testicles have either a greater sperm production or a higher daily sperm output than those with smaller testicles, and that testicular size is a good indicator of bull fertility (Brad and Michael, 2007). Venter *et al*. (1984) proposed that minimum scrotal circumference standards at certain ages should be known for individual breeds.

Dedo cattle type has the highest daily milk production (1.92±0.09 liters), but the shortest lactation length (7.31±0.31 months) and calving interval (12.87±0.59 months). Both males and females reach sexual maturity at earlier age than the Gera and Sigimo cattle types. The age at first calving is smaller than the other two cattle types (Table 21).

Fig 11: *Picture of cattle in Dedo Woreda, belonging to cluster 3*

4.16. Variability of Morphological Characters within Cluster

Gera cattle type had shown more variability in horn shape, dewlap size and hump size among other morphological characters with unalikeability coefficient of 0.63, 0.62 and 0.61, respectively. Similar to Gera, Sigimo cattle type showed more variability on naval flap size with unalikeability of 0.79 followed by udder size and teat size with unalikeability of 0.77 and 0.76, respectively. Dedo cattle type on the other hand showed more variability in teat size, naval flap size and testis size with unalikeability of 0.89, 0.85 and 0.62, respectively (Table 32). When the variability of the three districts were compared, more uniformity were observed for Dedo cattle breed suggesting the Dedo breed is close to bred true, means that able to produce offspring with that of the same phenotype. Whereas, Gera cattle were far from bred true and have higher heterogeneity.

Table 32: *Unlikeability of qualitative traits in the three* districts

Variable	Unalikeability in districts		
	Gera	Sigimo	Dedo
Coat color pattern	0.55	0.37	0.55
Dewlap size	0.62	0.49	0.20
Hump size	0.61	0.41	0.53
Face profile	0.50	0.50	0.44
Ear orientation	0.56	0.095	0
Horn shape	0.63	0.59	0.50
Horn orientation	0.53	0.61	0.55
Tail length	0.56	0.49	0.13
Udder size	0.57	0.77	0.36
Teat size	0.53	0.76	0.89
Naval flap	0.41	0.79	0.85
Testis size	0.58	0.34	0.62
Perpetual sheath	0.60	0.38	0.44

5. SUMMARY AND CONCLUSIONS

5.1. Summary

Description and understanding of the production system and characterization of the existing genetic resources are pre-requisites for designing sustainable breeding strategies and management of animal genetic resources. This study was conducted in Gera, Dedo and Sigimo to characterize the cattle types and the production system and aimed at recommending a community-based cattle breeding strategy. The study was conducted by implementing single visit questionnaire, observing and recording of cattle qualitative characters and by measuring quantitative linear body measurements. Thirteen qualitative and six quantitative variables on dimension and appearance of different parts of the body that is included in the standard breed descriptor list (FAO, 1986b) for the cattle were considered in the survey. The survey methodology was initially pretested at one site (Jetu PA) in Dedo area. A total of 180 sample cattle owners were formally interviewed about the traditional cattle management practices. A total of 253 male and 287 female cattle were considered in the present study.

Data on husbandry practices were analyzed by simple descriptive statistics. The variation in quantitative characteristics was analyzed using the General Linear Model procedure of SAS. Multivariate cluster analysis was employed to identify homogenous cattle populations that may represent distinct cattle types.

Cattle production in Gera, Sigimo and Dedo districts was characterized by low input subsistence and multiple production objectives in the environment. In the study area mixed crop-livestock production system was practiced. The mean numbers of cattle in Gera, Sigimo and Dedo, per household, were 7.47 ± 5.16, 10.13 ± 4.09 and 5.92 ± 1.81, respectively. Most farmers in all of the study districts keep male cattle primarily for work/traction and female cattle for milk production. Mating was predominantly uncontrolled. About 40%, 18% and 49% of the respondents kept their own breeding males in Gera, Sigimo and Dedo, respectively. Draught performance, size and color in favor of red and brown were rated as the most important traits in selecting breeding males and milk yield, size and color were rated as the most important traits in selecting breeding females. The different feed resources reported in the study area were natural pasture, crop residues, tethering and non-conventional feeds.

Average reported milk production per cow per day for all the three cattle types was 1.63±0.06 liters, while the average reported lactation length was 8.29±0.15. The age at sexual maturity 37.46 ± 0.44 and 36.16 ± 0.34 months for females and males, respectively was also reported for the entire cattle types. The average age at first calving was reported as 42.49 ± 0.66 months, whereas the average calving interval was 13.49 ± 0.33 months. There was significant ($p<0.01$) difference among the three cattle types in milk production, lactation length and age at sexual maturity in the female cattle.

For male cattle, high significant difference ($p<0.01$) was observed between districts on heart girth, body length, height at wither, ear length and pelvic width, while a significant difference ($p<0.05$) was noted between the three districts on horn length. For female cattle, high significance ($p<0.01$) difference was noted between districts on body length, ear length, pelvic width and horn length, while non-significant ($p>0.05$) difference was noted between districts on heart girth and height at wither. The respective R^2 values ranged from 6.48 for horn length to 78.41 for body length in male cattle and 3.80 for heart girth to 17.75 for ear length in female cattle and coefficient of variation (CV %) ranged from 3.04 for body length to 30.04 for horn length in male cattle and from 5.82 for body length to 32.66 for horn length in female cattle.

The quantitative traits recorded from linear surface body measurements of the cluster 1 (Gera cattle type) female cattle population averaged 145.18 ± 1.52 cm, 107.32 ± 0.70 cm, 105.62 ± 0.76 cm, 16.36 ± 0.27 cm, 31.54 ± 0.22 cm and 19.47 ± 0.55 cm for heart girth, body length, height at wither, ear length, pelvic width and horn length, respectively. The corresponding values for cluster 2 (Sigimo cattle type) female cattle were 147.72 ± 0.89 cm, 110.58 ± 0.59 cm, 105.30 ± 0.64 cm, 15.44±0.39 cm, 30.73 ± 0.19 cm and 14.65±0.94 cm, respectively. Cluster 3 (Dedo cattle type) female cattle on the other hand had 149.18 ± 1.05 cm heart girth, 107.63 ± 1.00 cm body length, 105.27 ± 1.09 cm height at wither, 17.78±0.23 cm ear length, 31.56 ± 0.32 pelvic width and 16.91±0.65 cm horn length.

The least squares means of heart girth, body length, height at wither, ear length, pelvic width and horn length in male cattle of cluster 1 were 153.51 ± 0.71 cm, 112.76 ± 0.27cm, 109.99 ± 0.40cm, 17.06 ± 0.19 cm, 31.75 ± 0.15 cm and 20.28±0.90 cm, respectively. The corresponding values for male cattle in the cluster 2 were 143.36 ± 1.47 cm, 110.96 ± 0.56, 105.99 ±0.84 cm, 16.35±0.43 cm, 30.51 ± 0.31 and 17.58±0.43 cm for heart girth, body length, height at wither, ear length, pelvic width and horn length, respectively. Cluster 3 male cattle on the other hand had 153.88 ± 1.59 cm heart girth, 113.40 ± 0.60 cm body length, 115.11 ± 0.90 cm height at wither, 18.41±0.40 cm ear length, 33.32± 0.34 cm pelvic width and 18.49 ± 0.97 cm horn length.

5.2. Conclusions

- In the light of findings of this survey, it can be concluded that the level of management of animal husbandry is diverse. Owners always have reasons for adopting one way of management rather than another. They do make decisions not only from the point of view of profitability, but also security, generation of critical cash as well as traditional and/or cultural values. They build their experience from their traditional experimentation.

- The present study confirmed the existence of three cattle types in the study area: the Gera cattle type, the Sigimo cattle type and the Dedo cattle type. Results of both quantitative and qualitative analysis clearly showed population level differentiation in to distinct cattle types. The differentiation among cattle types might be attributed to altitude stratifications and associated differences in terms of vegetation cover, management variability and disease prevalence differences.

- Cattle owners of the study area practiced selection for breeding male and female cattle. Draft performance, milk yield, body size and color are given due emphasis in selecting breeding animals.

- ❖ For setting up sustainable community-based breeding strategies, the present survey revealed several pertinent constraints which should be well addressed. These include: generally herd sizes are small (therefore, the scope of selection and the potential of opening up the nucleus for replacement within farms is limited), uncontrolled mating is predominant, absence of structured breeding seasons and rarely animals are separated by sex. Here utilization of indigenous institution such as herding groups available in the study area is very important and such type of indigenous cooperative is very crucial for sustainability of breeding program.

- ❖ The householder (husband) is the least involved in the management of cattle. Cattle are reared, tended and milked usually by children and the housewife. Group herding was reported in the study area. This may contribute to genetic diffusion and gradual inbreeding.

- ❖ The present study revealed that linear body measurements like heart girth, body length, height at wither, ear length, pelvic width and horn length were influenced by population and age. An increase in heart girth, body length, height at withers, ear length, pelvic width and horn length with age tends to demonstrate that cattle types in the three districts are late maturing.

5.3. Recommendations

This piece of work is just a start in characterizing Jimma cattle and their natural breeding tract. Thus, the following sets of recommendations were forwarded in response to the general growing concern on the status and performance of Jimma cattle types:

- ❖ Once the cattle types are identified breed characterization and improvement programs need to be designed and initiated at least for selected cattle types. Integrated on-farm and on-station investigations need to be carried out on basic and applied aspects of cattle husbandry. Draught power, milk yield, reproductive capacity and growth performance are important economic traits to assess the capacity of animals to adapt to specific environmental circumstances.

- ❖ Breeding strategies targeted at genetic improvement of Gera, Sigimo and Dedo cattle types need to incorporate the multi-functional roles that cattle play in these systems and focus on those functional traits identified as important by the owners of the animals themselves.

- ❖ The exploratory breed identification methodology developed and tested in this study is proposed for general reference to identify cattle types from the traditional populations of cattle.

- ❖ Cattle keepers in the study area could identify the main traits related to every function of the animal and they also identify targeted trait expressions. They have their own way of assessing expression of traits but they basically assess trait expressions mostly based on visual observations. Therefore, if training of farmers about the importance of identifying the traits is given, it will be important for animal selection and breeding and might also be used for the start of community based breeding program. In addition to this, the on-farm assessments made on the reproductive and productive performance need to be strengthened by further on-farm and/or on-station evaluations.

- ❖ The practice of tethering in the livestock feeding system will create a venue to introduce cut and carry feeding system to use the grazing land effectively and play a role in land resource management.

- ❖ Keeping small number of better performing cattle than keeping large number of unproductive one's is also forwarded as a solution in areas where there is shortage of land due to an increase human population.

- Since performance data for village animals are rarely available in most developing countries, screening is also a useful method for quickly obtaining performance data for the population. Therefore, to perform screening of animals for open nucleus herd formation cost and time efficient methods of field data collection like the present one is very important. The detail of data collection using the appropriate recording methods will be established later on after training the farmers and establishment of the nucleus herds.

- The genetic characterization is recommended to support the phenotypic characterization.

- More data on non-covered areas of the zone should be collected for further analysis

6. BIBILOGRAPHY

Ababu Dekeba, 2002. Evaluation of performance of Boran cows in the production of crossbred dairy heifers at Abernosa ranch, Ethiopia. M Sc Thesis. School of Graduate Studies, Alemaya University.

Abebe Lega, 2009. Characterization of selected cattle breeds in Gambella, South West Ethiopia. M Sc Thesis. School of Graduate Studies, Alemaya University of Agriculture.

Abule E. 1998. Role and decision making power of women in livestock production around Adami Tulu. ESAP (Ethiopian Society of Animal Production). Proceedings of 6th annual conference of the ESAP held in Addis Ababa, Ethiopia, August 14-15 May 1998. pp 95-102.

Adams, M., B. Kaufmann and A. Valle Z´arate, 2002. Indigenous characterisation of local camel populations and breeding methods of pastoralists in Northern Kenya. pp.122-128. Deutscher Tropentag, Kassel-Witzenhausen, Germany, 9–11 October 2002.

Addisu Tiruneh, Teklu Tesfaye, Wilfred Mwangi and Hugo Verkuiji. 1998. *Gender differentials in smallholder livestock production in the central highlands of Ethiopia.* ESAP (Ethiopian Society of Animal Production). Proceedings of 6th Annual Conference of the ESAP held in Addis Ababa, Ethiopia, August 14-15 May 1998. pp19-27.

Adekunle, O.A., O. I. Oladele and T. D. Olukaiyeja, 2002. Indigenous control methods for pests and diseases of cattle in Northern Nigeria. Livestock Research for Rural Development 14(2): 66–75.

Alberro, M. and Solomon Haile-Mariam, 1982a. The indigenous cattle of Ethiopia. Part I. *World Animal Review* (41).

Alberro, M. and Solomon Haile-Mariam, 1982b. The indigenous cattle of Ethiopia. Part II. *World Animal Review* (41).

Alganesh Tola, Mathewos Belissa and Gizaw Kebede, 2003. Survey on traditional livestock production systems in Manasibu district of West Wallaga, Ethiopia. pp 141-150. Proceedings of the 11th annual conference of the Ethiopian Society of Animal Production (ESAP) August 28-30, 2003. Addis Ababa, Ethiopia.

Arias A A, Revidatti M A, Capellari A and Slobodzian A 1996 Técnicas para la intensificación de la ganadería de cría. Manejo del destete precoz. Actas de Ciencia y Técnica UNNE 2: 427-430

Armstrong, J.B., 2006. Inbreeding: Why we will not do it? Accessed on February 05, 2010 from http://www.parispoodles.com/Inbreeding.html.

Arthur G H Noakes D E and Person H 1989 Veterinary Reproduction and Obstetrics.6th edition Bailliere-Tindall. London, UK. 344-442.

Ashwell, M. S., Heyen, D. W., Sonstegard, T. S., Van Tassell, C. P., Da, Y., VanRaden, P. M., Ron, M. J., Weller, I. & Lewin, H. A., 2004. Detection of quantitative trait loci affecting milk production, health, and reproductive traits in Holstein cattle. *J Dairy Sci*., 87: 468–475.

Asimwe L. and C Kifaro G.C., 2007. Effect of breed, season, year and parity on reproductive performance of dairy cattle under smallholder production system in Bukoba district, Tanzania.

Azage Tegegne and T.W.jr. Crawford, 2000. Draft animal power use in Ethiopia. Center for Tropical Veterinary Medicine, University of Edinburgh, Scotland. Draught animal news 33: 24-26.

Baker, R. L. and G. D.Gray, 2003. Appropriate breeds and breeding schemes for sheep and goats in the tropics: the importance of characterizing disease resistance and adaptation to tropical stresses. In: R. Sanibadoo.com, G. D. Gray, R. L. Baker (eds). Better Worm Control for Small Ruminants in Tropical Asia, Australian Centre for International Agricultural Research (ACIAR), Monograph, No. xx.

Bebe, B.O., H. M. J. Udo, G. J. Rowlands and W. Thorpe, 2003. Smallholder dairy systems in the Kenya highlands: breed preferences and breeding practices. Livestock Production Science, 82: 117–127.

Belete Shenkute, 2009. Production and marketing systems of small ruminants in Goma district of Jimma zone, western Ethiopia. M Sc Thesis. School of Graduate Studies, Hawasa University of Agriculture.

Beyene Kebede and Bruke Yemane, 1992. Animal genetic resource and breed Characterization works in Ethiopia. In: Rege, J.E.O.AND Lipner, M.E.eds.African animal genetic resources: Their characterization, conservation, and utilization. Proc of the research planning workshop held at ILCA, Addis Ababa Ethiopia. 19-21 February 1992.ILCA 9Internat5ional Livestock Center for Africa), Addis Ababa Ethiopia. Pp 77-82.

Bishop M.D. and Kappes S.M. et al. (1994). A genetic linkage map for cattle. Genetics 136 619-639.

Blackmore, D.W., McGulliard, L.D. & Lush, J.L., 1958. Genetic relationship between body measurements at three ages in Holstein. J. Dairy Sci. 41, 1045-1049

Brad R. Lea Master and Michael W. DuPonte, 2007. Bull Power: Examination of Beef Cattle Bulls for Breeding Soundness. Department of Human Nutrition, Food and Animal Sciences

Bradley, D.G., D.E. MacHugh, P. Cunningham, and R.T. Loftus, 1996. Mitochondrial diversity and the origins of African and European cattle. Evolution / anthropology. In: Proceedings of the National Academy of Sciences of the United States of America (PNAS) May 14, 1996. Science Vol. 93, Issue 10: 5131-5135.

Brown, J.E., Brown, C.J. & Butts, W.T., 1973. Evaluating relationships among immature measures of size, shape and performance on beef bulls 1; principal component as measures of size and shape in young Hereford and Angus bulls. J. Anim. Sci. 36, 1010-1020.

CACC (Central Agricultural Census Commission). 2008. Ethiopian Agricultural Sample Enumeration, 2007/08. Results at country level. Statistical report on socio-economic characteristics of the population in agricultural household, land use, and area and production of crops. Part I. (December 2008) Addis Ababa, Ethiopia.

CSA (Central Statistics Authority), 2005. The 2001/02 Ethiopian Agriculture Enumeration (EASE), Executive Summery, May 2004, Addis Ababa, Ethiopia.

CSA (Central Statistics Authority), 2008. Agricultural sample survey 2008/09 [2001 e.c.] volume ii report on livestock and livestock characteristics (private peasant holdings) Addis Ababa, Ethiopia. February 2008.

CSA, 2009. (Central Statistics Authority). Agricultural sample survey 2008/09: Report on livestock, poultry and beehives population (private peasant holdings). Volume II Statistical bulletin 132. CSA, Addis Ababa, Ethiopia. 188 p.

Chatfield, C. & Collin, A.J. \Introduction to Multivariate Analysis". Published in the USA by Chapman and Hall in Association with Methuen, Inc. 733 Third Avenue, New York NY. 10017, ISBN 0-412-16030-7. 1980.

Coffey, M. P., Emmans, G. C. and Brotherstone, S. 2001. Genetic evaluation of dairy bulls for energy balance traits using random regression. *Animal Science* 73: 29-40.

Cunningham, E. P., 1992. Animal genetic resources: The perspective for developing countries. pp. 7-10. In: J. E. O. Rege and M. E. Lipner (eds.). African animal genetic resources: Their characterization, conservation, and utilization. Proc. of the research planning Workshop held at ILCA. Addis Ababa, Ethiopia, 19-21 February 1992, ILCA (International livestock Centre for Africa), Addis Ababa, Ethiopia .

DAD-IS, 2000. (Domestic Animals Diversity Information System). FAO (Food and Agriculture Organization of the United Nations). http://dad.fao.org/en/home.htm. Accessed on 5 August 2010.

DAGRIS 2006. Domestic Animals Genetic Resources Information System (DAGRIS). (eds. J.E.O.Rege, W.Ayalew, E.Getahun, O.Hannote and T.Dessie). International Livestock Research Institute, Addis Ababa, Ethiopia http://dagrisilri.cgiar.org. Accessed on 14 August 2009.

DAGRIS 2007. Domestic Animal Genetic Resources Information System (DAGRIS). (e*ds. J.E.O. Rege, O. Hanotte, Y. Mamo, B. Asrat and T. Dessie*). International Livestock Research Institute, Addis Ababa, Ethiopia. http://dagris

Daniel Tewodros, 2008. Beef cattle production system and opportunities for market orientation in borena zone, southern Ethiopia. M Sc Thesis. School of Graduate Studies, Alemaya University of Agriculture.

Dechassa Lemessa 2000. Field Assessment Report: Jimma Zone of Oromia Region, UN-Emergencies Unit for Ethiopia.

Dereje Tadesse, 2005. On-Farm Phenotypic Characterization of Cattle Genetic Resources in South and North Wollo Zones of Amhara Region, North Eastern Ethiopia.

De Leeuw P.N. and R. T. Wilson, 1987. Comparative productivity of indigenous cattle under traditional management in sub-Saharan Africa. Quarterly Journal of International Agriculture 2:377–390.

Deza, C., G. T. Perez, C. N. Gardenal, L. Varela, M. Villar, S. Rubiales, C. Barioglio, 2000. discriminatory power of indigenous and laboratory assessments of the nutritive value of tree fodder. Agricultural Systems, **62**(2): 87–103.

Doran, M.H., A.R.C.Low and R.L.Kemp, 1979. Cattle as a store of wealth in Swaziland: Implications for livestock development and overgrazing in eastern and southern Africa. American Journal of Agricultural Economics 61: 41–47.

Drucker, A.G., J.P.Gibson, 2003. A legal framework for Animal Genetic Resources (AnGR)? Issues for consideration. 10pp. In: Proceedings of a Workshop on Farm AnGR Legal and Regulatory Framework. Maputo, Mozambique, 19-23 May 2003.

Dunn, T. G., J. E. Ingalls, D. R. Zimmerman, and J. N. Wiltbank. 1969. Reproductive performance of 2 year-old Hereford and Angus heifers as influenced by pre- and post-calving energy intake. J. Anim. Sci. 29:719.

Ellen Christina, 2001. Sheep husbandry and Ethnoveterinary knowledge of Raika sheep pastoralists in Rajasthan, India. Thesis submitted for partial fulfillment of the MSc degree in environmental Sciences. Wageningen University, the Netherlands. 86p.

Enyew Negussie, 1992. Reproductive performance of local and crossbred dairy cattle at the Asella livestock farm. n M Sc Thesis. School of Graduate Studies, Alemaya University of Agriculture. 140p.

Enyew N, Bränänag E and Rottmann O J 1999 Reproductive performance and herd life of crossbred dairy cattle with different levels European inheritance in Ethiopia. Proceedings of the 7th annual conference of Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia. 65-76.

Epstein H. 1957. The Sanga cattle of East Africa. *East African Agricultural Journal* 22: 149-164.

Essien, A. & Adesope, O.M., 2003.Linear body measurements of N'dama calves at 12 months in a South Western zone of Nigeria. Livest. Res. Rural Devel. (15) 4. http://www.cipav.org.co

Falconer, D.S. and T.F.C. Mackay, 1996. Introduction to Quantitative Genetics. 4th ed. Harlow, England, Longman. 438P.

Fall, A., 2000. Peul, Touabire and Djallonké sheep breeding programmes in Senegal. pp. 331-338. In: Galal, S., Boyazoglu, J., Hammond, K. (eds.).Workshop on Developing Breeding Strategies for Lower Input Animal Production Environments. Bella, Italy, 22-25 September 1999, ICAR Technical Series 3.

FAO, 1984 (Food and Agriculture Organization of the United Nations) ftp://ftp.fao.org/docrep/fao/010/a1250e/a1250e16.pdf

FAO, 1986b, (Food and Agriculture Organization of the United Nations) Animal Genetic Resources Data Banks.2.Descriptors list for Cattle, Buffalo, Sheep, Goats, and Pigs. Animal Production and Health Paper 59/2.fao.Rome,Italy.pp.96-129

FAO, 1992; FAO/ UNEP, 1998 ftp://ftp.fao.org/docrep/fao/010/a1250e/a1250e16.pdf

FAO, 2000. (Food and Agriculture Organization of the United Nations). World Watch List for Domestic Animal Diversity. D.S. Beate 3 rd ed. FAO, Rome, Italy. 726p

FAO, 2003. Smallholders and community-based management of farm animal genetic resources. In Community-based management of animal genetic resources. Proceedings of the workshop held in Mbabane, Swaziland, 7-11 May 2001, pp. 1-12. SADC/UNDP/FAO and GTZ.

FAO, 2004. (Food and Agriculture Organization of the United Nations). Chapter 5: Beyond production systems. (www.fao.org/docrep/x5303e/x5303e0e.htm. accessed on 20 August 2010).

FAO, 2007. The state of the world's animal genetic resources for food and agriculture. FAO, Rome.

FAO, 2009. (Food and Agriculture Organization of the United Nations). Commission on genetic resource for food and agricultural organization.Sixth session Rome 24-26, November 2010. (www.fqo.org/ag/againfo/ accessed on December 18, 2010)

FAO, 2011. (Food and Agriculture Organization of the United Nations). Commission on genetic resources for food and agriculture. Thirteenth regular session rome, 18 – 22 july 2011. Draft guidelines on phenotypic characterization of animal genetic resources.

Fatima, S., 2007. Study of genetic variability within Zalawadi, Gohilwadi and Surti breeds of goat using microsatellite markers. M. V. Sc. Thesis, Anand Agriculture University.

Faulkner D E and Epstein H. 1957. The indigenous cattle of the British dependent territories in Africa with material on certain other countries. *Communication on Agriculture, Animal Health and Forestry* No. 5. HMSO, London, UK.

Flower F C and Weary D M (2001). Effects of early separation on the dairy cow and calf: 2. Separation at 1 day and 2 weeks after birth. Applied Animal Behaviour Science 70: 4, 275-284

Frandson RD, Elmer HW (1981). Anatomy of the male Reproductive system In: Frandson RD (ed). Anatomy and Physiology of farm Animals 3rd edition pp 430-442 Lea and Febiger, Philadephia.

Galina C S, Rubio I, Basurto H and Orihuela A 2001 Consequences of different suckling systems for reproductive activity and productivity of cattle in tropical conditions. Applied Animal Behaviour Science 72: 3, 255-262

Galli I O, Monje A R and Hofer C C 1995 Destete precoz: clave para nuevos sistemas de producción. Boletín del Instituto Nacional de Tecnología Agropecuaria, Concepción del Uruguay, Argentina, p2-33

Georges M., Lathrop M., Bouquet Y et al. (1990). Linkage relationships among 20 genetic markers in cattle. Evidence for linkage between two pairs of blood group systems: B-Z and S-F/V respectively. Animal Genetics 21 95-105.

Georges M., Swillens S., Bouquet Y., Leguarre A.S and Hanset R. (1987). Genetic linkage between the bovine plasma protease inhibitor Z (Pi-Z) and S blood group loci. Animal Genetics 18 311-316.

Girma Balcha, 2004. Keynote address. Farm animal biodiversity in Ethiopia: Status and prospects. Proceedings of the 11th annual conference of the Ethiopian Society of Animal Production (ESAP) August 28-30, 2003. Addis Ababa, Ethiopia.

Grosclaude F., Francois D. and Wimitzky M. (1990). Evidence for absence of linkage between the B and Z as well as between the F and S systems of cattle blood groups. Animal Genetics 21 427-429.

Grum Gebreyesus, 2010 community-based participatory characterization of the short eared Somali goat population around Dire Dawa. M Sc Thesis. School of Graduate Studies, Alemaya University of Agriculture.

Hall, S.J.G. 1992. Conservation of livestock breeds. Pp. 11-16. In: Rege, J.E.O. and Lipner, M.E. (eds). Africa Animal Genetic Resources: Their Characterization, Conservation, and Utilization, Proc. Res. Plan. Workshop held at ILCA, Addis Ababa, Ethiopia, 19-21 Feb 1992, ILCA (International livestock center for Africa).

Hanotte O. Tawah C.L. Bradley D.G. Okomo M. Verjee Y. Ochieng J. and Rege J.E.O. 2002. Geographic distribution and frequency of a taurine Bos taurus and an indicine Bos indicus Y specific allele amongst sub-Saharan African cattle breeds. Molecular Ecology. 9 (4):387-396.

Hegde, B.P., 2005. Cattle breeding strategy to improve milk production in Ethiopia. Alemaya University.

Hines H.C. and Larsen B. (1990). Evidence against linkage between two pairs of bovine blood group loci: B-Z and F-S. Animal Genetics 21 431-432.

Hines H.C., Kiddy C.A., Brum E.W. and Arave C.W. (1969). Linkage among cattle blood group and milk polymorphisms. Genetics 62 401-412.

Houghton P L, Leménager R P, Horstman L A, Hendrix K S and Moss G E 1990 Effects of body composition, pre- and postpartum energy level and early weaning on reproductive performance of beef cows and preweaning calf gain. Journal of Animal Science 68: 5, 1438-1446

IBC (Institute of Biodiversity Conservation), 2004. State of Ethiopia's Animal Genetic Resource Country Report. Contribution to the first report on the state of the World's Animal Genetic Resources. IBC. May 2004.Addis Ababa Ethiopia.

ICRA (International Centre for Development Oriented Research in Agriculture), 1998. A participatory Systems Analysis of the Termite Situation in west Wollega, Oromia Region, Ethiopia. A joint publication by International Centre for Development Oriented Research in Agriculture, Ethiopian agricultural research Organization and Oromia Agricultural Development Bureau. Bako Research Centre. Working Document Series 68, Ethiopia.

IGAD, 2010. (Intergovernmental Authority on Development). The contribution of livestock to the economics of IGAD member states. www.igad-lpi.org. Accessed on December, 2010.

ILCA (International Livestock Centre for Africa). 1990. Livestock systems research manual. Working Paper 1, Vol. 1. ILCA, Addis Ababa, Ethiopia. 287 pp.

ILRI, 1998. (International Livestock Research Institute). ILRI 1997: Livestock people and the environment. ILRI, Nairobi, Kenya.

Jaitner J., J. Soweb, E.Secka-Njieb, and L. Demp, 2001. Ownership pattern and management practices of small ruminants in The Gambia-implications for a breeding programme. *Small Rumin. Res.*. 40:101-108.

Jaitner, J., N. Corr and L. Dempfle, 2003. Ownership pattern and management practices of cattle herds in The Gambia: implications for a breeding programme. Tropical Animal Health and Production, 35: 179–187.

Javed K, M. Abdullah , M. Akhtar and M. Afzal, 2004. Phenotypic and Genetic correlations between first lactation milk yield and some performance traits in Sahiwal cattle.

Jiregna, (2007) Characterization of cattle genetic resources in their production system context in danno district, west showa, oromia, Ethiopia. M Sc Thesis. School of Graduate Studies, Alemaya University of Agriculture.

JZMSR (Jimma Zone Meteorology Station report) 2004 Ten year's climatic data. JZMS. Jimma, Ethiopia.36.pp.

Johnson, S. C. (1967), "Hierarchical Clustering Schemes," Psychometrika, 32, 241–254.

Johansson, I and J Rendel 1968. *Genetics and Animal Breeding*. W H Freeman Co. San Fransisco.

Kader, G.D. and M. Perry, 2007. Variability for categorical variables. *Journal of Statistics Education,* Volume 15 Number 2. Accessed on February 06, 2010 from http://www.amstat.org/publications/jse/v15n2/kader.html

Kadarmideen, H.N., R. Thompson and G. Simm, 2000. Linear and threshold model genetic parameters for disease, fertility and milk production in dairy cattle. British Society of Animal Science. Animal Science 2000, 71: 411-419.

Kahi, A.K., 2000. Genetic and economic aspects of breeding for dairy production in Kenya. Verlag Grauer, Beuren and Stuttgart, Germany. 154 pp.

Kahi, A.K., T.O. Rewe and I.S. Kosgey, 2005. Sustainable community based organizations for the genetic improvement of livestock in developing countries. *Outlook on Agriculture* 34: 261-270.

Kanuya, N.L., Agger, J.F. and Pedersen, K.M., 1997. Assessing the reproductive performance of a Tanzanian dairy herd: the importance of proper record keeping. *Tanzania Veterinary Journal*, **17**, 63–71.

Kanuya N. L., Matiko M.K, Nkya R., Bittegeko S.B.P., Mgasa M.N., Reksen O. and Ropstad E., 2006. Seasonal changes in nutritional status and reproductive performance of Zebu cows kept under a traditional agro-pastoral system in Tanzania.

Kassa, A. and T. Arnason, 1986. Non-genetic factors affecting growth in Boran cattle. *Wld Rev Anim Prod* 22: 45-55.

Kemp, S J 1992. The potential contribution of biotechnology in breed characterization. In: Animal Genetic Resources: their characterization, conservation and utilization. J O E Rege and M E Lipner (eds.). Research planning worshop, ILCA, Addis Ababa, Ethiopia, 19-21 February, 1992. ILCA, Addis Ababa.

Klosterman, E. W., L. G. Sanford, and C. F. Parker. 1968. Effect of cow size and condition and ration protein content upon maintenance requirements of mature beef cows. J. Anim. sci. 27:242.

Knopf, L., Komoin, C., Betschart, B., Gottstein, B. and Zinsstag J., 2000. Productivity parameters of N'dama village cattle in relation to parasitism in the Guinea savannah of Cˆote d'Ivoire, (Unpublished report, Swiss Tropical Institute)

Kohler-Rollefson, I., and C. McCorkle, 2000. Domestic animal diversity, local knowledge and stock raisers' right. pp.25. In: Proceedings of the ASA Conference entitled 'Participating in Development: Approaches to Indigenous Knowledge', 2-5 April, 2000, London.

Koehler-Rollefson, I. and J. Wanyama, 2003. The Karen Commitment. Proceedings of a Conference of Indigenous Livestock Breeding Communities on Animal Genetic Resources. Karen, Kenya, 27–30 October 2003.

Kosgey I.S., 2004. Breeding objectives and breeding strategies for small ruminants in the Tropics. Ph.D. Thesis, Wageningen University, The Netherlands. (ISBW: 90-5808-990-8) Germany.271p.

Kosgey, I S., R.L. Baker and J.A.M. Arendonk, 2006a. Successes and failures of small ruminant breeding programmes in the tropics: a review. *Small Rumin. Res.* 61:13–28.

Larsen B., Christiansen K. And Agerholm J.S. (1992). A possible location of the bovine Z blood group system on chromosome 8. Animal Genetics 23 Supplement 1, 77

Lauvergne, J J 1982. The genetics of Animal Populations after domestication: inferences for breed conservation (in Spanish). 2nd World Congress of Genetics Applied to Livestock Livestock Production, Madrid. (6): 77-87

Laval, G. and Assegid Workalemahu, 2002. Traditional Horro cattle production in Boji district, west Wollega, Ethiopia. Ethiopian Journal of Animal Production 2(2): 97-114.

Leeftanq, P., 1993. Some observations on ethnoveterinary medicine in northern Nigeria. Veterinary Quarterly, 15(2), 72–73.

Lemke, U., L. T. Thuy, B. Kaufmann and A. Valle Z´arate, 2005. Evaluation of smallholder pig production systemsin North Vietnam considering input, management, output and comparing economic and biological efficiency. Book of Abstracts of the 56th Annual Meeting of the European Association for Animal Production (EAAP), Uppsala, Sweden, 5–8 June 2005.

Leveziel H. and Hines H.C. (1984). Linkage in cattle between the major histocompatability complex (BOLA) and the M blood group system. Genetics Selection Evolution 16 405-415.

Lindberg P.G. and Andersson L. (1988). Close association between DNA polymorphism of bovine major histocompatability complex class I genes and serological BoLA-A specificities. Animal Genetics. 19 245-255.

Lobago, F.,M.Bekaha, H.Gustatsson and H. Kindahi, 2006. Reproductive performance of dairy cows in smallholder production system in Selalle, central Ethiopia. Trop. Anim, Health PROD., 38:333-342.

Madibela, O.R., Boitumelo, W.S. and Kiflewahid, B., 2001. Reproductive performance of Tswana and Simmental X Tswana crosses in smallholder farms in Botswana. *Livestock Research for Rural Development*, **13**, 1–12

Mantysaari, E. and L. D. Van Vleck, 1989. Estimation of genetic parameters for production and reproduction in Finish Ayrshire cattle. J. Dairy Sci., 72: 2375-2386.

Mason I L and Maule J P. 1960. The indigenous livestock of eastern and southern Africa. *Commonwealth Bureau of Animal Breeding and Genetics Technical Communication* No. 14. CAB (Commonwealth Agricultural Bureaux), Farnham Royal, UK. 248 pp.

Mekonnen Haile-Mariam and Goshu Mekonnen, 1987. Reproductive performance of Fogera cattle and their Friesian crosses. *Eth J Agric Sci* 9 (2): 95 -114.

Michelmorte, R W, I Parin and R V Kesseli 1991. *Proc. Nat. Acad. Sci. (USA)*. 88: 9828 (cf. Kemp, 1992).

Ministry of agriculture, 1998. MoA, National Livestock Development Project (NLDP) Working Paper 1-4, Addis Ababa. Ethiopia.

Ministry of Agriculture (MoA) 2000. Agro ecological Zonations of Ethiopia. Addis Ababa, Ethiopia.

Morrison, B.J., M. A. Gold and D. O. Lantqne, 1996. Incorporating indigenous knowledge of fodder trees into small-scalesilvopastoral systems in Jamaica. Agroforestry Systems, 34(1): 101–107.

Mosi R.O., A. M. Okeyo, C. O. Ahuya and M. A. Okomo, 1996. Phenotypic characterization of zebu cattle in Kenya. Department of Animal Production, University of Nairobi, Nairobi, Kenya.

Msanga Y N, Bryant M J and Katule A M 1999 Effect of environmental factors and proportions of Holstein blood on days to first insemination and calving interval of crossbred dairy cattle on smallholder farmers in Northeast Tanzania. In: Proceedings of the Tanzania Society of Animal Production 26: 161-175.

Mukasa-Mugerwa, E., 1981. A study of traditional livestock production in Ada District of Ethiopia. Animal Reproduction and Health Unit, ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. 153 pp.

Mulugeta Kebede, Tesfaye Kumsa and Gebregziabher G/Yohannes, 1993. Some productive and reproductive performances of Horro cattle at Bako Research Center. pp. 78-83. In: proceedings of the Fourth National Livestock Improvement Conference. Addis Ababa, Ethiopia, 13-15 February 1988. Institute of Agricultural Research.

Musa, L.M-A., M-K. A. Ahmed, K. J. Peters, B. Zumbach and K. A. E. Gubartalla, 2005. The reproductive and milk performance merit of Butana cattle in Sudan. Archives of Animal Breeding 48: 445-459.

Mwacharo, J.M., C. J. Otieno, A.M. Okeyo and R. A Aman, 2002. Characteristics of indigenousfat-tailed and fat-rumped hair sheep in Kenya: diversity in blood proteins. Tropical Animal Health and Production, 34:515-524.

Mwacharo, J.M. and Drucker, A.G., 2005. Production objectives and management strategies of livestock keepers in south-east Kenya: Implications for a breeding progrmme. *Tropical Animal Health and Production.*37:635-652.

Mwandotto, B.A.J. 1985. Weight, growth and maturing characterstics of Kenya Sahiwal cattle. PhD. Dissertation, Texas A & M University, USA.

Nakhumwa, T.O., Chagunda, M.G.G., Safalaoh, A.C.L. & Mataya, C. 2000. Analysis of market potentials in the northern region of Malawi and preparation of a business plan for the foundation of improvement of animal health (FIAH), Mzuzu. Consultancy Report for GTZ, Lilongwe, Malawi.

Ndamukong, K.J.N., 1995. Haemoglobin polymorphism in grassland dwarf sheep and goat breeds of the North West province of Cameroon. Bulletin of Animal Production of Africa 43: 53-56.

Nicholson, M.J. and M. Butterworth, 1986. A guidance to scoring of zebu cattle. International Livestock Center for Africa (ILCA). Addis Ababa, Ethiopia.

Nicholson M J and Sayers A R. 1986b. Relationships between body weight, condition score and heart girth changes in Boran cattle. *Trop. Anim. Health Prod.*

Obese F Y, Okantah S A, Oddoye E O and Gyawu P 1999 Post-partum reproductive performance of Sanga cattle in smallholder peri-urban dairy herds in the Accra plains of Ghana. Tropical Animal Health and Production 31: 3, 181-90

Okeyo, A.M., and Workneh Ayalew, 2004. Livestock genetic resources: the opportunities for development of the livestock industry in Eastern Africa. pp.24. In: Proceedings of the Animal Production Society of Kenya (APSK) - Makerere University – Regional Animal Production Conference for East Africa. Nairobi, Kenya, 15-17 March 2004.

Oliver J. 1983. Beef cattle in Zimbabwe. *Zimbabwe Journal of Agricultural Research* 21: 1-17.

Olori V E, Monwissen T H and Veerkamp H 2002 Calving interval and survival breeding values as measure of cow fertility in a pasture-based production system with seasonal calving. Journal of Dairy Science 85 (3): 689-696.

Ouda, J.O., Kitilit, J.K., Indetie, D. and Irungu, K.R.G. 2001. The effects of levels of milking on lactation and growth of pre-weaning calves of grazing Boran cattle East African Agricultural and Forestry Journal. 67:73-79.

Ouma, E., Obare, G. and Staal, S., 2002. Cattle as Assets: Assessment of non-Market Benefits of Cattle in Smallholder Crop – Livestock Systems, Contributed paper at the 25th International Conference of Agricultural Economists, August 16 – 22nd 2003, Durban, South Africa.

Ouma, E., U. Janssen-Tapken, A. G. Drucker, J. P. Gibson, G. Obare, W. Ayalew, H. Kadarmideen, and A. Abdulai, 2004. "Developing Optimised Cattle Breeding Schemes with a Special Focus on Trypanotolerance, based on the Demands and Opportunities of Smallholder cattle Keepers in Eastern Africa". Focus Groups Discussion Report.

Perezgrovas, R., P. Pedraza and M. Peralta, 1992. Indigenous knowledge as the basis for sheep management programmes in Southern Mexico. pp.133–134. In: P.W. Daniels, S. Holden, E. Lewin and S. Dadi (eds). Livestock Services for

Smallholders: A critical evaluation of the delivery of animal health and production services to the small-scale farmer in the developing world, Proceedings of an International Seminar held in Yogyakarta, Indonesia, 15–21 November 1992.

Peters, K.J., 1991. Selection and breeding sterategies for production in warm climates. Proceedings of the International symposium on animal Husbandary in Warm climates. Viterbo, Italy, 25-27 October 1990, (EAAP Publication no. 55, 1991).

Philipsson, J., 2000. Sustainability of dairy cattle breeding systems utilising artificial insemination in less developed countries - examples of problems and prospects. pp. 551-562. In: S. Galal, J. Boyazoglu and K. Hammond (eds.). Workshop on Developing Breeding Strategies for Lower Input Animal Production Environments. Bella, Italy, 22-25 September 1999, ICAR Technical Series 3.

Phipps R H 1974 The performance of imported Kenyan and American Jerseys in Uganda. East African Agricultural and Forest Journal 39: 381-385

PSPDOR, 2009 (Physical and Socio-economic Profiles of 180 Districts of Oromiya Region).

Pullan, N.B., 1979. Productivity of White Fulani cattle on the Jos plateau, Nigeria. I. Herd structures and reproductive performance. Tropical Animal Health and Production, 11:231–238.

Rege JEO (1992). Back ground to ILCA characterization project. In: Rege JEO, Lipner ME (eds), African animal genetic resources: Their characterization, conservation and utilization. Proc. Res. Plan Workshop, Feb. 19-21, 1992. ILCA, Addis Ababa, Ethiopia.

Rege, J.E.O. and Lipner, M.E. (eds.), 1992. Africa Animal Genetic Resources: Their Characterization, Conservation, and Utilization. p164. Proc. Res. Plan Workshop at ILCA. Addis Ababa, Ethiopia, 19-21 Feb 1992, ILCA.

Rege, J.E.O., and J. Bester, 1998. Livestock resources and sustainable development in Africa. ICWCGALP.International Committee for World Congresses on Genetics Applied to Livestock Production, Armidale, NSW (Australia). Armidale (Australia). pp19-26.

Rege, J.E.O., A. Kahi, M. Okomo-Adhiambo, J. Mwacharo and O. Hanotte, 2001. Zebu cattle of Kenya: Uses, performance, farmers preferance, measures of genetic diversity and options for improved use. Animal genetic resources research 1. ILRI (International Livestock Research Institute) Nairobi, Kenya. 103p.

Rege, J.E.O. and J. P. Gibson, 2003. Animal Genetic Resources and Economic Development: Issues in Relation to Economic Valuation. Ecological Economics, 45: 319-330.

Rege, J.E.O., 2003. Defining livestock breeds in the context of community-based management of farm animal genetic resources. pp 27-35. Proceedings of Community-based management of animal genetic resources. Workshop held in Mbabane, Swaziland, 7-11 May 2001.

Rodriquez, L. and T. R. Preston, 1997. Local feed resources and indigenous breeds: Fundamental issues in integrated farming systems. Livestock Research for Rural Development, 9(2): 32–38.

Roothart, R.L. and S. Franzel, 2001. Farmers' preferences and uses of local fodder trees and shrubs in Kenya. Agroforestry Systems, 52(3): 239–252.

Saeed, A.M., Ward, P.N., Light, D., Durkin, J.W. and Wilson, R.T. 1987. Characterization of the Kenana cattle at Um Banein, Sudan. ILCA Research report 16. Addis Ababa, Ethiopia. pp 46.

Salisbury,G.W.,Van Dermark, N.L. and Lodge, J.R., 1978. *Physiology of Reproduction and Artificial Insemination of Cattle*, (W.H. Freeman, San Fransisco)

Samal, P.K., A. Shah, S. C. Tiwari and D. K. Aqrawal, 2002. Indigenous animal health care practices and their relevance to bioresource conservation in Indian Central Himalaya. International Journal of Sustainable Development and World Ecology 9(2):167–178.

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

SAS (Statistical Analysis System), 2002. SAS for windows, Release 9.2. SAS Institute, Inc.,Cary, NC, USA.

Shiferaw, Y.,BA.Tenhagen, M.Bekana and T. Kassa, 2005. Reproductive disorders of cross breed dairy cows in the central highlands of Ethiopia and their effect on reproductive performance. Trop. Anim. HealthProd., 37: 427-441

Sisay A. 2006. Livestock production systems and available feed resources in different agroecologies of north Gonder zone, Ethiopia. M.sc. Thesis. Alemaya University. Alemaya.

Sneath, P H A and R R Sokal 1973. *Numerical Taxonomy*. W H Freeman & Co., San Fransisco. 573pp.

Solkner, J.J., H. Nakimbugwe and A. Valle Zarate, 1998. Analysis of determinants for success and failure of village breeding programmes. pp. 273. In: Proceedings of the Sixth World Congress on Genetics Applied to Livestock Production, vol. 25. Armidale, NSW, Australia, 11-16 January 1998, Armidale.

SPSS for windows, 2006. Statistical Package for Social Science (SPSS). Release 16.0. The Apasche software foundation.

Steglich, M., 2006. Participatory assessment of local cattle breeding systems: The case study of Gambia. A PhD Thesis Presented to Humboldt University of Berlin, Germany.

Sun, W. B., Chen, H., Lei, C. Z., Lei, X. Q. & Zhang, Y. H., 2007. Study on population genetic characteristics of Qinchuan cows using microsatellite markers. *J. Genet. Genomics*, 34: 17–25.

Takele, 2005. On Farm Phenotypic Characterization of Sheko Breed of Cattle and Their Habitat in Bench Maji Zone, Ethiopia. M Sc Thesis. School of Graduate Studies, Alemaya University of Agriculture. 105p.

Tedla A, Tefera G M, Gebre-Wold A, Yemane B and Philip C 1991 Status of Dairying in Ethiopia and Strategies for Future Development. In Proceedings of the Third Livestock Improvement Conference, 24-26 May 1989, Institute of Agricultural Research, Addis Ababa, Ethiopia. pp. 25-36.

Tesfaye Tsegaye, 2009. Characterization of goat production systems and on- farm evaluation of the growth performance of grazing goats supplemented with different protein sources in Metema woreda, amhara region, Ethiopia. M Sc Thesis. School of graduate Studies, Alemaya University of Agriculture.

Tewolde, A., 2000. Breeding strategies for low input animal production systems: a case study from Central America and Mexico. In: S. Galal, J. Boyazoglu, K. Hammond (eds.).Workshop on Developing Breeding Strategies for Lower Input Animal Production. The Perkin Elmer Corporation, Foster City, California, USA.

Trail J.C.M., Gregory K.E., Durkin J. and Sandford J. 1984. Crossbreeding cattle in beef production programmes in Kenya. H. Comparison of purebred Boran and Boran crossed with the Red Poll and Santa Gertrudis breeds. Trop. Anim. Health Prod. 16:191-200.

Tsedeke Kocho,2007. Production and marketing systems of sheep and goats in Alaba, southern Ethiopia. M Sc Thesis. School of Graduate Studies, Alemaya University of Agriculture.

Ulfina Galmessa, Zelalem Belayneh, Jemal Dekebo, Gemeda Duguma, Chala Merera, Jiregna Dessalegn, Diriba Geleti, Lemma Gizachew Workneh Ayalew, Adam Drucker, 2005. Survey of cattle production and marketing practices in Danno District, western Ethiopia, using PRA tools. PRA Roport. (Inpress).

Van Dorland, H.A., Workneh Ayalew, Asfaw Tolessa, G.J. Rowlands, J. E. O. Rege, 2004. Understanding the purpose for helping cattle and their perceived traits by farmers in oromia Regional State, Ethiopia. Pp 191-201. Proceeding of the 11th

Annual Conference of the Ethiopia Society of Animal Production (ESAP) on Farm Animal Biodiversity in Ethiopia: Status and Prospects. Addis Ababa, Ethiopia, 28-30 August 2003, ESAP.

Verbeek, E., E. Kanis, R.C. Bett and I.S. Kosgey, 2007. Socio-economic factors influence small ruminant breeding in Kenya. *Livestock Research for Rural development*.19 1-11.

Venter, H.A.W., Van Zyl, J.G.E. and Tami Vasconcellos, O.A.D.R., 1984. Comparative testicular development in young beef bulls. In: proc.2nd WorldCongr.Sheep and Beef cattle Breeding. Eds. Hofmeyr, J.H. and Meyer, E.H.H., April 1984, Pretoria, SouthAfrica.

Walker, D.H., P. J. Thorne, F. L. Sinclair, B. Thapa, C. D. Wood and D. B. Subba, 1999. A systems approach to comparing indigenous and scientific knowledge: consistency and Development: Approaches to Indigenous Knowledge', 2-5 April, 2000, London, pp.25.

Wang, D. G., Fan, J. B., Siao, C., Berno, A., Young, P., Sapolsky, R., Ghandour, G., Perkins, N. , Winchester, E., Spencer, J., Kruglyak, L., Stein, L., Hsie, L., Topaloglou, T., Hubbell, E., Robinson, E., Mittmann, M., Morris, M. S., Shen, N., Kilburn, D., Rioux, J., Nusbaum, C., Rozen, S., Hudson, T. J. & Lander, E. S., 1998. Large–scale identification, mapping, and genotyping of singlenucleotide polymorphisms in the human genome. *Science,* 280: 1077–1082.

Weary D M and Chua B, 2000 Effects of early separation on the dairy cow and calf. 1. Separation at 6 h, 1 day and 4 days after birth. Applied Animal Behaviour Science 69: 3, 177-188

Weber, J. L. & May, P. E., 1989. Abundant class of DNA polymorphisms which can be typed using the polymerase chain reaction. *Am. J. Hum. Genet*., 44: 388–396.

Wildmann, E. E., Jones, G. M., Wagener, P. E., Boman, R. L., Troutt Jr, H. F. and Lesch, T. N. 1982. A dairy cow body condition scoring system and its relationship to selected production characteristics. *Journal of Dairy Science* 65: 495-501.

Williams, J, A Kubelic, K Livak, J Rafalski and S Tingey 1990. *Nucleic acid Res*. 18: 6531 (cf. Kemp, 1992).

Williamson G and Payne W J A. 1977. *An introduction to animal husbandry in the tropics.* 3rd edition. Longman, London, UK. 755 pp.

Wilson, R.T. and S. E. Clarke, 1975. Studies on the livestock of southern Darfur, Sudan. I. The ecology and livestock resources of the area. Tropical Animal Health and Production, 7:165–187.

Wilson, R. T., 1986. Livestock production in central Mali long term studies on cattle and small ruminants in the Agro-pastoral system. ILCA Research report No.14, ILCA (International Livestock Center for Africa), Addis Ababa, Ethiopia.

Wilson, R T 1991. *Small Ruminant Production and Small Ruminant Genetic Resources in Tropical Africa*. FAO Animal Production and Health Paper No.88. FAO, Rome.

Wiltbank. J. N., W. W. Rowden, J. E. Ingalls, K. E. Gregory, and R. M. Koch. 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. J. Anim. Sci. 21:219.

Wollny, C. B.A., 2003. The need to conserve farm animal genetic resources in Africa: should policy makers be concerned? *Ecological Economics* 45: 341- 351.

Womack J.E., Bolch S.N. and Fries R. (1992). Gene map of the cow (Bos Taurus). In Genetic Maps: Locus maps of complex genomes. (Ed. O'Brien S.J. 1993 6th edition). Cold Spring Harbor Laboratory Press 4, 264-275.

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

Workneh Ayalew, J. M. King, E. Bruns and B. Rischkowsky, 2003. Economic evaluation of a smallholder subsistence livestock production: lessons from an Ethiopia goat development program. Ecological Economics, 45(3): 473-485.

Workneh Ayalew, Ephrem Getahun, Markos Tibbo, Yetnayet Mamo and J.E.O. Rege, 2004. Current state of knowledge on characterization of farm animal genetic resources in Ethiopia. pp 1-22. Farm animal biodiversity in Ethiopia: status and prospects. Proceedings of the 11th annual conference of the Ethiopian Society of Animal Production (ESAP) August 28-30, 2003. Addis Ababa, Ethiopia.

Workneh Ayalew and Rowlands J. (eds). 2004. Design, execution and analysis of the livestock breed survey in Oromiya Regional State, Ethiopia. OADB (Oromiya Agricultural Development Bureau), Addis Ababa, Ethiopia, and ILRI (International Livestock Research Institute), Nairobi, Kenya. 260 pp.

Wurzinger, M., Ndumu, D., Maumung, R. Drucker, A.G., Okeyo, A. M., Semambo, D.K. and Sölkner, J., 2006. Assessing stated preferences through use of choice experiments: valuing (re) production versus aesthetics in the breeding goals of Ugandan Ankole cattle breeds.pp.1-4. In: Proceedings of the 8th World Congress on genetics applied to Livestock production, 13-18 August, 2006. Belo Horizonte, Brazil.

Yeshitila A. 2007. Efficiency of livestock feed resources utilization and forage development in Alaba woreda, southern Ethiopia. MSc Thesis. Haramaya University, Haramaya, Ethiopia.

Zewudu Edea, 2008. Characterization of bonga and horro indigenous sheep breeds of smallholders for designing community based breeding strategies in Ethiopia. MSc Thesis. Haramaya University, Haramaya, Ethiopia.

Zewdu Wuletaw, 2004. Survey of indigenous cattle genetic resources, husbandry practices and cattle breeding objectives in North Gondar, Ethiopia. MSc thesis, Alemaya University, Dire Dawa, Ethiopia.

Zewdu Wuletaw, Workineh, Ayalew, and Johan Sölkner, 2006. Breeding Scheme based on Analysis of Community breeding Objectives for Cattle in North-western Ethiopia. *Eth. J. Anim. Prod*. 6:33-66.

7. APPENDICES

Appendix Table 1: *Questionnaire*

Annex 1.1. *Household General Information*

1. Interviewee name____________________________

Position in household *(Tick one box)*

1. Household head ☐
2. Spouse of head ☐
3. Relative ☐
4. Son ☐
5. Daughter ☐

Other (specify)

6. ___________ ☐

2. Household head

Sex *(Tick one box)*

Male	☐
Female	☐

Age (yrs) *(Tick one box)*

<31	☐
31–40	☐
41–50	☐
51–60	☐
61–70	☐
>70	☐

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

	No
Children	
Males $\leq$ 15 yrs	
Females $\leq$ 15yrs	
Adults	
Males >15	
Females >15	

4. Land holding (in ha)

	Own	Rented
1. Crops(with fallow land)		
2. Grazing		
3. Other (specify) _______		
Total area		

5. Use of communal grazing *(Tick one box)*

Yes	☐
No	☐

6. Type of grazing land and ownership

	Own		Rented		Communal	
1. Open grassland						
2. Tree covered grassland						
3. Bush/shrub grassland						
4. Stone covered grassland						
5. 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.)

7. What is your major farming activity?*(Tick one box)*

1. Livestock production ☐
2. Crop production ☐
3. Both ☐

8. Numbers of cattle kept

Local cattle breeds	☐
Exotic cattle breeds	☐

Annex 1.2. *Cattle Production systems*

1. Production system *(Tick one box)*

1. Pastoralists	
2. Agro-pastoralists	
3. Crop–livestock system	

Other (specify)
4. _______________

2. Type of management *(Tick one box)*

1. Extensive	
2. Semi-intensive	
3. Intensive/backyard	

Other (specify)
4. ________________

3. Mobility *(Tick one or more boxes in each column)*

	Family	Livestock
1. Sedentary		
2.Transhumant		
3. Nomadic		

Other (specify)
4. ________________

4. Purpose of keeping cattle *

	Ox/bull		cow/heifer	
1. Meat				
2. Milk				
3. Work/draft				
4. Breeding				
5. Manure				
6. Blood				
7. Hide				
8. Savings				
9. Wealth status				
10. Dowry				
11. Ceremonies				
12. Commercial				
Other (specify)				
13. _________				

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

5. Members of household who own cattle *(Tick one or more boxes)*

Head	
Spouse	
Head & spouse together	
Sons	
Daughters	
The whole family	
Others *	

* *Describe*_____________________

6. Members of household and hired labor responsible for cattle activities *(Tick one or more boxes in each column and row; The first column refers to members* of the household and the second refers to hired labor).
(*F=Family, H= Hired)

	Adults Males (>15y) F*	H	Females (>15y) F	H	Children Boys (<15y) F	H	Girls (<15y) F	H
1. Purchasing cattle								
2. Selling cattle								
3. Herding								
4. Breeding								
5. Caring for sick animals								
6. Feeding								
7. Milking								
8. Making dairy products								
9. Selling dairy products								

Other (specify)

7a. Grazing *(Tick one or more boxes in each column)*

	Dry season	Wet season
1. Natural pasture	☐	☐
2. crop residue	☐	☐
3. Paddock	☐	☐
4. Grains	☐	☐
5. Indus. Byproducts	☐	☐
Other (specify)		
6. __________	☐	☐

8. Housing/enclosure for adult cattle (*Tick)*

A. With roof	1. In family house	☐
	2. Separate house	☐
	3. Veranda	☐
B. *Without roof*	4. Kraal	☐
	5. Yard	☐
	6. None	☐
	Other (specify)	
	7. _____________	☐

7b. Are calves grazed/fed with adults?*(Tick one box)* Yes ☐ No ☐

9. Type of housing materials
(Tick one or more boxes in each column)

	Roof	Wall	Floor
1. Iron sheets	☐	☐	☐
2. Grass/Bushes	☐	☐	☐
3. Wood	☐	☐	☐
4. Stone/bricks	☐	☐	☐
5. Earth/mud	☐	☐	☐
6. Concrete	☐	☐	☐
7. Thin			
Other (specify)			
8. _______________	☐	☐	☐

10. Are calves housed with adults?
(Tick one box)

Yes ☐ No ☐

If no, specify ________________________________

11. Animals housed under roof
(Tick one or more boxes)

	Dry season	Wet season
1. Cows	☐	☐
2. Bulls	☐	☐
3. Oxen	☐	☐
4. Calves (< 1 yr)	☐	☐
5. Other young stock (1-3 yrs)	☐	☐
6. All of them		

12. Source of water

(Tick one or more boxes in each column)

	Dry season	Wet season
1. Borehole/water well	☐	☐
2. Dam/pond	☐	☐
3. River	☐	☐
4. Spring	☐	☐
5. Pipe water	☐	☐
6. Rain water	☐	☐
Other (specify)	__	___

13. Distance to nearest watering point for adult animals
(Tick one box in each column)

	Dry season	Wet season
1. Watered at home*	☐	☐
2. <1km	☐	☐
3. 1–5 km	☐	☐
4. 6–10 km	☐	☐
5. >10 km	☐	☐

14. Are calves watered with the adults?

☐ ☐

If no, describe watering distance and frequency

15. Frequency of watering for adult animals
(Tick one box in each column)

	Dry season	Wet season
1. Freely available	☐	☐
2. Once a day	☐	☐
3. Twice a day	☐	☐
4. Three times per day	☐	☐

Other (specify)----

16. Water quality
(Tick one box in each column)

	Dry season	Wet season
1. Clean	☐	☐
2. Muddy	☐	☐
3. Salty	☐	☐
4. Smelly	☐	☐

(Tick one or more boxes in each column)

Annex 1.3. *Cattle Health*

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

1. Government veterinarian ☐
2. Private veterinarian ☐
3. Shop or market ☐

Other (specify)
4. ____________________ ☐

2. Distance to nearest veterinary services
(Tick one box)

1. < 1km ☐
2. 1–5 km ☐
3. 6–10 km ☐
4. >10km ☐

3. Prevalent diseases
Name of disease (or symptoms when name is not known)

Type of treatment
(*Tick one or more boxes)*

	Code	Traditional	Modern	Both
1. ____________________	☐	☐	☐	
2. ____________________	☐	☐	☐	
3. ____________________	☐	☐	☐	

If traditional, specify Code

____________________ ☐

____

4. For what diseases vaccinations are given
Name of disease (or symptoms when name is not known)

	Code	Done routinely	Done when need arises
1. ____________________	☐	☐	☐
2. ____________________	☐	☐	☐
3. ____________________	☐	☐	☐

(Tick one box)

5. Disease tolerance/resistance

Name of breed	Code	Name/symptoms of disease 1	Code	Name/symptoms of disease 2	Code
1. ____________	☐	1.____________________	☐	2. ______________________	☐
2. ____________	☐	1. ____________________	☐	2.______________________	☐
3. ____________	☐	1. ____________________	☐	2.______________________	☐
4. ____________	☐	1. ____________________	☐	2.______________________	☐
5. ____________	☐	1. ____________________	☐	2.______________________	☐

6a. Trypanosomes control method
(Tick one or more boxes)

No control ☐
Traditional ☐
Modern ☐
If traditional, (specify) ___________________________

____

6b. Application methods

		Done routinely Modern	Done routinely Trad	Not done routinely* Modern	Not done routinely* Trad
1. None	☐				
2. Dip	☐	☐	☐	☐	☐
3. Spray	☐	☐	☐	☐	☐
4. Pour-on	☐	☐	☐	☐	☐
5. Rubbing	☐	☐	☐	☐	☐
Other (specify)					
6. ________	☐	☐	☐	☐	☐

6c. If not done routinely, reasons for not done routinely *(Tick one or more boxes)*

1. Lack of money ☐
2. Lack of drugs locally ☐
3. Done when need arises ☐
4. Available drugs are too far away ☐

Other (specify) ☐
5. _________________________ ☐

7.External parasite control method	Is it done routinely?	If yes, what type of application method is used?
1.No control		1.No control
2.Traditional	1.yes	2.Dip
3.Modern	2.No	3.Spray
4.Both		4.Pour-on
		5.Rubbing
		6.Other

If no, what is the reason?
1.Lack of money
2.Lack of drugs locally
3.Done when the need arises
4.Available drugs are too far away
5.Other

8.Internal parasite control method	Is it done routinely?	If yes, what type of application method is used?
1.No control 2.Traditional 3.Modern 4.Both	1.yes 2.No	1.No control 2.Drench 3.Bolus/Tablet 4.Other

If no, what is the reason?
1.Lack of money
2.Lack of drugs locally
3.Done when the need arises
4.Available drugs are too far away
5.Other

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

	Calves <1 yr	Young 1–3 yrs	Adults ≥3 yrs
Male			
Female			

10. Reasons for death
(Tick one or more boxes, then rank top 3)

1. Predators		
2. Disease		
3. Accident		
4. Poisoning		
5. Unknown		
6. Drought		

Other (specify)

Annex 1.4. *Cattle Breeding*

1. Reason for keeping bull(s)
(Tick one or more boxes)

1. Mating ☐
2. Socio-cultural ☐
3. Draft/work ☐

Other (specify)

4. ________________ ☐

2. Criteria for choice of bull(s) *

1. Size		
2. Color		
3. Horns		
4. Character		
5. Availability (no choice)		
6. Performance*		

Other (specify)

7. ________________ ☐☐

* *If performance, specify*
____

Code ☐

3a. Breeding/mating
(Tick one or more boxes and rank)

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

1. Natural ☐☐
2. Artificial ☐☐

3b. If natural, what type of natural mating?

1. Controlled ☐☐ *(Tick one or more boxes and rank)*
2. Uncontrolled ☐☐

4. Source of bull(s) within the last 12 months*

Breed name(s) *(specify if known)*

Tick one or more boxes		Breed 1 Common name	Code	Breed 2 Common name	Code
1. Own bull (bred)	☐	________	☐☐	________	☐☐
2. Own bull (bought)	☐	________	☐☐	________	☐☐
3. Bull donated	☐	________	☐☐	________	☐☐
4. Bull borrowed	☐	________	☐☐	________	☐☐
5. Neighbor's bull	☐	________	☐☐	________	☐☐
6. Communal bull	☐	________	☐☐	________	☐☐
7. Unknown bull	☐	________	☐☐	________	☐☐

**(When crossbred, enter names of the breeds responsible for the cross)*

Annex 1.5. *Breed specific information*

.1. Common/local breed name (s) ______________________________

2. Numbers by age and sex
(Enter numbers)

	Young (>3 yr)	Adults (>3 yr)
Intact male	☐	☐
Castrate	☐	☐
Female	☐	☐

3. Trend for this breed *(Tick one)*
   - Increasing ☐
   - Stable ☐
   - Decreasing ☐
   - Unknown ☐

How old is the oldest animal?

Male ☐ Years
Female ☐ Years

4. Reasons for the population trend
(Tick one or more boxes)

1. Increased interest of the farmer ☐
2. Breed is very available ☐
3. Decreased interest of the farmer ☐
4. Breed has become rare ☐
5. Competition with exotic breeds ☐
6. Competition with other local breeds ☐

5. Origin/source of breed
(Tick one or more boxes)

1. Inherited ☐
2. Neighbor ☐
3. State farm * ☐
4. Market * ☐
5. NGO/project* ☐
6. Gift/bride price ☐
7. Own bred ☐

6. Quality of traits perceived by owner for this breed

(For each trait tick c box in a row)

	Not important	Poor	Average	Good	very good
1. Size…….. ……	☐	☐	☐	☐	☐
2. Color ………	☐	☐	☐	☐	☐
3. Horns …	☐	☐	☐	☐	☐
4. Heat tolerance	☐	☐	☐	☐	☐
5. Cold tolerance…	☐	☐	☐	☐	☐
6. Character…..	☐	☐	☐	☐	☐
7. Work/draft power	☐	☐	☐	☐	☐
8. Milk yield …………	☐	☐	☐	☐	☐
9. Meat quality………	☐	☐	☐	☐	☐
10. Growth rate ………	☐	☐	☐	☐	☐
11. Ability to walk long distances	☐	☐	☐	☐	☐
12. Fertility ……………	☐	☐	☐	☐	☐
13. Longevity…………	☐	☐	☐	☐	☐
14. Disease tolerance…	☐	☐	☐	☐	☐
15. Drought tolerance…	☐	☐	☐	☐	☐
Other (specify)					
16. ________________	☐	☐	☐	☐	☐

Annex 1.6. *Reproduction characteristics*

1. Average age at sexual maturity
   - Male animals ☐ Months
   - Female animals ☐ Months

2. Age at first calving
   - Average ☐ Months
   - Maximum ☐ Months
   - Minimum ☐ Months

3. Calving interval
   - Average ☐ Months
   - Maximum ☐ Months
   - Minimum ☐ Months

4. Calving pattern, occurrence of most births

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

(Tick one or more boxes then rank top three in second half of box)

5. Average marketable age of young stock
   - Males ☐ Months
   - Females ☐ Months

6. Is the breed milked?
   - Yes ☐ *(Tick one box)*
   - No ☐

7. Milk production per animal per day
   - Average ☐ Liters*
   - Maximum ☐ Liters
   - Minimum ☐ Liters

   Assume 1 liter = 1 kg

8. Lactation length
   - Average ☐ Months
   - Maximum ☐ Months
   - Minimum ☐ Months

9. Frequency of milking
(Tick one box)

1. Once a day ☐
2. Twice a day ☐
3. Three times a day ☐

10. Average weaning age of calves

(Tick one box)

1. < 3 months ☐
2. 3–4 months ☐
3. 5–6 months ☐
4. > 6 months ☐

11. Milk feeding up to weaning *(Tick one box)*

1. Unrestricted suckling ☐
2. Restricted suckling ☐
3. Bucket feeding ☐

Other (specify)

4. ________________ ☐

Annex 1.7. *Phenotypic Descriptions*

CATTLE Pure indigenous/local breed 1 – Phenotypic description

To complete this page, select an adult female and an adult intact/castrated male. If they are not present on the farm, indicate what other kind of age group you selected (e.g. calf, ox, etc.).

For female: A. cow B. heifer

For male: A. ox (castrated/intact)
B. bull (castrated/intact)

Cattle code: _____________________

Cattle code: _______________

13. Coat description

		male		female
Pattern…	Uniform…	☐	..…	☐
	Pied……	☐	…..	☐
	Spotty…	☐	…..	☐
	Shaded……	☐		☐
Hair…………	Short……….	☐	…..	☐
	Medium……	☐	…..	☐
	Long………	☐	…..	☐
Hair type…	Straight…….	☐	…..	☐
	Curly………	☐	…..	☐

19. Horns

		Female		Male
Present…….	Yes…………	☐	….	☐
	No…………	☐	….	☐
Dehorned…	Yes…………	☐	….	☐
	No…………..	☐	….	☐
Shape……	Straight……	☐	….	☐
	Curved……	☐	….	☐
	Lyre-shaped	☐	….	☐
		___		______

14. Body | cm | cm

Height at withers …

Heart girth …

Body length …

Dewlap… Absent… / Small……… / Medium… / Large………

15. Hump

Size………… Absent… / Small……… / Medium…… / Large………

Shape…… Erect……… / Dropping

Position… Thoracic….. / Cervicothoracic

16. Profile

Face………… Flat…… / Convex……. / Concave

Back…… Curved……. / Straight……

Rump…… Flat……… / Sloping… / Roofy……

17. Ears

Length (cm) …………..

Shape…….. Rounded… / Straight edge

Orientation…. Upright……. / Lateral…… / Dropping…

18. Pelvic width (in cm)

Orientation Forward…… / Lateral……… / Upright… / Dropping…

Spacing…… Narrow…… / Wide………

Length (cm)… …………

Horn shaping Natural…… / Modified

20. Tail

Length… Short…… / Medium…… / Long………

21. Udder (after peak lactation)

Size………… Small……… / Medium… / Large……

Teats……… Small……... / Medium… / Large………

Naval flap… Absent…… / Small…… / Medium… / Large……

22. Testis

Size……… Small…………… / Medium………… / Large………………

Perpetual sheath Absent…………… / Small…………… / Medium………… / Large……………

23. Body condition score

1 (L-)	2 (L)	3 (L+)	4(M-)	5(M)	6 (M+)	7 (F-)	8(F)	9 (F+)

Where: L=Lean, M=Medium and F=Fat

24. Age of cattle

1 (18-30 months	
2 (31-40 months)	
3 (≥42 months)	

Appendix Table 2: *Focus group discussion checklist*

1. History of the breed
2. How cattle are herded across different seasons?
3. Communal land utilization and management
4. Trend in grazing land
5. Occurrence and frequency of disease, drought, conflict, flood and other disasters
6. Copping mechanism during these problems
7. Major feed resources during different seasons
8. Indigenous knowledge in managing the breed

- Breed identification
    - Special qualities of the breed
    - Good and undesirable character of cattle compared with other livestock
    - Trait preference

9. Major cattle production constraints
10. The most common cattle diseases and measures taken
11. Type of services in cattle husbandry
12. Cattle population trend in the last 10 years
13. Quality of traits perceived by cattle owners for the breed
14. Any practice of bull sharing within the community (s)
15. Feed sources

Appendix Table 3: *Secondary data collection checklist*

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___________Others_______

6. Climatic data (distribution and amount)

  - Temperature (◦c)

      Annual average temperature____________________

      Maximum______________Minimium____________

    - Rainfall (mm)

      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 cattle in the farmers' livelihood (Income contribution of the activity in percent)

13. Major cattle production constraints in each district?

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

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

16. Major cattle diseases, occurrence, mortality, and treatment

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

Appendix Table 4: *Quantitative traits and their definition that were used for each sample animal as a checklist*

1.Body length (BL)	The horizontal distance from the point of shoulder to the pin bone to the nearest centimeter.
2. Chest girth (CG)	The distance around the animal measured directly behind the front leg to the nearest centimeter.
3. 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.
4. Height at wither (WH)	The height from the bottom of the front foot to the highest point of the shoulder between the withers to the nearest centimeter.
5. Horn length (HL)	The length of the horn to the nearest centimeter.
6. Pelvic width (PW)	The distance between the pelvic bones, across dorsum to the nearest centimeter.

Appendix Table 5: The *Generalized Linear Model Procedure for Age at sexual maturity (AASM), Age at first calving (AFC), Calving interval (CI), Marketable age (MA), Lactation length (LL) in months and Milk production (MP) per cow per day in liters.*

Class Level Information

The GLM Procedure

Class Level Information		
Class	Levels	Values
Age of cattle	3	1 2 3
Cluster	3	1 2 3

Number of Observations Read	180
Number of Observations Used	180

Table 5.1a: *Dependent Variable: ASM (Age at sexual maturity) in months of female cattle*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	17065.78164	4266.44541	243.93	<.0001
Error	175	3060.86280	17.49064		
Corrected Total	179	20126.64444			

R-Square	Coeff Var	Root MSE	ASM Mean
0.847920	11.16572	4.182182	36.15556

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	16890.22229	8445.11115	482.84	<.0001
Cluster	2	175.55935	87.77968	5.02	0.0076

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	11390.53720	5695.26860	325.62	<.0001
Cluster	2	175.55935	87.77968	5.02	0.0076

Table 5.1b: *Dependent Variable: ASM (Age at sexual maturity) in months of male cattle*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	9807.73671	2451.93418	359.40	<.0001
Error	175	1193.90774	6.82233		
Corrected Total	179	11001.64444			

R-Square	Coeff Var	Root MSE	ASM Mean
0.891479	7.224226	2.611959	37.45556

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Cluster	2	1830.044444	915.022222	134.12	<.0001
Age of cattle	2	7977.692265	3988.846132	584.68	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Cluster	2	2.315646	1.157823	0.17	0.8440
Age of cattle	2	7977.692265	3988.846132	584.68	<.0001

Table 5.2: *Dependent Variable: AFC (Age at first calving) in months of female cattle*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	6352.35103	1588.08776	68.00	<.0001
Error	175	4086.86425	23.35351		
Corrected Total	179	10439.21528			

R-Square	Coeff Var	Root MSE	AFC Mean
0.608508	11.37442	4.832547	42.48611

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	6289.383799	3144.691899	134.66	<.0001
Cluster	2	62.967230	31.483615	1.35	0.2624

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	4795.032973	2397.516486	102.66	<.0001
Cluster	2	62.967230	31.483615	1.35	0.2624

Table 5.3: *Dependent Variable: CI (Calving interval) in months of female cattle*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	2205.306101	551.326525	79.98	<.0001
Error	175	1206.284177	6.893052		
Corrected Total	179	3411.590278			

R-Square	Coeff Var	Root MSE	CI Mean
0.646416	19.46790	2.625462	13.48611

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	2172.523950	1086.261975	157.59	<.0001
Cluster	2	32.782151	16.391075	2.38	0.0957
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	1327.325545	663.662773	96.28	<.0001
Cluster	2	32.782151	16.391075	2.38	0.0957

Table 5.4: *Dependent Variable: MP (Milk production) in liters per cow per day*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	3.01162310	0.75290578	5.19	0.0006
Error	175	25.39086301	0.14509065		
Corrected Total	179	28.40248611			

R-Square	Coeff Var	Root MSE	MP Mean
0.106034	23.43647	0.380908	1.625278

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	1.10627399	0.55313699	3.81	0.0240
Cluster	2	1.90534911	0.95267456	6.57	0.0018

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	1.79494255	0.89747127	6.19	0.0025
Cluster	2	1.90534911	0.95267456	6.57	0.0018

Table 5.5: *Dependent Variable: LL (Lactation length) in months of female cattle*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	87.4280930	21.8570233	11.73	<.0001
Error	175	325.9621848	1.8626411		
Corrected Total	179	413.3902778			

R-Square	Coeff Var	Root MSE	LL Mean
0.211490	16.47077	1.364786	8.286111

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	69.29895125	34.64947562	18.60	<.0001
Cluster	2	18.12914177	9.06457088	4.87	0.0088

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	67.74753746	33.87376873	18.19	<.0001
Cluster	2	18.12914177	9.06457088	4.87	0.0088

Appendix Table 6: The *Generalized Linear Model Procedure for quantitative data set: Heart girth (HG), Body length (BL), Height at wither (HW), Ear length (EL), Pelvic width (PW) and Horn length (HL) of male cattle*

The GLM Procedure

Class Level Information		
Class	Levels	Values
Age of cattle	3	1 2 3
Cluster	3	1 2 3

Number of Observations Read	253
Number of Observations Used	253

Table 6.1: *Dependent Variable: Heart Girth in centimeters*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	12277.87176	3069.46794	38.12	<.0001
Error	248	19967.81994	80.51540		
Corrected Total	252	32245.69170			

R-Square	Coeff Var	Root MSE	Heart Girth Mean
0.380760	5.909922	8.973038	151.8300

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	8967.480819	4483.740410	55.69	<.0001
Cluster	2	3310.390936	1655.195468	20.56	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	4965.276250	2482.638125	30.83	<.0001
Cluster	2	3310.390936	1655.195468	20.56	<.0001

Table 6.2: *Dependent Variable: Body Length in centimeters*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	10482.83337	2620.70834	225.10	<.0001
Error	248	2887.27730	11.64225		
Corrected Total	252	13370.11067			

R-Square	Coeff Var	Root MSE	Body Length Mean
0.784050	3.037490	3.412074	112.3320

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	10363.35108	5181.67554	445.08	<.0001
Cluster	2	119.48229	59.74115	5.13	0.0066

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	7684.367345	3842.183672	330.02	<.0001
Cluster	2	119.482294	59.741147	5.13	0.0066

Table 6.3: *Dependent Variable: Height at Wither in centimeters*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	10325.66090	2581.41523	98.90	<.0001
Error	248	6473.32724	26.10213		
Corrected Total	252	16798.98814			

R-Square	Coeff Var	Root MSE	Height at Wither Mean
0.614660	4.647239	5.109024	109.9368

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	9037.252194	4518.626097	173.11	<.0001
Cluster	2	1288.408709	644.204355	24.68	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	4871.746527	2435.873263	93.32	<.0001
Cluster	2	1288.408709	644.204355	24.68	<.0001

Table 6.4: *Dependent Variable: Ear Length in centimeters*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	146.919472	36.729868	6.14	0.0001
Error	248	1484.756417	5.986921		
Corrected Total	252	1631.675889			

R-Square	Coeff Var	Root MSE	Ear Length Mean
0.090042	14.26043	2.446819	17.15810

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	71.19648969	35.59824484	5.95	0.0030
Cluster	2	75.72298256	37.86149128	6.32	0.0021

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	117.9913294	58.9956647	9.85	<.0001
Cluster	2	75.7229826	37.8614913	6.32	0.0021

Table 6.5: *Dependent Variable: Pelvic Width*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	270.005837	67.501459	18.84	<.0001
Error	248	888.713530	3.583522		
Corrected Total	252	1158.719368			

R-Square	Coeff Var	Root MSE	Pelvic Width Mean
0.233021	5.953187	1.893019	31.79842

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	147.3236569	73.6618284	20.56	<.0001
Cluster	2	122.6821806	61.3410903	17.12	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	43.3633585	21.6816792	6.05	0.0027
Cluster	2	122.6821806	61.3410903	17.12	<.0001

Table 6.6: *Dependent Variable: Horn Length in centimeters*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	514.309365	128.577341	4.29	0.0022
Error	248	7428.734113	29.954573		
Corrected Total	252	7943.043478			

R-Square	Coeff Var	Root MSE	Horn Length Mean
0.064750	30.04314	5.473077	18.21739

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	273.3140513	136.6570256	4.56	0.0113
Cluster	2	240.9953139	120.4976569	4.02	0.0191

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	316.2614608	158.1307304	5.28	0.0057
Cluster	2	240.9953139	120.4976569	4.02	0.0191

Appendix Table 7: The *Generalized Linear Model Procedure for quantitative data set: Heart girth (HG), Body length (BL), Height at wither (HW), Ear length (EL), Pelvic width (PW) and Horn length (HL) of female cattle*

The GLM Procedure

Class Level Information		
Class	Levels	Values
Age of cattle	3	1 2 3
Cluster	3	1 2 3

Number of Observations Read	287
Number of Observations Used	287

Table 7.1: *Dependent Variable: Heart Girth in centimeters*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1090.89139	272.72285	2.92	0.0216
Error	282	26323.45007	93.34557		
Corrected Total	286	27414.34146			

R-Square	Coeff Var	Root MSE	Heart Girth Mean
0.039793	6.516262	9.661551	148.2683

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	700.8142164	350.4071082	3.75	0.0246
Cluster	2	390.0771753	195.0385877	2.09	0.1257

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	961.7296501	480.8648250	5.15	0.0063
Cluster	2	390.0771753	195.0385877	2.09	0.1257

Table 7.2: *Dependent Variable: Body Length in centimeters*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1852.56354	463.14089	11.36	<.0001
Error	282	11498.69082	40.77550		
Corrected Total	286	13351.25436			

R-Square	Coeff Var	Root MSE	Body Length Mean
0.138756	5.819626	6.385570	109.7247

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	1145.784928	572.892464	14.05	<.0001
Cluster	2	706.778612	353.389306	8.67	0.0002

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	1142.686505	571.343253	14.01	<.0001
Cluster	2	706.778612	353.389306	8.67	0.0002

Table 7.3: *Dependent Variable: Height at Wither in centimeters*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1622.40205	405.60051	8.43	<.0001
Error	282	13575.81398	48.14118		
Corrected Total	286	15198.21603			

R-Square	Coeff Var	Root MSE	Height at Wither Mean
0.106750	6.542420	6.938385	106.0523

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	1615.858833	807.929416	16.78	<.0001
Cluster	2	6.543212	3.271606	0.07	0.9343

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	1484.161267	742.080633	15.41	<.0001
Cluster	2	6.543212	3.271606	0.07	0.9343

Table 7.4: *Dependent Variable: Ear Length in centimeters*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	375.388608	93.847152	15.22	<.0001
Error	282	1739.254249	6.167568		
Corrected Total	286	2114.642857			

R-Square	Coeff Var	Root MSE	Ear Length Mean
0.177519	14.30799	2.483459	17.35714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	140.3352784	70.1676392	11.38	<.0001
Cluster	2	235.0533299	117.5266650	19.06	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	208.8277091	104.4138545	16.93	<.0001
Cluster	2	235.0533299	117.5266650	19.06	<.0001

Table 7.5: *Dependent Variable: Pelvic Width in centimeters*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	103.142521	25.785630	6.08	0.0001
Error	282	1195.150162	4.238121		
Corrected Total	286	1298.292683			

R-Square	Coeff Var	Root MSE	Pelvic Width Mean
0.079445	6.558311	2.058670	31.39024

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	55.80361816	27.90180908	6.58	0.0016
Cluster	2	47.33890320	23.66945160	5.58	0.0042

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	39.02756539	19.51378270	4.60	0.0100
Cluster	2	47.33890320	23.66945160	5.58	0.0042

Table 7.6: *Dependent Variable: Horn Length*

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1181.94985	295.48746	8.31	<.0001
Error	282	10026.97001	35.55663		
Corrected Total	286	11208.91986			

R-Square	Coeff Var	Root MSE	Horn Length Mean
0.105447	32.65960	5.962938	18.25784

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Age of cattle	2	259.9553775	129.9776888	3.66	0.0271
Cluster	2	921.9944698	460.9972349	12.97	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Age of cattle	2	474.0069513	237.0034757	6.67	0.0015
Cluster	2	921.9944698	460.9972349	12.97	<.0001