

**PHENOTYPIC AND GENETIC CHARACTERIZATION OF INDIGENOUS CHICKEN
IN SOUTHWEST SHOWA AND GURAGE ZONES OF ETHIOPIA**

PhD Dissertation

**A dissertation submitted to the College of Veterinary Medicine and Agriculture of Addis
Ababa University in partial fulfillment of the requirements for the degree of Doctor of
Philosophy in Animal Production**

By

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January, 2015

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PHENOTYPIC AND GENETIC CHARACTERIZATION OF INDIGENOUS CHICKEN IN SOUTHWEST SHOWA AND GURAGE ZONES OF ETHIOPIA

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PhD thesis

Addis Ababa University (2014)

ABSTRACT

This study was conducted to characterize and describe the genetic diversity and phenotypic variations in four indigenous chicken ecotypes of Southwest Showa and Gurage zones of Ethiopia under village production system. The genetic diversity of four indigenous chicken ecotypes was studied using ten microsatellite markers. Fayomi and Swedish breeds were included for comparison. The production and reproductive performances and egg quality traits of indigenous chickens were evaluated under extensive management system. Two districts from each of Southwest Showa and Gurage zones and 3 kebeles from each district and 25 households from each kebele were selected using random sampling. A survey was conducted on 295 selected households to describe the village-based poultry production systems. In majority of the households women (79.1%) were responsible for chicken rearing. Night shelter was provided by all farmers either in kitchen (0.4 %) or main house (4.7 %), or perch (90.9 %), bamboo cages (3.7 %) or separate shed (0.3 %). In both zones along with full day scavenging about 96.3 % of the respondents provided feed supplement and 99.7% provided water to their chicken. Most of the respondents (72.3%) cull their birds for income followed by consumption and income (16.9%), consumption (9.1%) and to sacrifice for religious rituals (1.7%). 70.3% of the respondents reported that pullet and cockerels reached sexual maturity at the average age of 5.5 months while 20.6% and 9.1% of the respondents reported they reached sexual maturity at the average age of 6.5 and 7.5 months respectively. Sexually mature female's weight at 6 month was 750±222.30, 587±116.08, 925± 162.87 and 670±385.29g in Dawo, Sedan Soda, Mehale Amba and Mehurena Aklile districts, respectively. The average number of eggs per clutch per hen in the study area was 12 with a maximum of 3 clutches/hen/year. Average number of eggs incubated per hen was 11 eggs. Average hatchability and chick survivability to adulthood were 76.6% and 65.5% respectively. The mean egg weight, shell weight, albumin weight, yolk weight, egg shell thickness, albumin thickness and yolk colour in south west zone were 42.59±2.64g, 7.08±2.35g, 18.58±3.23g, 16.93±2.22g, 0.32±0.05mm, 3.43±0.79mm, and 9.23±0.99, respectively and for Gurage zone were 42.36±5.55g, 8.34±1.89g, 17.24±4.64g, 16.7±2.727g, 0.30±0.05mm, 3.5±1.08mm and 8.86±0.66, respectively. Average fertility, hatchability (TES)

and hatchability (FES) of Southwest Showa zone were 86.13, 46.79 and 51.85% and for Gurage zone were 85.67, 46.53 and 51.57%, respectively. About 91.9% respondents in the study area obtained their initial chick stock by purchasing, 4.4% by hatching and 3.7% as gift. Majority of replacement chicks (63.9%) in the study area were obtained by hatching followed by purchasing (31.1%) and gifts (5.1%). Finance sources to replace and start chicken production were sells of crops (46.36 %), egg (20.50%), poultry (6.65%), other animal (5.55%), and cash crop (4.43%) and off farm income (16.50%). Almost all respondents (97.6%) reported Newcastle disease outbreak. Unstable price, disease outbreak, poor infrastructure and seasonal demand were factors influencing the marketing of chicken and eggs as reported by 58.9, 9.6, 6.0 and 0.7% of the respondents, respectively. About 60.1% respondents used extension services in poultry production. Identifiable chicken's plumage colors were brown (32.8%), grey mixture (14.4%), reddish brownish (14.4%), white (10.3%), black (9.2%) and red (5.1%). Major qualitative characteristics were rose (41.5%) and single (43.6%) comb types; plain (54.9 %) and crest (45.1%) head shapes; unfeathered shanks (98.48%); white (33.73 %), and yellow (32.48%) shank colour and red and white (34.9%), red (32.2%) and white (31.7%) earlobe colours. The correlation between shank and body length were positive and significant. The number of alleles in Ethiopian ecotypes ranged from lowest 3 alleles per locus in Seden Sodo ecotype at MCW0014 and MCW0078 to 11 alleles per locus in Mehale Amba chicken at LEI0094 marker. The mean heterozygosity values ranged from 19 to 55% in overall population and from 50 to 55% in Ethiopian ecotypes. In the phylogenetic tree the Swedish, Fayomi and the Ethiopian chicken could be grouped separately in three different groups. Ethiopian local chickens were different from exotic breeds and there is a tendency of sub-clustering within Ethiopian ecotypes which needs further investigation using more number of informative markers and advanced clustering tools such as structure programme. Furthermore, studies need to be made to characterize the two sub-clusters of Ethiopian ecotypes for performance traits.

Key Words: Indigenous chicken, village production system, phenotypic variation, genetic diversity

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Statement of author

First, I declare that the dissertation is my *bona fide* work and that all source of material used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirement for a PhD degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the university/ collage library to be made available to borrowers under rules of the Library. I solemnly declare this thesis is not submitted to any other Institution anywhere for the award of any academic degree, diploma, or certificate.

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ACKNOWLEDGEMENTS

First of all, I would like to express my heartfelt thanks to my supervisor Prof. Harpal Singh. I greatly appreciate his meticulous guidance, patience, encouragement and leadership to complete my study. I am extremely thankful to my co-supervisor Dr Anna Maria Johansson for financial support for molecular work and the conducive environment that she created for me to complete my laboratory work at Swedish University of Agricultural Science smoothly and on time. My sincere thanks to my co-supervisors Dr Tesefaye Sisaye for his valuable support, encouragement and technical guidance during the survey work of my research and Dr Zemelak Sahile for his patience, encouragement and valuable support and comments specially for the molecular part of the PhD dissertation write up.

Special thanks are due to the Department of Animal production studies for allowing me to join the PhD programme in this department. Special thanks to Professor Berehan, Dr Ashenafi, Dr Tariku and secretary of the Department W/O Hirute. I express my sincere thanks to all staff members of Microbiology laboratory of veterinary medicine, National Veterinary Institute (NVI) and Sebeta National Animal Health Research Center for their co-operation for the use of the laboratory facilities. I am highly grateful to staff members of Animal breeding and genetics department of Swedish university of agricultural science for allowing me to use the available facilities in the Department. Special thanks goes to Charlotte Grundel, Dr Sofia Mikko, Louise HÜbinette and other staff members of Animal breeding and genetics laboratory for their kind and prompt response to all enquiries during the laboratory work of this study.

My sincere thanks and acknowledgements to the Rural capacity building project (RCBP) and SIDASARIC (Swedish) for the financial support without which the study would not have been possible. I would like to express my thanks to the Ethiopian Institute of Agricultural Research particularly the Livestock Research Directorate for allowing me to join the PhD program. I would like to express my gratitude to all staff members of poultry research case team of Deber Zeit Research Center. I wish to thank the Agricultural office of the two study zones: Southwest Showa and Gurage Zone for their willing and support for the survey work of this study. I would like to express my thanks to all the farmers who participated in this study, for their patience and time, and willingness to share their experiences.

I would like to express my deep gratitude from the inner core of my heart to members of my family, my father, Moreda Bekerie, brothers, Wendemu Moreda, Kumessa Moreda and Sentayhu Moreda and sisters Alem Moreda and Tegist Moreda for their moral support, prayers and encouragement.

Yoseph: thank you very much. Our kids: Saron, Meriam and Anna: thank you very much for your affection, love and patience a source of inspiration, motivation and strength for me to complete this study I love you and again thank you very much.

Above all, I thank the Almighty God JAH, for giving me the inner strength and ability to accomplish this study.

DEDICATION

I dedicate this work to my beloved father Moreda Bekerie and my late mother Semegne W/tsadiq who were at my side to add courage.

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List of abbreviations and acronyms

AFLP	Amplified Fragment Length Polymorphism
AnGR	Animal Genetic Resource
bp	Base Pair
°C	Degree Centigrade
DAD-IS	Domestic Animal Diversity Information System
DNA	Deoxyribonucleic Acid
FES	Fertile Egg Set
H _e	Expected Heterozygosity
HH	House Holds
H _o	Observed Heterozygosity
IBD	Infectious Bursal Disease
IFPRI	International Food Policy Research Institute
MD	Mareks Disease
MoA	Ministry of Agriculture
MoDAD	Measurement of Domestic Animals Diversity
N	Sample Size
NA	Not Available
ND	Newcastle Disease
NJ	Neighbour-Joining
PAs	Peasant Associations
PCR	Polymerase Chain Reaction
PIC	Polymorphism Information Content
RAPD	Random Amplified Polymorphic DNA
RFLP	Restriction Fragment Length Polymorphism
SE	Standard Error
SNNP	South Nations and Nationalities People
SPSS	Statistical Package for Social Sciences
TES	Total Egg Set

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1. INTRODUCTION

Poultry is the largest livestock species worldwide (FAO, 2000), accounting for more than 30% of all animal protein consumption (Permin & Pedersen, 2000). The International Food Policy Research Institute (IFPRI, 2000) has estimated that by the year 2015 poultry will account for 40 % of all animal protein. Chickens largely dominate flock composition and make up about 98 % of the total poultry (chickens, ducks and turkeys) population kept in Africa (Gueye, 2003). Small scale and semi-commercial poultry production is seen as a vital tool in reducing poverty and hunger in developing countries. Poultry keeping is making an important contribution to the livelihoods of the most vulnerable rural households in developing countries. During the last decade, the consumption of poultry products in developing countries has grown by 5.8 percent per year (FAO, 2000).

In Ethiopia the four major Regional States in terms of land area and human population (Oromiya, Amhara, South Nations and Nationalities people [SNNP], and Tigray) collectively account for about 96% of the total national poultry population. Chicken rearing is not common in the lowlands of Ethiopia i.e. Somali, Gambella, Afar and Benishangul-Gumze Regional States, which collectively own 3.24% of the total national chicken population (FAO, 2007; Dawit *et al.*, 2008). Poultry production is categorized into traditional scavenging, small and large-scale market orientated sectors, which is based on the objective of the producer, the type of inputs used, and the number and types of chickens kept (Alemu, 1995; Halima, 2007). The rural poultry sector constitutes about 98 % of the total chicken population (FAO, 2007) and are largely consists of the indigenous or native domestic fowl. The traditional scavenging production is characterized by a low level of input and output. Rural poultry production contributes over 98% of national egg and over 99% of poultry meat production (Alemu and Tadelle, 1997), with annual output of 78,000 metric tons of eggs and 72,300 metric tons of meat (FAO, 2007) in the country. Nevertheless, poultry raised on small scale market oriented production make a significant contribution, along with the commercial sector, to meet up the rapidly growing demand for poultry products especially in large and growing regional cities.

Chicken rearing is especially favorable to small holder farmers due to its low capital requirement, high cost efficiency, flexible production systems and low production risk (Tadelle, 2003; Halima *et al.*, 2007). Chickens contributes to various livelihoods outcomes including gender equality and cash income, in addition to its role in cultural, religious, and traditional practices (Kitalyi, 1998; Tadelle *et al.*, 2003; Bush, 2006). In central highlands of Ethiopia, more than 60% of the families were reported to own chickens, and in most cases women were the one who manage and control the income (Tadelle and Ogle, 2001). The traditional back yard systems are characterized by mainly low-input and small-scale, with 4–10 mature birds per household, reared in the back yards with inadequate housing, feeding and health care. Scavenging is the most important component of the poultry diet and they are usually capable of finding feeds for their maintenance requirement plus the production of few eggs (Tadelle, 1996).

Large combs, large wattles and long legs are important morphological traits that allow better heat dissipation in the tropical hot environment. This specialized structure makes up about 40% of the major heat losses, by radiation, convection and conduction of heat produced from body surfaces at environmental temperature below 80⁰F (Nesheim *et al.*,1979). Indigenous chickens in Ethiopia are in general hardy, adaptive to rural environments, survive on little or no inputs and adjust to fluctuations in feed availability (Tadelle, 2003; Halima *et al.*, 2007; FAO, 2007). However, the indigenous chicken population of Ethiopia has been undergoing genetic erosion especially in the central and other parts of the country following the introduction of improved stock from developed countries. Efforts to sustain commercial hybrid broiler and layer chicken farming under intensive and semi-intensive production models have been conducted in central and other parts of Ethiopia. On the other hand it is well known that indigenous chickens are preferred to exotic chickens because of their pigmentation, taste, flavor and leanness. Systematic characterization, breed improvement and conservation programs may help to sustain village chicken production system in Ethiopia and could be a useful micro-economic strategy in the on-going poverty alleviation process in the country.

Despite the important role-played by tropical fowl as a supplier of meat and eggs in developing countries, there is very little information on its genetic makeup. The most important genes proved for their special utility in the tropics are Naked neck, Frizzle, Dwarf, Silky, Slow

feathering, Noninhibitor, Fibro-melanosis, Peacomb and Blue shell_(Horst,1989). Even though the information collected in the FAO Domestic Animal Diversity Information System (DAD-IS) and other sources show that these genes are prevalent in the local populations across the African countries, little information exists on the genetic make-up of the indigenous chicken of Africa.

Phenotypic and genetic characterization contribute to breed definition especially populations, which are not well defined and provide an indication of the genetic diversity of these lines. It also has potential to identify unique alleles in the breeds or lines studied. Up to date no information is available on the genetic diversity of south and southwest Ethiopian native chickens, which are important to design effective selection and conservation strategies. The chicken is the first bird, as well as the first agricultural animal, to have its genome sequenced and analyzed. As the first livestock species to be fully sequenced, the chicken genome sequence is a landmark in both avian biology and agriculture (Burt, 2005) and therefore provides a vast number of microsatellite markers for diversity studies. A number of microsatellite markers based on the degree of polymorphism and genome coverage have been recommended by the Measurement of Domestic Animals Diversity (MoDAD) FAO (2004), for application in diversity studies and detail information on the microsatellite markers are available on FAO website (www.dadfao.org/en/refer/library/guidelin/marker.pdf). Microsatellites are highly polymorphic tandem repeat loci with a core motif of 1 to 6 base pairs (bp) repeated several times (Tautz, 1989). They are the preferred markers for diversity studies and have been used in a number of animal genetic variation studies.

Very little is known about the indigenous chicken flocks in south and southwest parts of the country. The genetic makeup, management, bird performance, disease resistance and adaptation to local conditions have not been exhaustively assessed. Thus, this study will undertake phenotypic and genetic analyses of indigenous chicken populations to describe their performance and indicate traits of economic interest and assess genetic diversity of indigenous chickens and their relationship to a reference exotic breed using microsatellite markers. This information, combined with phenotypic performance data is crucial to suggest how they could be improved under the existing village conditions of the country and for the development of genetic improvement programs of indigenous chickens in Ethiopia.

Therefore, the objectives of the present study are:

1. To generate information on backyard village based indigenous chicken husbandry practices, utilizations including value chain analysis, opportunities and challenges.
2. To characterize and describe the phenotypic variation of indigenous chicken populations.
3. To study on-farm performance of the growth, reproduction and egg production traits of indigenous chickens.
4. To characterize the genetic diversity and population structure of indigenous chickens using microsatellite markers

2. LITERATURE REVIEW

2.1 Domestication of chickens

The process of domestication of animals began about ten thousand years ago and the different stocks were distributed in the course of domestication and human migration to the north, east and west, which means domesticated animals, have been carried by migratory humans to various regions of the earth. The domestication of chicken took place between 8000 to 3000 BC. The domestic chicken is believed to have descended from the wild Indian and Southeast Asian red jungle fowl. The evolutionary history of the domestic fowl can be divided into three phases. The first phase started with the evolution of the genus *Gallus*, followed by the emergence of the domestic fowl from its progenitors and lastly the appearance of the large number of the current breeds, varieties, strains and lines. The domestication of fowl in the region of the Indus valley is believed to have occurred by 2000 BC (Zeuner, 1963), but more recent archaeological evidences showed that a much earlier domestication occurred in China 6000 BC (West & Zhou, 1989). Four species of *Gallus* have been considered as progenitors of the domesticated fowl: *Gallus gallus* (Red jungle fowl), *Gallus lafayettei* (Ceylon jungle fowl), *Gallus sonnerati* (Grey jungle fowl) and *Gallus varius* (Green jungle fowl) and all found in regions of Southeast Asia (Stevens, 1991).

The red jungle fowl is one of the oldest domesticated birds and its popularity quickly spread to Europe. Oddly enough, its original popularity till the beginning of the 19th century was not for meat but for game of cock fighting and use in religious rituals (Singh, 2000). The utilization of poultry for meat and eggs came into picture during the 20th century when the poultry industry developed as a commercial industry (Crawford, 1990). The industry has been very quick to adopt new advances in genetics and breeding and new advances in technology. In the due course the number of breeds, varieties and strains used in food production have declined to the very few which now dominate the breeding and products industry. Most commercial birds are results of crossing of several purebred lines being selected on the basis of desirable traits. With ever increasing production intensities and desire to improve performance levels the breeding industry began to specialize in either egg or meat type birds. The genome of the domestic chicken has a

haploid number of 39 chromosomes, eight pairs of macro chromosomes, one pair of sex chromosomes (Z and W) and 30 pairs of micro chromosomes. The size of the chicken genome is estimated to be 1.2×10^9 bp (Olofsson & Bernardi, 1983; Groenen *et al.*, 2000). Chickens, like other avian species, differ from mammals in that the female is the heterogametic sex (ZW) and the male is the homogametic sex (ZZ), the Z and W chromosomes displaying heteromorphism (Singh, 2000).

2.2. Genetic diversity in domestic chicken

Unlike the developed countries, developing countries still have indigenous chicken with diverse uses and benefits to the households. Birds are non-descriptive, known in their ability to survive on irregular supplies of feed and water, and with no health care, and parts of a "balanced" farming system. Retrospective research studies on some of the indigenous birds from the tropics have shown that their potential for egg and meat production is low. The village chicken is a poor egg producer, laying on average 40 to 60 eggs per year in three or four clutches, with an average egg weight around 35–45 grams (Guèye, 1998). They generally have small body size; for various African chicken breeds, mature body weight varies between 1.3 and 1.9 kg for males and between 1.0 and 1.4 kg for females (Shanawany and Banerjee, 1991). These results are very low when compared with the improved egg and meat type breeds, which can produce + 250 eggs/hen/year and +2 kg body weight in 6 weeks with an average egg weight of 60 g. Egyptian breeds seem to be somewhat heavier: around 2 kg for the males and 1.7 kg for the females. Village chickens require very little attention from the farmer, but closer management could improve production. Although the local chicks are slow growing and poor layers of small sized eggs, they are, however, ideal mothers, good sitters (Tadelle and Ogle, 2001), excellent foragers, and hardy (Teketel, 1986; Dorgham, 1989 and Darwish *et al.*, 1990) and possess natural immunity against common diseases (Mtambo 2000).

In spite of the expected variations among the different strains, they are characterised by having small body size with not more than 1.5kg mature body weight (Horst, 1989). The small body size is a desirable character in tropical and sub-tropical environments. In line with this, Youssef (1993) reported that most of the native strains are characterised with having relatively longer legs and lighter body weights. One of the most important positive characters of village chicken is

their hardiness, which is the aptitude to tolerate the harsh environmental conditions and poor husbandry practices (climate, handling, watering, and feeding) without an excessive drop in production. According to Dorgham (1989) and Darwish *et al.* (1990), local Egyptian chickens are more tolerant to feed restrictions compared to Leghorn and New Hampshire. Teketel (1986), after testing five indigenous ecotypes on-station conclude that indigenous birds had the capacity of sustained egg production at times of increased environmental temperatures and also in the second year of laying compared to the reference breed, White Leghorn. One of the most important fitness traits in chicken is fertility. Teketel (1986) and Saleh *et al.* (1994), from Ethiopia and Egypt reported higher fertility rates of eggs from local stocks as compared to eggs from White Leghorns. Moreover, Mtambo (2000) reported that rural chicken showed resistance to *Salmonella gallinarum* and typhoid infections. However, unlike specialised high performing chicken breeds, indigenous birds in developing countries are non-uniform regarding plumage colour, comb type, down colour, feather cover and morphometrics.

According to Horst (1989), despite the important role-played by tropical fowl as a supplier of meat and eggs in developing countries, there is very little information on its genetic makeup. The most important genes already proved for their special utility in the tropics are namely Na (naked neck), F (frizzle), dw (dwarf), h (silky), k (slow feathering), id (noninhibitor), Fm (fibromelanosis), p (peacomb) and O (blue shell) which are dominant or recessive or sex-linked traits of local chickens of the tropics (Valle Zarate *et al.*, 1988; Horst, 1989). Even though the information collected in the FAO Domestic Animal Diversity Information System (DAD-IS) and other sources show that these genes are prevalent in the local populations across the African countries, but little information exists on the genetic make-up of the indigenous chicken of Africa.

Few attempts have been made on the incorporation of the above genes mentioned in genetic improvement. Mathur *et al.* (1989) reported an increase in egg production through incorporating naked neck (Na) genes in a crossbreeding programme of local Fayoumi. Similarly, Horst (1989) and Mathur (1989) reported favourable effects of naked neck (Na) and frizzle (F) genes on egg production and egg weight and of the dwarf (dw) gene on feed efficiency of chickens under heat stress.

Although, indigenous birds have a number of adaptive traits and genes with special utility in the tropics, the real value of indigenous breeds is often under-estimated mostly due to their poor appearance, relatively low productivity and alleged low "commercial" value. As stated by Hodges (1990), developing countries in most cases look for high performing commercial breeds from developed countries to increase animal productivity through crossbreeding or if conditions allow by breed substitution without properly investigating the production potential of the indigenous birds. According to Peters (1988), there is an apparent lack of information regarding the existing production problems, possible intervention and performance of animals within the prevailing production systems to properly utilise the available genetic diversity to enhance production. This is particularly true in developing countries where breeds or types have not yet been fully identified and characterised, despite the fact that the indigenous breeds survive and produce under unfavourable environments and limited availability of feed, above all they are also parts of the prevailing production system.

There is a trend that high producing breeds or strains are replacing indigenous, locally adapted breeds, which subsequently decline in numbers and sometimes become extinct (Blackburn, 2006). However, in developing countries, the less intensive production systems are the mainstay of the existing species and breeds. It is, therefore, absolutely necessary to evaluate existing genetic resources from a standpoint of bio-diversity and from the standpoint of matching available genotypes with the environment and feed resource under which they are maintained.

Understanding the roles of local chicken in the socio-economic life of the farming community, through economic appraisal of traits, breeding objectives and selection criteria of poultry producers need to be dealt with, to quantify the performance values attributable to animals and quantifying these values in order to develop implementing mechanisms and policies that permit the 'capture' and improvement of these performance values.

2.3. Structure of the Ethiopian Poultry production

The poultry production in Ethiopia can be categorized into three major production systems based on some selected parameters such as breed, flock size, housing, feeding, health care, bio-security and other technologies. These are traditional backyard Indigenous chicken production system, small scale intensive and semi intensive market oriented poultry production system, commercial poultry production system (FAO, 2007).

Table 1. Characteristics of Ethiopian poultry production systems

Characteristic	Intensive- commercial	Small scale market oriented	Scavenging
Breed and flock size	Specialized breeds: 2,500–50, 000 (18 farms)	Specialized and dual-purpose breeds: 50–1000	Local indigenous type: <50
Housing	Modern housing, generally with concrete walls and regulated internal environment	Varies from modern houses to simple housing made from locally available materials	Specific poultry houses are rare
Feed resource	Commercially compounded feeds	Commercially compounded, homemade mixtures and scavenging	Scavenging and occasional feeding with home grains and refuse
Health programme	Standard and regular animal health program	Disease control and health program at varying levels	No regular health program of disease control measures
Markets	Cold chain system for input-output distribution	Input and output distribution is based on existing trading centers	No formal marketing channels

Adopted from FAO, 2007

2.4. Indigenous Chicken Production in Ethiopia

Family chicken production is an appropriate system that makes the best use of locally available resources (Tadelle *et al.*, 2003a). Data on livestock populations in Africa show that chicken population is the highest (Sonaiya *et al.*, 1998). In sub-Saharan Africa, 85% of all households keep chicken under free range/extensive system, with women owning 70% of it, providing scarce animal protein in the form of meat and eggs as well as being a reliable source of cash income (Gueye, 1998; Sonaiya and Swan, 2004; Abubakar *et al.*, 2007).

Ethiopia is one of the few African countries with a significantly large population of chicken, estimated at 38.1 million (CSA, 2009). However, the number of chicken flocks per household in most Ethiopian rural communities is small; constituting an average of 7–10 mature chicken, 2–4 adult hens, a male bird (cock) and a number of growers of various ages (Tadelle and Ogle 2001). Alemu and Tadelle (1997) also reported that the local chicken in Ethiopia vary widely in body size, conformation, plumage colour, comb type and feather cover.

2.5. Importance of village chicken production

According to Bishop (1995), chicken were among the most adaptable domesticated animals and more people are directly involved in chicken production throughout the world than in any other single agricultural enterprise. The impact of village chicken in the national economy of developing countries and its role in improving the nutritional status, income, food security and livelihood of many smallholders is significant owing to its low cost of production (FAO, 1997; Gondwe, 2004; Abdelqader *et al.*, 2007; Abubakar *et al.*, 2007).

According to Moreki *et al.* (2001), family chicken are rarely the sole means of livelihood for the family, but is one of a number of integrated farming activities contributing to the overall well-being of the households. It provides employment and income generating opportunity and is a priority animal for holy day and religious sacrifices (Sonaiya, 2000; Tadelle and Ogle, 2001; Gueye, 2003). Village chicken also play a role of converting household leftovers, wastes and insects into valuable and high quality protein (Doviet, 2005). There are only few alternative

animal protein sources available in the tropics including chicken and eggs (Odunsi 2003). Family chicken meat and eggs contribute 20–30% to the total animal protein supply in low-income and food-deficit countries. Village chicken could be particularly important in improving the diet of young children in sub-Saharan Africa (Alam, 1997).

Chicken provide major opportunities for increased protein production and incomes for smallholder farmers because of short generation interval, high rate of productivity, the ease with which its products can be supplied to different areas, the ease with which its products can be sold due to their relatively low economic values, its minimal association with religious taboos and its complementary role played in relation to other crop–livestock activities (Muchenje *et al.* 2000).

According to Tadelle (2003), in Ethiopia, village chicken production systems are characterized by low input–low output levels. A range of factors such as suboptimal management, lack of supplementary feed, low genetic potential and high mortality rate are the major causes for the apparent low output level. However, village chicken production is part of a balanced farming system, plays an important role in the supply of high quality protein to the family food balance, and provides small disposable cash income in addition to the socio-religious functions important in the rural people's lives.

2.6. Production and Reproduction Performances of Village Chicken

The productivity of village chicken production systems in general and the free range system in particular is low (Kondombo 2005). This is due to low egg production and high mortality rate (Nigussie *et al.*, 2003). Abera (2000) also characterized the low productivity of local chicken as expressed by low egg production performance, production of small sized eggs, slow growth rate, late maturity, small clutch size, an instinctive inclination to broodiness and high mortality of chicks.

In Ethiopia, a local scavenging hen on average lays about 36–40 eggs/year (Tadelle *et al.*, 2000; FAO, 2004). The average egg weight of local hens around Arsi, Ethiopia, was reported to be 38 gm (Brannang and Persson, 1990). The average number of eggs/clutch of local hens in Burkina

Faso was estimated to be 12 eggs (Kondombo, 2005), which is comparable to the range of 12–18 eggs reported by Gueye (1998), but higher than that of 10 eggs/clutch reported by Mourad *et al.* (1997) in Guinea and 9 eggs/clutch by Kuit *et al.* (1986) in Mali. Halima (2007) reported an average productivity of 9–19 eggs/clutch with 2–3 clutch periods/hen per year and an average total egg production ranged from 18–57 eggs/year per hen for local hens in North-West Ethiopia. The average number of clutches/ hen per year and the number of eggs/clutch of local chicken in Sudan were 3 and 12 eggs, respectively (Khalafalla *et al.* 2001).

Table 2. Productivity indicators of indigenous chicken production

	At research farm (Andassa)	Breeding Centers	Commercial farms	Reference
Mean day-old body wt/bird (g) n 446	35.24	NA	NA	Halima, 2007
Mean male mature body wt (g) at 44 weeks	2314.00 ± 168.89	NA	NA	Halima, 2007
Mean female mature body wt (g) at 44 weeks	1588.87 ± 52.35	NA	NA	Halima, 2007
Age at first egg (days)	149.67	150	145	Halima, 2007 FAO, 2007
Average egg weight (g)	56.73	56	56	Halima, 2007 FAO, 2007
Fertility (%)	94	80	90	Halima, 2007 FAO, 2007
Hatchability(%)		65	80	Halima, 2007 FAO, 2007
Eggs/hen/year (no.)	197.40	200	230	Halima, 2007 FAO, 2007
Chick mortality (%)		5-10	5-6	Halima, 2007 FAO, 2007
Mortality to 4 weeks (%)	7.40	NA	NA	Halima, 2007
Mortality 5 to 8 weeks (%)	1.80	NA	NA	Halima, 2007

NA = Not available

According to Sonaiya *et al.* (1998), Aini (1990) and Gueye (2000), the annual egg production/hen of local hens in village conditions ranged from 20 to 100 eggs; with an average egg weight 40 gm. According to Gueye (2000), the adult male and female weight of African village chicken range from 1.2 to 3.2 kg and from 0.7 to 2.1 kg, respectively.

2.7. Opportunities and Challenges in Village Chicken Production Systems

Indigenous chickens provide major opportunities for increased protein production and income for smallholders (Sonaiya, 1997). Chickens have a short generation interval and a high rate of productivity. They can also be transported with ease to different areas and are relatively affordable and consumed by the rural people as compared with other farm animals such as cattle and small ruminants. Indigenous chickens are good scavengers as well as foragers and are said to have good levels of disease tolerance, possess good maternal qualities and are adapted to harsh conditions and poor quality feeds as compared to the exotic breeds (Kitalyi, 1998). In some communities, village chickens are important as starter of livelihood improvement.

The most striking problem in village chicken production systems is the high mortality rate which could reach as high as 80–90% within the first few weeks after hatching, due to diseases and predation (Wilson *et al.* 1987). Newcastle disease (NCD) is highly infectious and causes more losses than any other diseases in the tropics. The disease spreads rapidly through the flock and mortality could reach up to 100% (Aini, 1990; Bishop, 1995; Nigussie *et al.*, 2003; Serkalem *et al.*, 2005; Nwanta *et al.*, 2008).

Among the infectious diseases, NCD, salmonellosis, coccidiosis and fowl pox are considered to be the most important causes of mortality in local chicken while predators are an additional cause of loss (Eshetu *et al.*, 2001). According to Tadelle (2001), the high mortality of chicks under village chicken production in the central highlands of Ethiopia is due to diseases, parasites, predation, lack of feed, poor housing and insufficient water supply.

The other major limiting factor of village chicken production is feed, in terms of both quantity and quality (Saleem and Tedla, 1995). The nutritional status of local laying hens from chemical

analysis of crop contents indicated that protein was below the requirement for optimum egg production and the deficiency is more serious during the short rainy and dry seasons (Tegene 1992; Alemu and Tadelle 1997).

In addition to the above mentioned constraints; Singh (1990) reported other vital problems affecting the productivity of village chicken including: low productivity of local chicken, poor extension services and inadequate credit facilities, availability of few or limited research activities, lack of organized marketing system, seasonal fluctuation of price and lack of processing facilities.

2.8. Role of Women in Village Chicken Production and Ownership

Chicken production in most developing countries is based mainly on scavenging system and rural women and children traditionally play an important management role. They are generally in charge of most chicken husbandry practices, since small-scale animal production does not require heavy manual labour (Bishop, 1995; Riise *et al.*, 2004b).

According to Bradley (1992), family poultry could be easily managed within homesteads and the management has been associated with women for various historical and social factors. A survey in four African countries (Ethiopia, Gambia, Tanzania and Zimbabwe), showed that women dominate most activities of village chicken husbandry, except for shelter construction and marketing. The result also showed that various gender based constraints such as poor access to information and heavy workloads should be addressed to meet the needs of women and opportunities for improving village chicken production (Kitalyi and Andre, 1998).

According to Abubakar *et al.* (2007), in a study conducted on village chicken production in some parts of Nigeria and Cameroon, all gender categories are involved in chicken management, with children having the highest responsibility of housing the chicken at night and letting them out in the morning. Based on the result of the study, women own the majority of chicken (52.7%) followed by children (26.9%) and men (20.4%) in Cameroon; unlike the situation in Nigeria, where the majority of the chickens are owned by men (55.6%) followed by women (38.9%) and

children (11.1%). In Bangladesh, women are able to operate and manage technical enterprises like broiler farming, layer farming and duck farming efficiently with a high economic return on the investment (Riise *et al.*, 2004). Halima (2007) also reported that rural women in North-West Ethiopia are more responsible for chicken rearing in both male and female headed households, while men are responsible for crop cultivation and other off-farm activities.

In a number of African countries, approximately 80% of the chicken flocks are owned and largely controlled and managed by rural women (Gueye 1998; Mcainsh *et al.* 2004). In male headed households, the wife and husband are co-owners of the chickens but sometimes children own some chicken in the flock and are allowed to sell their chicken and eggs to cover expenses for school or to purchase clothes.

According to Gueye (2003), the management of rural chicken in Africa is a family affair. Construction of chicken house and major decisions on sale of chicken and eggs and consumption of chicken products is under the control of men, while looking after chicken, controlling and utilizing the earnings from the sale of eggs and chicken belongs to women. Similarly, Tadelle and Ogle (2001) indicated that in Ethiopia, management of chicken is fully in the domain of women, while decision on control and access to resources varies considerably. Kitalyi and Andre (1998) also reported that there is gender plurality in decision-making in village chicken production in the Gambia.

2.9. Marketing Systems of Village Chicken and Eggs in Ethiopia

In Ethiopia marketing chicken and eggs is one of the functions of keeping free range chickens by smallholder farmers. Village chicken and eggs are sold in local and urban markets to traders (collectors) or directly to consumers depending on the location of the farm dwelling. Women are the primary owners and managers of chickens. Income generated from poultry productions are most of the time controlled by women (Tadelle, 1996; Aklilu, 2007). The informal marketing of poultry and poultry products at open markets is common throughout the country and both live birds and eggs are sold on road sides (Mekonnen, 2007; Moges *et al.*, 2010b). According to Assefa (2007) and Halima (2007), smallholder village chicken owners found in different parts of

the country sell chicken and eggs to purchase food items, to cover school fees, to get cash for grain milling services, to purchase improved seeds and to adjust flock size. Tadelle (2001) also reported that few farmers in central highlands of Ethiopia exchanged their free range chicken for food and household items.

Most consumers in Ethiopia prefer to buy local chicken from village producers, since they are considered to be tasty and better suited for preparation of the traditional chicken sauce (locally called 'doro wot'). Eggs from local chicken are often favoured because of their deep yellow coloured yolks. As a result, free ranging local chicken are in higher demand and fetch higher market prices in urban markets (ILRI, 1995). According to Halima (2007), the price of chicken is highly related to holy days, non-fasting season for the Orthodox Christians, plumage colour, comb type, size, age, sex, market site and health status of chicken. The chicken and egg marketing channels in the country are informal and poorly developed. Chicken and eggs are sold to consumers within the villages, on roadsides and in local and urban markets (ILRI, 1995).

2.10. Extension Interventions to Improve Village Chicken Production

Improvement of the genetic potential of the local chicken could be done through selection within and/or upgrading through crossbreeding with exotic breeds. In Ethiopia, scientists and the government have been promoting a crossbreeding scheme through distribution of cockerels from selected exotic breeds with the intention of improving the productive performance of the local chicken for the last four decades. An alternative scheme to improve poultry production is introduction of exotic poultry breeds. The extension system has been disseminating exotic chicken breeds (dominantly White Leghorn [WLH] and Rhode Island Red [RIR]) as a poultry extension package to improve the productivity of local chickens. Unfortunately, no systematic effort has been made to evaluate the performance of these schemes. This is mainly because ownership pattern, control and access of resources, distribution of benefits and marketing have not been adequately addressed in the process of the interventions (Sonaiya 1990). Lack of recorded data on the performance of chicken and all aspects of management, lack of regular chicken health program and market information makes it difficult to assess the importance and contributions of the past attempts to improve the sector.

2.11. Characterization and Conservation of Chicken Genetic Resources

Genetic diversity can be observed within and between breeds or populations (Granevitze *et al.*, 2007; Muchadeyi *et al.*, 2007; Tadelle, 2003; Van Marle-Koester & Nel, 2000; Wimmers *et al.* 2000). However, there is a trend that high producing breeds or strains are replacing indigenous, locally adapted breeds, which subsequently decline in numbers and sometimes become extinct (Hammond, 1994; Blackburn, 2006). This loss of genetic diversity within and among breeds is a negative trend, not only from the perspective of culture, but also with regard to utility. Traits, genotypes and alleles with possible economic interest are at risk of being lost. Further, breeds are exposed to a great loss of alleles and haplotypes as a consequence of small effective population size or, equivalently, high rates of inbreeding (Falconer and Mackay, 1996). Continued loss of within population genetic diversity also diminishes the possibility of genetic improvement of breeds in future (Eding, 2001).

The Food and Agriculture Organization (FAO) of the United Nations has proposed an integrated programme for the global management of genetic resources (Project MoDAD, http://www.fao.org/dad_is) on an international level (Sherf, 1995; Gandini & Oldenbroek, 1999). In addition, a communication and information system called the Domestic Animal Diversity Information System (DAD-IS) is being developed by FAO, with the main objective to assist countries by providing extensive searchable database and guidelines for better characterization, utilization and conservation of animal genetic resources. Such programmes are important because the Animal genetic resource (AnGR) have faced genetic dilution due to foreign or exotic germplasm use, changes in production systems, markets preferences and environments, natural catastrophes, unstable policies from public and private sectors and the availability of very limited funds for conservation activities (Rege & Gibson, 2003).

Characterization includes a clear definition of the genetic attributes of an animal species or breed, which has a unique genetic identity and the environment to which species or breed populations are adapted or known to be partially or not adapted at all (FAO, 1984; Rege, 1992). It should also include the population size of the animal genetic resources, its physical description, adaptations, uses, prevalent breeding systems, population trends, predominant

production systems, description of the environment in which it is predominantly found, indications of performance levels (meat, growth, reproduction, egg) and the genetic distinctiveness of the animal (Weigend & Romanov, 2002). This provides a basis for distinguishing among different animal genetic resources and for assessing the available diversity (FAO, 1984).

Characterization, conservation and use of indigenous animal genetic resources under low levels of input in the tropics are usually more productive than is the case with exotic breeds (FAO, 2007a; FAO, 2007b). The locally adapted animals are also more readily available to resource-poor farmers and they can adapt to rural environments and survive on little or no inputs (Mengesha and Tsega 2011). Yet, lack of information about the genetic resources present in the indigenous farm animals in developing countries has led to their under utilization, replacement and dilution through cross-breeding (<http://www.nuffic.nl/ciran/ikdm/6-3/networks.html>). Therefore, characterization, utilization and conservation of these indigenous genetic resources are of paramount importance.

With its long history of animal husbandry and diversified geographical conditions, Ethiopia has a wide variety of indigenous poultry resources (Duguma, 2006). However, the population sizes of some indigenous chicken breeds have been rapidly decreasing. The decrease in population sizes of indigenous chicken is mainly attributed to the introduction of exotic breeds and local breeds have often been diluted by indiscriminate cross-breeding with imported stocks (FAO, 2007). The reduction in local poultry breeds due to replacement with cosmopolitan ones suggests a need for conservation of local genetic resources. Conservation efforts should be as efficient as possible, securing a maximum amount of genetic diversity in a given limited resources (Tadelle, 2003; Halima, 2007; Mengesha and Tsega, 2011). The question to be answered is, which breeds we need to conserve? Decisions on which breeds to conserve can be based on a number of different considerations (Ruane 1999). However, the quantitative assessment of genetic diversity within and between populations is an important tool for decision making in genetic conservation plans (Weigend *et al.* 1995). In the process of developing strategies to conserve genetic diversity in indigenous chicken, it is important to assess the genetic uniqueness of a given population, which may be deduced from genetic distances (Hillel *et al.* 2003).

In the absence of comprehensive breed characterization data and documentation of the origin of breeding populations, molecular marker information may provide reliable estimates of genetic diversity within and between a given set of populations. It is useful to explore genetic diversity within and between breeds or populations to analyze genetic relationships and admixtures and to provide information on evolutionary relationships and parentage within populations. Moreover, for breeds undergoing conservation, molecular data should be integrated with other information (i.e., adaptive, productive, and reproductive performances; extinction probabilities) to guide decision makers (Zanetti *et al.*, 2010).

2.11.1. Methods for measuring genetic diversity

Genetic variation between populations can be the result of a number of factors including natural and artificial selection, mutation, migration, genetic drift and non-random mating (Hedrick, 1975). While breeding domesticated animals, man has strongly forced the accumulation of genetic differences between breeds and populations by isolating and selecting them for favourable traits. Therefore, to set up efficient conservation and utilization measures reliable information about genetic differences between individuals, populations and breeds are required. Quantitative assessment of genetic diversity within and among populations is an important tool for decision making in genetic conservation and utilization plans. The most widely used method to quantify these genetic diversities is by utilizing phenotypic characters, biochemical traits and molecular markers (Hedrick, 1975).

2.11.1.1 Phenotypic characters

Phenotypic markers are cheap and easy to apply but they are subjected to environmental influences due to the nature of the qualitative and quantitative traits to be considered. Nikiforov *et al.* (1998) compared the Russian, Mediterranean and Asian chicken breeds with the red jungle fowl using morphological traits and clustered them into five different groups. The diversity of the local chickens reported so far is mostly on phenotypes including adult body weight, egg weight, reproduction performance and immune responses to various diseases (Gueye, 1998; Msoffe *et al.*, 2001; 2004). The economically important traits are strongly influenced by environment so they are poorly situated for classification. Traits used for classification purposes

should be largely independent of the environment so morphological traits have limited usefulness to study the genetic variation or the divergence between population since appearance is not necessarily a good guide to genetic variation. Kidd and Sgaramella-Zonta (1972) suggested that, morphological classifications are difficult to relate quantitatively to average between genetic differences. Which is mainly because of the fact that morphological traits (such as plumage colour, comb type) are linked to a small number of loci and can be rather modified rapidly by artificial selection. Thus, they are not ideal measures of genetic similarities or differences.

2.11.1.2. Biochemical markers

Similarly, protein polymorphisms/ biochemical markers have been applied to estimate the genetic variation within and among chicken populations (Bondarenko, 1974; Singh & Nordskog, 1981; Mina *et al.*, 1991; Moiseyeva *et al.*, 1984, 1994; Romanov, 1994). Blood groups, blood protein and proteins found in blood plasma, serum and milk have been largely used in detection of genetic differences in farm animals (Hines, 1999). The first biomarkers to be widely used in livestock characterization were protein polymorphisms known as allozymes (Queller *et al.*, 1993). Protein polymorphisms, although still used in population studies, are of limited value this is largely because of the relatively low levels of polymorphism found in protein loci, resulting in a lower taxonomic limit for the resolving power of protein electrophoresis. Molecular DNA polymorphisms are now the tools of choice for the assessment of genetic diversity among livestock breeds.

2.11.1.3. Molecular markers

Genetic distance is a more reliable measure of difference between breeds through examining the number and frequency of alleles. Classification based on genetic markers or molecular markers does provide a stable unbiased measurement of average similarities and differences. According to Hannotte and Jianlin (2005), important assumptions that are needed for the use of genetic markers include: (i) neutrality of the polymorphisms and (ii) the use of a relatively small number of independently segregating marker loci are a good predictor of the overall genomic diversity of a population.

During the last two decades several Deoxyribonucleic acid (DNA) markers such as Random Amplified Polymorphic DNA (RAPD), Amplified Fragment Length Polymorphism (AFLP), Restriction Fragment Length Polymorphism (RFLP) and microsatellites have been developed and utilized in genetic diversity analysis (Weber & May, 1989; Williams *et al.*, 1990; Vos *et al.*, 1995; Dodgson *et al.*, 1997). In contrast to using morphological traits and/or measurements for characterization, DNA-based methods are independent of environmental factors and provide useful information about genetic diversity (Karp *et al.*, 1997; <http://www.fao.org/biotech/logs/c13logs.htm>). This holds particularly true for DNA-profiling methods, which is based on the polymerase Chain Reaction (PCR). Among the above DNA markers microsatellite markers are preferred for investigating genetic relationships and breed differentiation. The rest have their own drawback. For instance, the major drawback of RAPDs is that they are dominant markers and heterozygotes are typically scored as homozygotes, which decreases their information content.

Microsatellites are tandemly repeated loci with a core motif of 1 to 6 bp repeated several times. (Vanhala *et al.*, 1998). Microsatellites are highly polymorphic, densely distributed in the genome, highly variable, and relatively easy to detect using the polymerase chain reaction. Microsatellites have been isolated in large numbers from most livestock species and FAO (2004) has recommended a list of microsatellite markers for genetic diversity studies that are now publicly available (<http://www.fao.org/dad-is>)

They have been useful in determining genetic variation and phylogenic relationships among populations of the same species (Buchanan *et al.*, 1994; MacHugh *et al.*, 1994). In pigs, microsatellites have been used in a number of studies to address the biodiversity in commercial as well as rare breeds (van Zeveren *et al.*, 1995; Laval *et al.*, 2000; Martinez *et al.*, 2000). Microsatellite markers have been successfully used in chicken diversity studies (Crooijmans *et al.*, 1996; Ponsuksili *et al.*, 1996; Vanhala *et al.*, 1998; Groenen *et al.*, 2000; van Marle-Köster & Nel, 2000; Weigend & Romanov, 2001; Tadelle, 2003). Prior studies have used microsatellites as genetic markers for mapping purposes to estimate gene flow, effective population size and inbreeding as well as in parentage determination and forensics (Kacirek *et al.*, 1998). The

following table shows the studies done on chickens using microsatellite markers with various population numbers and sample sizes.

Table 3. Estimation of the genetic relationship and distinctness of chickens using microsatellite markers

Title	Origin	Name and number of chicken population studied	Reference
Genetic distinctness of African, Asian & South American local chickens	Tanzania	Singida (20), Songea(20), Iringa(20), Mbeya(20), Coast(20), Arusha (20), Dodoma(20)	Wimmers <i>et al.</i> (2000)
	Nigeria	Sagamu (11), Makurdi (13), Ile-Ife (15),Ilorin (9), Kaduna (15),Jos (4)	
	India	Aseel (20), Naked neck (20), Frizzle (20), Kadaknath (20)	
	Bolivia	North-East (20),Central (20), North (20), North-West 20),	
	Cameron	Cameron (18)	
	Germany	Dahlem red (20)	
Analysis of genetic relationships between various populations of domestic & jungle fowl using microsatellite markers	Ukraine	UP (10), P6 (10), P14 (10),	Romanov & Weigend (2001)
	Russia	YC (10)	
	Australia	ABU (10), ABG1 (14), ABG2 (14)	
	Southeast Asia	GG1 (9), GG2 (12), GG3 (6)	
	Germany	BK1 (12), BK2 (7), BK3 (6), BS1 (6), BS2 (8), BS3 (8), RW (22), WT (10), L1 (17), L2 (23)	
Genetic characterization of biodiversity in highly inbred chicken lines by microsatellite markers		Leghorn, Jungle fowl, Fayoumi, Spanish }= 2 to 4 samples	Zhou & Lamont (1999)

This methodology also provides information for establishing preservation priorities for livestock breeds (Barker 1999). So assessing the genetic structure and diversity in indigenous chicken breeds with a number of microsatellite markers, and determining their genetic relationships by different methods is very useful to understand genetic differentiation of the important local chicken breeds in Ethiopia and also in developing more efficient conservation strategies.

2.11.2. Statistical analysis of gene diversity and genetic distance

Genetic characterization through the use of molecular markers associated with powerful statistical approaches is providing new avenues for decision making choices for the conservation and rational management of AnGRs (Okabayashi *et al.*, 1998; Hanotte & Jianlin, 2005). Genetic distances are metrics which have been developed to summarize allele frequency differences among populations. So far, no general consensus exists as to which of the many genetic distance estimates would be the best for the analysis of variation within and between populations. However, the standard genetic distances (D_s) of Nei (1972; 1978), the chord distance (D_A) of Nei *et al.* (1983) and the Weir & Cockerham (1984) measure of genetic structure (F_{ST} , in which its values can range from 0 to 1) were chosen among the many available genetic distance estimating methods, because they are all relatively popular and have distinct properties to measure the genetic distance between populations (Kalinowski, 2002).

3. MATERIALS AND METHODS

3.1 Description of the Study Area

The study was conducted in South West part of Oromia Regional state and South Nations and Nationalities people regional state of Ethiopia. Four districts, two districts namely Dawo and Seden Sodo from Southwest Showa Zone of Oromia regional state and two districts namely Mehale Amba and Mehurena Aklile from Gurage Zone of South Nations and Nationalities people regional state of Ethiopia.

3.1.1 Dawo district

Dawo district is found in Southwest Showa Zone of Oromia regional state. Dawo covers an area of 41,434.00 ha and the total population is 86,603.00. Dawo is on Long.46°34 '36 ' 'E with an elevation of 1550-3100 m.a.s.l. The average annual rainfall is 1150 mm and the average monthly temperature is 19.5 °c.

3.1.2 Seden Sodo district

Seden Sodo district is also found in Southwest Showa Zone of Oromia regional state. Seden Sodo covers an area of 49,169.00 ha and the total population is 85,126.00. Seden Sodo is on Long.46°34 '36' 'E with an elevation of 1600-3576 m.a.s.l. The average annual rainfall is 1150mm and the average monthly temperature is 19.5°c.

3.1.3 Mehale Amba district

Mehale Amba district is found in Gurage Zone of South Nations and Nationalities people of Ethiopia. It covers an area of 54,500.00 ha. The site is located at an altitude of 1501-3500m.a.s.l. The area receives an average annual rainfall of 1200mm and the average monthly temperature of 13.75°c, respectively.

3.1.4 Mehurena Aklile district

Mehurena Aklile district is also found in Gurage Zone of South Nations and Nationalities people of Ethiopia. It covers an area of 42,120.00 ha. The site is located at an altitude of 1501-

3500m.a.s.l. The area receives an average annual rainfall of 1200mm and the average monthly temperature of 13.75°C, respectively.

(Source for the above information was office of Agriculture of the study area)

3.2 Survey of the Study Area

3.2.1 Selection of the study area

The study areas were selected based on purposive sampling method (Workneh & Rowlands, 2004). The areas purposely selected were those areas where poultry technology interventions such as introduction of exotic breeds are less or not at all.

Multi Stage sampling method was used to select districts from Southwest Showa Zone of Oromia regional state and Gurage Zone of Southern Nations Nationalities people regional state. A rapid field survey was done before the main survey, to map out the distribution and concentration of local chicken ecotypes based on the information gathered through the rapid field survey and in consultations with district agriculture experts two districts from each zone and three PAs from each district were selected. During selection, extension agents and farmers were communicated and those area where poultry technology interventions are less or not at all selected and road accessibility were also considered. Within each district considering earlier poultry technology interventions, appropriate peasant associations (PAs) were selected. The total households included in the study were determined according to the formula given by Arsham (2002).

$$N=0.25/SE^2 \quad \text{Where, } N= \text{Sample size, } SE= \text{Standard error}$$

Thus, using the standard error of 0.041 with 95% confidence level, a sample size of 150 households from each zone were decided to be included in the study. However, finally a total of 295 households (147 from Southwest Showa zone and 148 from Gurage zone) participated in interviews. This included 75 households (HH) from Dawo, 72 HH from Seden Sodo, 75 HH from Mehale Amba and 73 HH from Mehurena Aklile districts.

3.2.2 Data collection

Structured questionnaires were prepared and pre-tested in the selected districts and PAs. In each sampling site farmers were briefed about the objective of the study before starting the data collection. In total, 295 households (147 households from Southwest Showa zone and 148 households from Gurage zone) were interviewed. The interviews were conducted at the farmers' residences with the assistance of local extension officers. Data like chicken management practices such as housing, feeding and marketing, the socio-economic characteristics of the farmers, chicken types, chicken production systems, farming support services provided by the Ministry of Agriculture (MoA) were captured.

The phenotypic characteristics of indigenous chicken types were recorded. Moreover, visual appraisal of the appearance of the indigenous chicken types and their typical features were collected using a structured questionnaire formats for morphological description (Batty & Francis, 1979). A total of 221 individual chicken from the two study area; Southwest Showa zone and Gurage zone of Ethiopia were used for phenotypic data collection. For body measurement traits measuring tapes and a spring balance were used to measure the respective shank length, body length and body weight of individual chickens in the field. During this part of study evaluation of external and internal egg qualities were done and eggs were evaluated for percent fertility and hatchability.

Eggs were purchased at household level (from the interviewed farmers when available) and only 147 eggs were obtained from the four districts. Then the eggs were transported to Deber zeit reaserch center (Poultry division). Each egg was individually weighed using a two digit sensitive balance and out of the total eggs 47 eggs were carefully opened (broken) onto a flat plate. The yolk and albumen were carefully separated and weighed using the balance. The shell weight was also weighed by the same balance. Egg shell thickness was measured at the middle, big size and small size of the shell by using calibrated micrometer screw gauge and the average value was taken. Yolk color was measured using roach color fun. The remaining 100 eggs (all had normal shape, size and desirable shell structure) were incubated using Deber zeit poultry research divission hatchery. Incubators and all the fixtures were fumigated in advance using 70ml of

formalin plus 35g potassium permanganate (Altman *et al.*, 1997). The incubation temperature, humidity and turning device were adjusted according to the recommendations of the manufacturer. Candling was done on the 7th and 14th day of incubation. Finally hatchability was calculated as follow.

Total Hatchability = $100[\text{Number of chicks hatched}] / \text{Number of total eggs set}$

Fertile Hatchability = $100[\text{Number of chicks hatched}] / \text{Number of fertile eggs set}$

3.3 Blood sample collection

Indigenous chicken mentioned in section 3.2.2 were used in this study. A total of 205 chickens from four indigenous chicken populations: Dawo (n = 57), Seden Sodo (n = 33), Mehale Amba (n = 75) and Mehurena Aklile (n = 40) were used for blood sample collection. The Fayomi (n= 25) and Swedish local chicken (n= 17) breeds were included as control. Blood samples from Ethiopian indigenous chicken and Fayomi were collected in 2 ml tubes containing EDTA in the form of K3E, as anticoagulant and stored at – 70 °C until DNA extraction. For the Swedish local chicken (they were not found in Ethiopia) blood sample were not collected.

3.3.1 DNA extraction

Genomic DNA from Ethiopian indigenous chicken and the Fayomi breed was extracted from blood using the QIA amp ® DNA blood mini kit according to Sambrook *et al.* (1989). DNA concentrations were quantified spectrophotometrically. For the Swedish local chicken (this breeds were not found in Ethiopia); extracted DNA which was already stored at Animal breeding and genetics laboratory of Swedish Agricultural University (SLU) was used.

3.3.2 Marker selection

A total of 26 microsatellite markers (Table 4) were used for this study and all of them had already been used in the AVIANDIV project (Aviandiv, 2011) and the markers were selected based on FAO (2004) recommendations. Determination of genetic distances using neutral, highly

polymorphic microsatellite markers are currently the method of choice for investigating genetic relationships and breed differentiation.

3.3.3. Polymerase Chain Reaction (PCR)

Polymerase chain reaction (PCR) was used to amplify the specific DNA fragments containing microsatellites. Three to five pairs of primers were run in one tube. A PCR reaction mixture with a total volume of 10 μ l containing 0.5 μ l of genomic DNA, 1 μ l of 10 X Buffer including MgCl₂, 0.1 μ l of 25 mM dNTP, 0.1 μ l of each (10 pmol/ μ l) forward and reverse primers, 0.2 μ l of AT Gold (*Taq* DNA polymerase), and the remaining volume free nucleic water were prepared. The ingredients were thoroughly mixed by vortexing in order to produce a homogenous mix.

The amplification protocol involved initial denaturation of DNA and enzyme activation, at 95 °c for 15minute followed by 35 cycles of denaturation at 95 °c for 1min, primer annealing at temperature 55 °c for 1minute, extension at 72 °c for 1minute, and final extension at 72 °c for 10 minute using an automated thermal cycler (Master cycler, Eppendorf, Hamburg, Germany).

Thereafter, a mixture of 7.5 μ l LIZ600 internal size standard and 300 μ l Formamide was made and from this mix 12 μ l was taken and mix with 1 μ l of PCR products and this mix was allowed for heat denatured at 95 °c for about 3 minutes. Each sample was prepared and performed as single runs and analyzed on POP-7xl_900s polymer using a 36 cm capillary with 55 injection at 15 KV and run for 28 minutes at 15 KV + 9 μ A on ABI 310 genetic analyzer following the Applied Biosystem user manual version 2.1. The fragment sizes were calculated based on the internal size standards of LIZ 600 using the Gene Mapper and exported to Microsoft excel for preparation of input files for statistical analyses.

3.4 Data management and statistical analysis

The data collected from the quantitative variables were analyzed to obtain mean and standard error of the mean using GLM multivariate analyses SPSS software, version 12 (SPSS, 2002).

Similarly, the qualitative parameters were analyzed using descriptive statistics and compared as percentages using the same software packages.

Model statement regarding the effect of district on various productive and reproductive parameter of indigenous chicken was $Y_{ij} = \mu + m_i + \epsilon_{ij}$

Where:

Y_{ij} : is chicken performance parameter estimate for bird j in i district

μ : is the overall mean

m_i =the effect of districts ($i= 1-4$, Dawo, Seden Sedo, Mehale Amba, and Mehurena Akilile)

ϵ_{ij} = is the residual error

The statistical model used for phenotypic observation was: $Y_{ij} = \mu + m_i + \epsilon_{ij}$

Where:

Y_{ij} : is individual phenotypic observation

μ : is the population mean

m_i : the ecotype effect (1-4)

ϵ_{ij} : is the residual error

GENEPOP software version 4.1 (1995) was used to calculate observed number of alleles, observed heterozygosity (H_o) and expected heterozygosity (H_e) per microsatellite marker. Heterozygosity per microsatellite marker was calculated according to Rousset and Raymond (1995). The within and among population variation was analyzed by Analysis of molecular variance (AMOVA). Unbiased genetic distances between populations were calculated according to Nei (1978). Genetic population relationships were estimated by constructing both Neighbour-Joining (NJ) method and Unweighted Pair-Group Method with Arithmetic mean (UPGMA) tree based on Nei's standard genetic distance (1978). The Polymorphism Information Content (PIC) values were calculated based on the method described by Botstein *et al.* (1980) to assess how polymorphic microsatellite markers are in the studied population using Power Stat version 12 software based on the following formula:

$$PIC = 1 - \left(\sum_{i=1}^{n-1} p_i^2 \right) - \sum_{i=1}^{n-1} \sum_{j=i+1}^n 2 p_i^2 p_j^2$$

Where: n = number of different alleles for the specific locus

P_i^2 and P_j^2 = the population frequencies of the i^{th} and j^{th} allele

Table 4. Characteristics of microsatellite markers used for this study

Markers	Repeat motif	Annealing temp (°C)	Expected size range, bp	dye
ADL0268	(CT) ₃ (CC) ₂ (AC) ₂ (CA)(GA)(TA)	55	102-116	FAM
ADL0278	(CC)(AG)(CA)(GT)(CT) ₃ (AC)(TC)(AT)	55	114-126	VIC
MCW0216	(GG) ₃ (GT)(TT)(TA)(CA)(AT)(GA)(CG)	55	139-149	NED
MCW0248	(GT)(TG) ₃ (TT)(CA) ₂ (AA) ₂ (AG)(GA)	55	205-225	PET
LEI0094	(GA) ₂ (TC) ₂ (AC)(CA)(GT)(AT)(GC)(TG)C	55	247-287	FAM
MCW0295	(AT)(CA) ₂ (CT) ₂ (AC)(AG)(AA)(CC)C	55	88-106	FAM
MCW0081	(GT)(TG)(CT) ₂ (GA) ₂ (GC)(GG)(TG)(CA)G	55	112-135	VIC
MCW0069	(GC)(AC) ₂ (TC)(GA) ₂ (AA)(TT)(CC)(TG)(CG)	55	158-176	NED
MCW0034	(TG)(CA)(CG)(CA)(CT) ₂ (TA) ₃ (CA)(GA) ₂	55	212-246	PET
MCW0222	(GC)(AG)(TT) ₂ (AC)(AT) ₂ (TG)(AA)(GA)(CC)	55	220-226	FAM
MCW0111	(GC)(TC)(CA)(TG) ₂ (AA)(GT)(GG)(TT)(TA)	55	96-128	FAM
MCW0037	(AC) ₂ (CG)(GT)(GC)(CA)(TC)(AA)(TT) (CT)(AT)(TA)	55	146-160	VIC
MCW0016	(AT) ₃ (GG)(CG) ₂ (CA)(GA)(AG) ₂ (GC)(AA)	55	162-206	NED
LEI0234	(AT) ₂ (GC)(CA) ₂ (GA)(TT) ₂ (GG)(TA)A	55	216-364	PET
LEI0166	(CT) ₂ (CC) ₂ (TG)(TA) ₂ (GC)(CG)(CA)	55	340-370	FAM
ADL0112	(GG)(CT) ₂ (TA)(AG)(GA)(CC)(CA)(TT)(AT)	55	120-134	FAM
MCW0014	(TA)(TT)(GG)(CT) ₂ (AG)(GA)(AC)(TG)(TC)	55	164-182	VIC
MCW0183	(AT)(CC)(CA)(GT) ₂ (CG) ₂ (AG)(TA)(TC)A	55	288-326	FAM
MCW0123	(CC)(AC)(TA)(GA)(AA) ₂ (AG)(CA)(TC)(CT)C	55	73-100	FAM
MCW0165	(CA) ₃ (GA)(TG) ₂ (CC)(GA)(TG)A	55	114-118	VIC
MCW0020	(TC)(TT) ₃ (CT)(GA)(CA) ₂ (TG)(AA)(GG)	55	179-185	NED
MCW0104	(TA)(GC)(AC)(AA)(CT) ₂ (CA)(AG)(GT)(GA)G	55	162-234	FAM
MCW0078	CCACACGGAGAGGAGAAGGTCT	55	135-147	FAM
MCW0067	(GC) ₂ (AC)(TA)(CT)(GT) ₃ (TG)(CA)(TT)	55	176-186	VIC
MCW0330	(TG)(GA) ₂ (CC)(TC)(AT)(CA) ₂ (GT)(CT)G	55	256-300	NED
MCW0098	(GG)(CT) ₃ (GC)(TT)(TG) ₂ (TC) ₂ G	55	251-265	FAM

*FAM=Blue, VIC=Green, NED=Yellow, PET=Red,

4. RESULTS

4.1. Characterization of Village Chicken Production System

4.1.1. Household characteristics and respondents profile

The household characteristics of the respondents are presented in Table 5. From the total interviewed local chicken owners, 94.7, 72.2, 64 and 85.1% were female in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively.

Table 5. Socio-economic status of respondent chicken owners of Southwest Showa Zone and Gurage Zone of Ethiopia

Parameters	Study Zones				Over all mean
	Southwest Showa Zone		Gurage Zone		
	Districts				
	Dawo	Seden Sodo	Mehale Amba	Mehurena Aklile	
Sample size (no)	75	72	75	73	
Sex of the respondents (%)					
Female	94.7	72.2	64	85.1	79.1
Male	5.3	27.8	36	14.9	20.9
Average age of respondents (years)	40.9	40.9	36.3	42.6	40.2
Educational level (%)					
Illiterates	16.0	61.1	50.6	37.8	41.5
Read and write	5.0	5.6	12.0	14.9	9.5
Primery school	64.0	33.3	30.7	44.6	42.6
Secondary school	15.0	0.0	6.7	2.7	6.4
Mean land size (ha)	2.17	1.73	0.89	1.11	1.47
Family size (no of persons)	7.00	6.79	5.84	5.97	6.40

The proportion of female respondents was higher than males in all districts. Higher proportion of female respondents (79.1%) than males reflected to the fact that village poultry rearing is mainly managed by females. The average age of respondents is 40.9 years both for Dawo and Seden Sodo while for Mehale Amba and Mehurena Aklile is 36.3 years and 42.6 years respectively. Education level of respondents showed that about 17.3, 61.1, 50.7 and 37.8 % are illiterate in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively.

About 5.0, 5.6, 12 and 14.9% of respondents have basic education (reading and writing) in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively. On an average 42.6% of the respondents in the study districts have gone through primary school and about 6.4% of the respondents completed secondary school and above.

The average land holding per household in the study area was 1.47 ha (range 0.89 - 2.17ha). The highest average land holding/house hold (2 ha) was recorded in the districts of Southwest Showa Zone and the lowest average land holding/ household (1 ha) was recorded in the districts of Gurage Zone. The average family size (family members) of the respondents in the study area was 7.00, 6.79, 5.84 and 5.97 for Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively with overall mean family size of 6.4 per house hold in the study area.

4.1.2. Live stock holding

Live stock holding of the respondents in the study area (last year of the survey year) is presented in Table 6. Among the large livestock species, cattle (5.11 ± 0.140) dominate in all the districts followed by sheep (1.96 ± 0.096) and goats (1.14 ± 0.094) and the majority of the farmers used cattle as source of draught power and milk. The average cattle holding/household was 6.40, 5.08, 4.27 and 4.67 in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively while the average chicken holding per household was observed to be 9.48, 4.63, 6.01 and 5.23 for the above four districts respectively, with an overall mean of 6.4 chicken per family in the study area. Regarding draft animals, a considerable number of donkeys (0.74 ± 0.071), horses (0.46 ± 0.015) and mules (0.01 ± 0.016) per house hold were recorded in four districts of the two study zones.

Table 6. Live stock holding of the respondents in the study area (last year of the survey year)

Live stock holding (Mean)	Study Districts				Over all mean+SD
	Dawo (N=75)	Seden Sodo (N=72)	Mehale Amba (N=75)	Mehurena Aklile (N=73)	
Cattle	6.40	5.08	4.27	4.67	5.11 ±0.140
Sheep	0.80	3.81	2.77	0.49	1.96±0.096
Goat	2.08	0.67	0.45	1.32	1.14±0.094
Donkey	1.35	0.78	0.77	0.04	0.74±0.071
Horse	0.44	0.90	0.45	0.04	0.46±0.015
Mule	0.03	0.00	0.03	0.00	0.01±0.016
Chicken	9.48	4.63	6.01	5.23	6.36±0.084

4.1.3. Flock structure and husbandry practice

4.1.3.1. Flock structure

The average chicken flock size per household and flock structure in the studied households are presented in Table 7. Average chicken flock size per house hold in the four districts was observed to be 5.41, 4.11, 5.13 and 4.75 birds, respectively with an overall mean flock size of 4.85 birds. Out of the total flocks, hens account for 62.66, 51.34, 52.83 and 41.90% for Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively with an overall average of 52.57% in the study area. Similarly out of the total flocks counted, young chicks accounted for 20.15, 14.84, 19.30 and 21.90% for Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively with an overall mean of 19.18 %, followed by cocks to be 10.17, 12.90, 7.80, and 16.64% with an overall average of 11.75 % and pullets to be 6.10, 14.60, 10.72, 10.94% with an overall average of 10.31% and cockerels to be 0.92, 6.33, 9.36 and 8.63% with an overall mean of 6.18 % in above four districts of the study area, respectively.

Table 7. Average chicken flock composition per household in four districts of Southwest Showa and Gurage Zone of Ethiopia

Average chicken flock composition per household					
Different type of chicken	Study Districts				Overall mean (No = 295)
	Dawo (No=75)	Seden Sodo (No=72)	Mehale Amba (No=75)	Mehurena Aklile (No=73)	
Average chicken (no)	5.41±0.11	4.11±0.10	5.13±0.12	4.75±0.02	4.85±0.11
Chicks (%)	20.15	14.84	19.30	21.90	19.18
Cockerel (%)	0.92	6.33	9.36	8.63	6.18
Pullet (%)	6.10	14.60	10.72	10.94	10.31
Hens (%)	62.66	51.31	52.83	41.90	52.57
Cock (%)	10.17	12.90	7.80	16.64	11.75
Total (%)	100	100	100	100	100

4.1.3.2. Chicken management practices

The various chicken management systems, feeds and feeding practices and housing as observed in the four districts of the two study zones are presented in Table 8.

Chicken management systems

Two major prevailing chicken management systems were extensive (traditional) and semi-extensive chicken management system. About 97.3, 69.4, 58.7 and 60.8% of respondents in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively with an overall average of 71.55% of the respondents in the study area follow extensive management system, while 2.7, 30.6, 41.3 and 39.2% respondents in four districts, respectively with an overall mean of 28.45%, of the respondents in the study area follow semi- extensive chicken management system.

Table 8. Chicken management system, feeding practice and housing management in the study area

Parameters (%)	Study Districts				Over all mean
	Dawo (N=75)	Seden Sodo (N=72)	Mehale Amba (N=75)	Mehurena Aklile (N=73)	
Chicken management system					
Extensive	97.3	69.4	58.7	60.8	71.55
Semi-extensive	2.7	30.6	41.3	39.2	28.45
Supplementary feeding					
Yes	100.0	95.8	94.7	94.6	96.3
No	0.0	4.2	5.3	5.4	3.7
Means of feeding					
Thrown on the ground	4.0	5.6	8.0	27.0	11.2
Provide with container	96.0	94.4	92.0	73.0	88.8
Frequency of feeding					
Once per day	40.0	26.4	24.0	36.5	31.7
Twice per day	44.0	44.4	49.3	40.5	44.6
Three time per day	16.0	29.2	26.7	23.0	23.6
Housing /Rest at night					
In kitchen	1.3	0.0	0.0	0.0	0.4
In main house	6.7	11.1	0.0	1.4	4.7
On perch	78.7	88.9	98.7	97.2	90.9
Bamboo cage	13.3	0.0	0.0	1.4	3.7
Poultry house	0.0	0.0	1.3	0.0	0.3
Cleaning of the shelter					
Every day	5.3	16.7	5.3	18.9	17.2
Once per week	28.0	11.1	28.0	41.9	31.8
Once per month	36.0	45.0	36.0	25.7	30.1
Once per year	24.0	6.9	24.0	5.4	11.1
None	6.7	19.4	6.4	8.1	9.8

Feed and feeding practices

Study of Table 8 reveals that almost all (96.3%) farmers in the study area provided supplementary feeding to their chickens and chickens of different age groups were fed together and 88.8% of the farmers provide the feed with containers and the rest throw on the ground.

The farmers reported that the major supplementary feed is composed of a mix of various crops produced on-farm and the amount of supplementary feed provided depends upon availability of resources in the house. The majority of the farmers who practiced supplementary feeding systems used maize, wheat, *enset* and household waste products to feed their chickens.

Housing

It is evident from Table 8 that all the village chicken owners (100%) provide shelter to their bird during night. Most of the respondents (90.9%) keep their birds on perches inside the house while small number of respondents keep their birds in the main house (4.7 %), in bamboo cages (3.7%), in part of the kitchen (0.4 %) or in separate sheds purpose-made for chickens (0.3 %). These shelters were made of locally available materials such as tree and bamboo. Chickens were confined only during the night and that 27.0 % of the households cleaned their chickens house every day, while 31.8, 30.1 and 11.1 % of the owners cleaned once per week, month and year, respectively in the study area.

Watering practices

The information recorded for provision of water, type of waterer and frequency of cleaning waterer are presented in Table 9. It is revealed from this table that almost all respondents (99.7%) in the four districts of two study zones had water provision for their poultry birds. The majority of chicken owners (76.4%) provide water in plastic container followed by clay pots (20.3%) and a very small number of respondents use wooden (2.7%) or metallic (0.7%) containers. It can also be seen from Table 9 that 55.4 % of the respondents cleaned the waterier daily followed by once per week (10.8%), twice per month (7.1%) and sometimes (4.1%) while on an average 22.6% of the respondents in the study area do not clean the chicken waterer at all.

Table 9. Provision of water for chicken in four districts of two zones in study area

Parameters (%)	Study Districts				Overall mean
	Dawo (N=75)	Seden Sodo (N=72)	Mehale Amba (N=75)	Mehurena Aklile (N=73)	
Provision of water					
Yes	100.0	100.0	98.7	100.0	99.7
No	0.0	0.0	1.3	0.0	0.3
Type of waterer					
Clay material	28.0	12.5	17.3	23.0	20.3
Wooden material	1.3	8.3	1.3	0.0	2.7
Metallic container	0.0	0.0	2.7	0.0	0.7
Plastic	70.7	79.2	78.7	77.0	76.4
Frequency of cleaning waterer					
Every day	64.0	34.7	65.3	56.8	55.4
Once per week	9.3	6.9	9.3	17.6	10.8
Twice per month	2.7	5.6	10.7	9.5	7.1
Sometimes	9.3	1.4	0.0	5.4	4.1
Not clean	14.7	51.4	14.7	10.8	22.6

4.1.3.3. Culling of chicken

In the survey area, farmers have their own criteria and strategies of culling and depopulating birds that are unproductive at any time of the year. Table 10 reveals that majority of respondents in all four districts cull their bird for selling purpose (income) with an overall average of 72.3% in the study area followed by culling for home consumption and income (16.9%), and for only home consumption (9.1%) while a small number of respondents cull their birds to sacrifice for religious rituals. In addition, the respondents cited poor productivity (31.8%), old age (26.7%), before rainy season (13.5%) and the outbreaks of disease (19.6%) and lack of capacity to manage large number of bird (8.4%) as major determining factors in culling and reducing the number of chickens.

Table 10. Culling practice of chicken in four study districts

Parameter (%)	Study Districts				Overall mean
	Dawo (N=75)	Seden Sodo (N=72)	Mehale Amba (N=75)	Mehurena Aklile (N=73)	
Purpose for culling					
Consumption	16.0	0.0	16.0	4.1	9.1
Sell for Income	66.7	90.3	61.3	71.6	72.3
Consumption and sell	17.3	8.3	22.7	18.9	16.9
Sacrifice	0.0	1.4	0.0	5.4	1.7
Reason for culling					
Poor productivity	37.3	44.4	18.7	27.0	31.8
Old age	36.0	20.8	21.3	28.4	26.7
Before rainy season	2.7	4.2	24.0	23.0	13.5
Sick	9.3	29.2	32.0	8.1	19.6
Large no of chickens	14.7	1.4	4.0	13.5	8.4

4.1.4. Production and reproductive performance

4.1.4.1 Egg production performance

The average number of eggs per clutch per hen reported from overall study area was 12 (with a range of 6-18 eggs) with a maximum of 3 clutches/hen/year, as a result the highest total number of eggs produced was 54 eggs/year/ hen, which is very low . On an overall basis average number of eggs incubated for hatching was 11 and average hatchability and chick survivability to adulthood stage were observed as 76.6% and 65.5%, respectively (Table 11).

All respondents reported that they use broody hens for hatching eggs and growing chicks. Most of the farmers incubate eggs using their brooder hens during the dry seasons when there is good feed resource, less disease risk and favorable environment for growing chicks.

Table 11. Hatchability and rate of chick survival in four districts of two zones in study area

Parameters	Study Districts				Overall mean
	Dawo (N=75)	Seden Sodo (N=72)	Mehale Amba (N=75)	Mehurena Aklile (N=73)	
No. of eggs incubated for hatching	9.0	12.0	11.5	12.0	11.0
Hatchability (%)	81.2	77.1	77.4	70.8	76.60
Chicks survival rate to adulthood (%)	67.3	65.0	61.7	67.9	65.45
No. of clutch per hen per year (%)					
One	40.0	1.4	1.3	2.7	11.5
Two	48.0	43.1	32.0	54.1	44.3
Three	12.0	48.6	53.3	40.5	38.5
Four	0.0	6.90	13.3	2.7	5.7
Egg production per clutch (eggs)	12.0	12.0	11.5	12.0	12.0

Though broodiness in local chicken is an important trait and the sole and essential means of egg incubation and brooding of young chicks, it is one of the major reasons for the low egg productivity. As a result, farmers use different techniques to reduce broodiness of the local hens. Changing the location of the hen's house is the most preferred and effective practice. Other practices include hanging the hen upside down and spraying water on the hen's body.

4.1.4.2 Egg quality traits

The mean performance for egg quality traits of indigenous chicken are shown in Table 12. The mean egg weight, shell weight, albumin weight, yolk weight, egg shell thickness, albumin thickens and egg yolk colour in Southwest zone were 42.59g, 7.08g, 18.58g, 16.93g, 0.32mm, 3.43mm, and 9.23, respectively and for Gurage zone were 42.36g, 8.34g, 17.24g, 16.77g, 0.30mm, 3.5mm and 8.86, respectively.

Table 12. Mean (\pm S.D.) for egg quality traits of indigenous chicken in two study zones

Characters	Study zones	
	Southwest Showa zone (N=26)	Gurage zone (N=21)
Egg wt (g)	42.59 \pm 2.64	42.36 \pm 5.55
Shell wt (g)	7.08 \pm 2.35	8.34 \pm 1.89
Albumin wt (g)	18.58 \pm 3.23	17.24 \pm 4.61
Yolk wt (g)	16.93 \pm 2.22	16.77 \pm 2.72
Egg shell thickness (mm)	0.32 \pm 0.05	0.30 \pm 0.05
Albumin height (mm)	3.43 \pm 0.79	3.5 \pm 1.08
Yolk colour (Roche fan(1-15))	9.23 \pm 0.99	8.86 \pm 0.66

4.1.4.3 Reproductive traits

Average performance for fertility, hatchability from total egg (TES) and hatchability from fertile egg set (FES) of Southwest Showa zone were 86.13%, 46.79% and 51.85%, respectively and for Gurage zone were 85.67%, 46.53% and 51.57% respectively (Table.13)

Table 13. Mean (%) for reproductive trait on indigenous chicken in the study zone

Traits	Study zones	
	Southwest Showa zone (N=50)	Gurage Zone (N=50)
Fertility (%)	86.13	85.67
Hatchability (TES)(%)	46.79	46.53
Hatchability (FES) (%)	51.85	51.57

Age at sexual maturity for pullets and cockerels is listed in Table 14. 70.3% of the respondents reported that pullet and cockerels reached sexual maturity at the average age of 5.5 months while 20.6% and 9.1% of the respondents reported they reached sexual maturity at the average age 6.5 and 7.5 months respectively.

Table 14. Age at sexual maturity of female and male local chicken

Age at sexual maturity (months)	Study Districts				Overall mean
	Dawo	Seden	Mehale	Mehurena	
	(N=75)	(N=72)	(N=75)	(N=73)	
In females					
5.5	73.3	73.6	77.3	56.8	70.3
6.5	6.7	26.4	14.7	35.1	20.6
7.5	20.0	0.0	8.0	8.1	9.1
In males					
5.5	73.3	73.6	77.3	56.8	70.3
6.5	6.7	26.4	14.7	35.1	20.6
7.5	20.0	0.0	8.0	8.1	9.1

The average mature body weights computed from 25 indigenous female chickens from each of four districts under study are presented in Table 15.

Table 15. Mean mature body weight of female indigenous chickens in four districts

Study districts	Sample size	Body weight (g) Mean ±SD
Dawo	25	750±222.30
Seden Sodo	25	587±116.08
Mehale Amba	25	925±162.87
Mehurena Aklile	25	670±385.29

The average sexually mature body weight of female indigenous chicken in the study area at the age of about 6 months (Table 15) were observed to be 750, 587, 925 and 670g in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively.

4.1.5. Source of initial stock and replacement chick's and finance

The results obtained for source of procurement of initial chicks stock, replacement chicks and finance in the study area are given in Table 16.

Table 16. Source of chicks, replacement stock and finance for village chicken production

Parameter	Study Districts				Over all mean
	Dawo (N=75)	Seden (N=72)	Mehale Amba (N=75)	Mehurena Aklie (73)	
Source of initial chick stock					
Purchased (%)	96.0	97.2	90.7	83.8	91.9
Hatched(%)	2.7	2.8	1.3	10.8	4.4
Inherited/gift (%)	1.3	0.0	8.0	5.4	3.7
Source of replacement chicks					
Hatched (%)	41.3	90.3	69.3	55.4	63.9
Purchased (%)	58.7	6.9	18.7	39.2	31.1
Inherited/gift (%)	0.0	2.8	12.0	5.4	5.1
Source of money for poultry production					
Sells of poultry (%)	2.7	5.6	13.3	5.0	6.65
Sells of egg (%)	10.0	18.0	28.0	26.0	20.50
Sells of other animal (%)	15.3	2.8	2.7	1.4	5.55
Sells of crop (%)	70.7	61.1	21.3	32.4	46.36
Sells of cash crop (%)	0.0	2.8	0.0	14.9	4.43
Off farm income (%)	1.3	9.7	34.7	20.3	16.50

These results revealed that 96.0, 97.2, 90.7 and 83.8% of the respondents in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively with an overall average of 91.9% respondents in the study area obtained chicks initially by purchasing from nearby local market and very small proportions 2.7, 2.8, 1.3 and 10.8% of chicks in the above four districts,

respectively with an overall average of 4.4% in the study area were obtained by hatching and 1.3, 0.0, 8.0 and 5.4% in the four districts, respectively with an overall average of 3.7% as gift from parents or relatives. Table 16 also revealed that 41.3, 90.3, 69.3 and 55.4% of respondents obtained their replacement stocks in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively, with an overall average of 63.9% respondents in the study area by own hatching, while 58.7, 6.9, 18.7 and 39.2 % of respondents, respectively in the above four districts with an overall average of 31.1% respondents obtained their replacement chicks by purchasing and a small proportions of 0.0, 2.8, 12.0 and 5.4% respectively in four districts with an overall average of 5.1% of respondents obtained replacement chicks as inherited or gifts from parents and relatives.

The overall major finance source to replace and to start chicken production was sells of crops (46.36 %) followed by sells of egg (20.50%), off farm income (16.50%), sells of poultry (6.65%), sells of other animal 5.55% and sells of cash crop (4.43%) in the study area (Table 16). The same trends were observed almost in all districts except in Mehale Amba district where the major source of money for replacing the chicken stock was observed to be off farm income (34.7%), followed by sells of eggs (28.0%), sells of crops (21.35%), sells of poultry (13.3%), sells of other animals (2.7%) and sells of cash crop (0.0 %).

4.1.6. Chicken disease prevalence and control measures

The observations recorded on prevalence of chicken diseases and their control measures are summarized in Table 17. These results revealed that 100, 95.8, 94.7 and 100% of the respondents in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively, with an overall average of 97.6% respondents in the study area experienced chicken disease problems while 0.0, 4.2, 5.3 and 0.0 % respectively in the above four districts with an overall average of 2.4% of respondents did not observed any disease problem in their poultry birds.

The majority of the respondents (89.5%) in the study area indicated that Newcastle Disease was the most prevalent and economically important disease that devastates village chicken

production. However, small proportions of respondents indicated that ectoparasite (6.5%), cough (1.7%) and no disease problem was indicated by 2.4% of the respondents in the study area.

Table 17. Chicken disease prevalence and control measures

Parameter (%)	Study Districts				Over all mean
	Dawo (N=75)	Seden Sodo (N=72)	Mehale Amba (N=75)	Mehurena Aklile (N=73)	
Occurrence of disease					
Yes	100.0	95.8	94.7	100.0	97.6
No	0.0	4.2	5.3	0.0	2.4
Main disease					
Newcastle Disease	100.0	95.8	94.7	67.6	89.5
Exoparasite	0.0	0.0	0.0	25.7	6.4
Cough	0.0	0.0	0.0	6.8	1.7
None	0.0	4.2	5.3	0.0	2.4
Treatment					
Traditional treatment	92.0	63.9	77.3	58.1	73.0
No treatment	8.0	36.1	22.7	9.5	18.9
Consult vet	0.0	0.0	0.0	32.4	8.1

Further these results (Table17) revealed that about 92.0, 63.9,77.3 and 58.1% respondents in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively with an overall average of 73% respondents in study area uses traditional treatment for chicken diseases, while 8.0, 36.1, 22.7 and 9.5%,respondents, respectively in the above four districts with an overall average of 18.9% respondents in the study area uses no treatment for any poultry disease and 32.4 % of the respondents only in Mehurena Aklile districts with an overall average of 8.1% respondents in the study area consult veterinarian for treatment of their poultry birds

4.1.7 Marketing

Indigenous chickens are kept for both egg and meat production. The eggs produced are used for chick hatching, sale for income and home consumption. Depending on the location of the farm dwelling, birds and eggs are taken by the farmer to the local market and sold to traders or directly to consumers. Traders from urban areas buy eggs from village markets to sell in big

cities or to owners of restaurants. During group discussions, farmers mentioned specific colours, comb types and down feather colours with corresponding sex and age are high in demand for particular traditional and religious festivals and fetch higher prices as compared to birds with the same colour, comb type and down feather colour during normal market days.

The information recorded on factors influencing marketing of chicken and eggs, in respondent's family who sells the chicken and eggs and user of the income from the selling of chicken and eggs in the four districts under study area are presented in Table 18.

Table 18. Marketing of chicken and eggs in the four study districts.

Parameters (%)	Study Districts				Overall mean
	Dawo (N=75)	Mehale (N=72)	Mehurena (N=75)	Seden (N=73)	
Factors influence marketing					
Unstable price	88.0	50.7	40.0	56.9	58.9
Seasonal demand	0.0	0.0	1.4	1.4	0.7
Poor infrastructure	8.0	13.3	2.7	0.0	6.0
No problem	0.0	20.3	30.3	40.3	22.7
Disease outbreak	4.0	17.3	25.7	1.4	9.6
Who sells					
Father	0.0	0.0	10.8	5.6	4.1
Mother	90.7	65.3	67.6	75.0	74.7
Children	4.0	22.7	5.4	12.5	11.1
Mother and children	5.3	12.0	16.2	6.9	10.1
User of the income					
Father	0.0	1.3	2.7	5.6	2.4
Mother	82.7	73.3	73.0	75.0	76.0
Children	16.0	13.3	4.1	18.1	12.8
Mother and children	1.3	12.0	20.3	1.4	8.8

The results obtained from recorded information on marketing of chicken and eggs in four districts of the two study zones (Table 18) revealed that 88.0, 50.7, 40.0 and 56.9% of respondents from Dawo, Mehale Ambe, Mehurena Aklile and Seden Sodo districts, respectively with an overall average of 58.9%, respondents in the study area reported unstable price as the most important factor influencing the marketing of chicken and eggs. Disease outbreak (9.6%), Poor infrastructure (6.0%) and Seasonal demand (0.7%) were reported other problems influencing the marketing of chicken and eggs in the study area. However, 22.7% of the respondents reported no problem in the marketing of poultry products in the area of study.

Further, from Table 18 it is revealed that 90.7, 65.3, 67.6 and 75% in Dawo, Mehale Ambe, Mehurena Aklile and Seden Sodo districts, respectively with an overall average of 74.7% respondents in the study area females (mother) sells the chicken and eggs followed by children 11.1%), mother and children (10.1 % and father (4.1%) in the study area. It was also observed that the main user of the money received from the sell was also mother (76.0%) followed by children (12.8%), mother and children both (8.8%) and father (2.4%).

4.1. 8 Extension service

The information available on extension services which includes advisory service, trainings, credit and input supply to increase crop and livestock production and productivity were analyzed and presented in Table19.

It is revealed from Table 19 that 48, 59.7, 46.7 and 86.5 % respondents in Dawo, Mehale Ambe, Mehurena Aklile and Seden Sodo districts, respectively with an overall average of 60.1% respondents in the study area reported that they have used extension services in their poultry production. While 52, 43.3, 53.3 and 13.5% respondents in four districts, respectively with an overall average of 39.9% respondents did not use any extension service. In terms of place of contact with extension agents, the most common meeting place is farmers' homes (48.5%), followed by extension agent's office (23.6%), association meetings (17.6%) demonstration sites (8.5%) and by chance (1.8%). About 84.1 % of the farmers obtained chicken

related information and 95.1% of the sources of information were agricultural extension agents and the rest sources (8.5%) were neighbors, relatives, market and radio. In the study area almost all farmers (98%) had an interest of expanding their poultry production.

Table 19. Provision of extension services, place of meeting and awareness about chicken production in the study area

Parameter (%)	Study Districts				Overall mean
	Dawo (N=75)	Seden Sodo (N=72)	Mehale Amba (N=75)	Mehurena Aklile (N=73)	
Provision of extension service	48	59.7	46.7	86.5	60.1
Yes	52	40.3	53.3	13.5	39.9
No					
Place of meeting					
Extension office	15.2	75.7	11.4	3.3	23.6
Farmer's house	33.3	10.8	51.4	78.3	48.5
By chance	0.0	2.7	5.7	0.0	1.8
Association meeting	39.4	2.7	20.0	13.3	17.6
Demonstration site	12.1	8.1	11.4	5.0	8.5
Awareness for improved breed and management					
Yes	93.3	76.4	74.7	91.9	84.1
No	6.7	23.6	25.3	8.1	15.8
Source of information					
Extension agent	90.9	86.5	86.6	96.7	91.5
Other (neighbors,relatives, market, radio)	9.1	13.5	11.4	3.3	8.5
Interest of expansion					
Yes	94.7	100.0	97.3	100.0	98.0
No	5.3	0.0	2.7	0.0	2.0

4.2. Morphological Traits

4.2.1. Qualitative traits

Qualitative traits such as plumage colour, earlobe colour, shank colour, comb type, head shape and earlobe type were studied among indigenous chicken population in Southwest Showa and Gurage zones of Ethiopia.

4.2.1.1. Plumage colour

The phenotypic variations in plumage colour of the local chicken found in four districts under study were recorded, analyzed and results are given in Table 20.

Table 20. Plumage colour characteristics of indigenous chicken population of the study areas

Plumage colour (%)	Study Zone				Over all mean
	Southwest Showa zone		Gurage zone		
	Dawo	Seden Sodo	Mehale Aneba	Mehurena Aklile	
Sample size	70	61	29	61	221
Black	7.0	11.3	13.3	6.3	9.2
Black with white strips	4.2	0.0	3.3	0.0	2.1
Brown	32.4	48.4	13.3	21.9	32.8
Brown with white and black strips	11.3	12.9	10.0	12.5	11.8
Grey mixture (neck gebesems)	4.2	9.7	40.0	21.9	14.4
Red	8.5	4.8	3.3	0.0	5.1
Red brownish with black (key gebesema)	19.7	6.5	6.7	25.0	14.4
White	12.7	6.5	10.0	12.5	10.3

In the present study very diverse plumage color is observed among chicken population studied.

Table 20 indicates that brown is the predominant colour in Dawo (32.4%) and Seden Sodo (48.4%) districts of Southwest Showa zones while grey mixture (40%) in Mehale Amba district

and red brownish with black (25%) in Mehurena Aklile districts of Gurage zone are the predominant chicken plumage colour. The overall predominant plumage colour of the local chicken populations in the study area of Southwest Showa zone and Gurage zone of Ethiopia is brown (32.8%) followed by gray mixture (14.4%) and red brownish with black (14.4%). However, considerable numbers of chickens showed heterogeneity and have diverse plumage colour like black, black with white tips, brown with white and black strips, red and white which accounted for 9.2, 2.1, 11.8, 5.1 and 10.3%, respectively that aid for camouflage against predators.

4.2.1.2. Morphological characteristics of head region of indigenous chicken

Morphological characteristics of head region of indigenous chicken are given in Table 21. The study of comb types in indigenous chicken of Dawo district revealed that 59.2% of chicken had single comb followed by rose comb (31.8%) and double comb (9.9%). Indigenous chicken from Seden Sodo had single comb (46.8%), followed by rose comb (43.5%) and double comb (9.7%). The Mehale Amba indigenous chicken was dominated by rose comb (46.7%) followed by single comb (33.3%) then Strawberry comb (16.7%) and double combs (3.3%). In indigenous chicken from Mehurena Aklile rose comb was the predominant comb pattern(56.3%) followed by double comb (18.8%) pattern, strawberry comb (12.5%) and single comb (12.5%).

Regarding the head shape (Table 21), it is evident from the results that 54.9, 79.0, 96.7 and 78.1% of the indigenous birds in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively with an overall 72.8% of the chicken in the study area had plain head shape and the remaining 45.1, 21.0, 3.3 and 21.9% in four districts, respectively with an overall average of 27.2 % in the study area had crest head shape.

The observations on ear lobe colour (Table21) revealed that red ear lobe colour was predominant in Dawo (45.8%) and in Mehurena Aklile (38.5%) while red & white ear lobes were predomiinant in Seden Sodo (39.3%) and Mehahe Ameba (43.3%) chicken population. However, on overall basis in the study area the predominant ear lob colour was red & white

(34.93) followed by red (32.2%) and white (31.7%) . Yellow and black ear lobe colours were also recorded with a very low frequency of 0.8 and 0.1% respectively.

Table 21. Morphological characteristics of the head region of indigenous chicken population in the study area

Traits		Study zone				Over all mean
		Southwest showa zone		Gurage zone		
		Dawo	Seden	Mehale	Mehurena	
		(N=70)	(N=61)	Amba	Aklile	
Comb pattern (%)	Rose	31.0	43.5	46.7	56.3	41.5
	Strawberry	0.0	0.0	16.7	12.5	4.6
	Single	59.2	46.8	33.3	12.5	43.6
	double	9.9	9.7	3.3	18.8	10.3
Head shape (%)	Plain	54.9	79.0	96.7	78.1	72.8
	Crest (guteya)	45.1	21.0	3.3	21.9	27.2
Ear lob colour (%)	Red	45.8	37.5	6.7	38.5	32.2
	White	29.2	23.2	43.3	30.8	31.7
	Red & White	22.9	39.3	46.7	30.8	34.9
	Yellow	0.0	0.0	3.3	0.0	0.8
	black	2.1	0.0	0.0	0.0	0.1

4.2.1.3 Morphological characteristics of the leg region of indigenous chicken

Information recorded on morphological characteristics of leg region of indigenous chicken under the study area are presented in Table 22. Almost all chicken in the study area (98.4%) had no shank feathers. However, variations were observed in shank colour and the overall mean indicated that about 32.48, 33.73, 26.3 and 7.75% of the chickens had yellow, white, brown and black shank colour, respectively.

Table 22. Morphological characteristics of the leg region of indigenous chicken of the study area

Traits	Study zone				Over all mean	
	Southwest Showa zone		Gurage zone			
	Dawo (N=70)	Seden Sodo (N=61)	Mehale Amba (N=29)	Mehurena Aklile (N=61)		
Shank feather (%)	Yes	2.8	0.0	3.3	0.0	1.52
	No	97.2	100.0	96.7	100.0	98.48
Shank colour (%)	Yellow	38.0	40.3	11.0	40.6	32.48
	White	47.9	29.0	8.0	50.0	33.73
	Brown	8.5	19.4	70.0	6.30	26.30
	Black	5.6	11.3	11.0	3.10	7.75

4.2.2. Quantitative traits (Body measurement traits)

4.2.2.1 Averages of body measurement traits

Quantitative measurements of wattle length, shank length, and body length and body weight of indigenous chicken are shown in Table 23.

Data presented in Table 23 showed that wattle length in male chicken varied significantly ($p < 0.05$) between different indigenous chicken ecotypes found in four different study districts. The highest wattle length for male chicken was observed in Dawo and there was no significant difference in wattle length of female chicken found in four districts under study.

The shank lengths (Table 23) were higher in males than female in four ecotypes of four studied districts and on an overall basis under study area. The Mehale Amba male indigenous chicken had longest shank length of 12.2 cm among all four ecotypes, which was significantly ($p < 0.05$) longer compared to the shank lengths of males in other three chicken ecotypes in this study. Like that of male chicken female indigenous chicken of Mehale Amba (10.26cm) had significantly ($p < 0.05$) longer shank length as compared to females of other three indigenous chicken ecotypes, but there were no significant difference in shank length between Dawo and Seden

Sodo and also between Seden Sodo and Mehurena Aklile while shank lengths in female chicken found in Mehurena Aklile (8.97cm) were significantly($p<0.05$) longer than shank lengths of indigenous female chicken of Dawo district.

Table 23. Mean of wattle length, shank length, body length and body weight of indigenous chicken at the age of about 6 months in the study area

parameter	Sex	Study Districts				Over all mean
		Dawo (25)	Seden Sodo (25)	Mehale Amba (25)	Mehurena Aklile (25)	
Wattle length (cm)	M	2.05 ± 1.25 ^a	1.37±0.93 ^b	1.22±0.99 ^b	1.52±1.12 ^b	1.68±1.17
	F	1.84 ± 1.13 ^a	1.32 ± 0.69 ^a	1.02 ± 1.22 ^a	1.40 ± 1.16 ^a	1.53 ± 1.13
Shank length (cm)	M	9.8 ± 2.12 ^a	10.5 ± 1.91 ^a	12.2 ± 2.31 ^b	10.0 ± 1.81 ^a	10.21 ± 2.12
	F	7.87 ± 0.37 ^a	8.15 ± 0.47 ^{a,c}	10.26 ± 2.16 ^b	8.97 ± 1.65 ^c	8.58 ± 1.45
Body length (cm)	M	28.00 ± 3.59 ^a	31.90 ± 3.81 ^b	33.55 ± 4.34 ^c	28.83 ± 4.58 ^a	29.32 ± 4.27
	F	26.49 ± 2.60 ^a	30.85 ± 2.5 ^b	32.33 ± 6.36 ^b	26.88 ± 4.69 ^a	27.84 ± 4.29
Body weight (g)	M	1297.18 ± 560.4 ^a	1380.33 ± 651.7 ^a	1955.00 ± 612.6 ^c	1013.46 ± 353.14 ^b	1358.15 ± 621.5
	F	750 ± 222.3 ^a	587 ± 116.08 ^b	925 ± 162.87 ^c	670 ± 385.29 ^a	733 ± 385.29

*The difference in mean body weight is significant ($p<0.05$). Means within row with different subscript differ significantly ($p<0.05$)

The body lengths (Table 23) of male indigenous chicken found in Mehale Amba were significantly($p<0.05$) longer than male chicken of Seden sodo districts while body lengths of female indigenous chicken from Seden sodo district was not significantly different than female indigenous chicken of Mehale Amba district.

The mature body weights (Table 23) of male indigenous chicken from Mehale Amba (1955g) were significantly higher ($p<0.05$) than male chicken of Dawo and Seden Sodo and Mehurena Aklile ecotypes while mature body weights of male chicken of Seden Sodo ecotype (1380.33g) were significantly higher than of Mehurena Aklile ecotypes. There was also significant difference between Mehale Amba and Mehurena Aklile (1013.46g) but there was no significant difference in mature body weights of Dawo and Seden Sodo ecotypes. The mature body weights of female indigenous chicken of four ecotypes did not vary significantly except Seden Sodo and

Mehale Amba ecotypes who differed significantly ($p < 0.05$), Mehale Amba (925g) being heavier than Seden Sodo (587g) ecotype.

4.2.2.2 Correlations of body measurement traits

The correlations among the different body measurement traits were computed and presented in Table 24. These results indicated that there was significantly positive relationship ($r = 0.973$) between shank length and body length in all indigenous chicken in the study area while positive correlation of shank length with body weight ($r = 0.789$) and body length and body weight ($r = 0.634$) were found positive but non-significant.

Table 24. Correlation between shank length, body length and body weight of indigenous chicken in the study area

Correlations	Correlation coefficients (r)
Correlation coefficient between shank length with body weight	0.789 ^{ns}
Correlation coefficient between shank length with body length	0.973 [*]
Correlation coefficient between body length with body weight	0.634 ^{ns}

r = correlation coefficient; ns = none significant; * = significant ($p < 0.05$)

4.2.3. Morphological description of indigenous chicken ecotypes

The Morphological outlooks of Dawo, Seden Sodo, Mehale Amba, and Mehurena Aklile chicken ecotypes were studied using their photographs, presented in figure 1 to 4, respectively.

4.2.3.1. Dawo chickens

Study of Figure 1 revealed that predominant plumage colour in Dawo male indigenous chicken is light red with rich brown on the back and brown on the breast and thighs with black tinted tail. While females have brown colour with black tail and in some case light brown with white tinted on the breast, thighs and head part with black tail.



Fig.1. Dawo Male (Left top) and females (Top right and bottom right and left) indigenous chicken

4.2.3.2. *Seden Sodo chickens*

The study of Figure 2 shows that males of Seden Sodo chicken ecotype are reddish brown colours with black tails; also predominantly white body plumage with golden spotted wings. The females have black with white tinted body and yellow colored hackles, breasts and thighs with black tail. In some case there are completely black plumages with a green sheen to their back.



Fig. 2. Seden Sodo males (Left) and females (Right) indigenous chicken

4.2.3.3. *Mehale Amba chickens*

The predominant plumage colour (Fig.3) for both male and female of Mehale Amba chickens is light golden with cream coloured breast feathers and white tails. The males are also black with multicolored wings and white hackles. In some case the females are completely black.



Fig. 3. Mehale Amba males (Left top and bottom) and females (Right top and bottom) indigenous chicken

4.2.3.4. *Mehurena Aklile chickens*

The males of *Mehurena Aklile* chickens ecotypes (Fig. 4) are multicoloured, the most common combination are brownish black with brown hackles and red with deep brown and black tails. Some have a green sheen to their black bodies and others are white with golden wings and white with creamy hackle and black tails. The plumage colour of females is black with brownish hackle and a green sheen to their hackle. In some case creamy plumage with multicoloured hackle, brown breast and black tail.



Fig.4. *Mehurena Aklile* male (Left top and right bottom) and female(Right top and left bottom) indigenous chicken

4.3. Measurement of genetic diversity

4.3.1. Microsatellite markers allele distribution

Out of the 26 microsatellite markers that were sorted in the studied population only ten of them were used for diversity analysis. The rest of the markers were discarded due to their bad amplification and low polymorphic results. The number of alleles and range of observed and expected number of base pairs of alleles in the whole population are given in Table 25.

Table 25. Number of alleles and observed and expected base pairs range at each locus in whole chicken populations under study

Markers/ locus	No of alleles observed	Observed alleles	Observed base pairs range (bp)	Expected base pairs range (bp)
ADL0268	6	100 106 108 110 112 111	100-112	102-116
LEI0094	14	244 245 246 252 258 260 262 264 266 268 274 276 278 280	244-280	247-287
MCW0034	10	221,222, 224 226 228 230 232 234 242 244	221-244	212-246
MCW0069	9	153 155 157 160 162 164 166 170 172	153-172	158-176
MCW0081	6	109 111 117 125 127 131	109-131	112-135
MCW0222	4	215 217 219 221	215-221	220-226
MCW0295	8	83 85 87 89 93 95 97 100	83-100	88-106
ADL0112	5	120 122 124 126 128	120-128	120-134
MCW0014	8	162 168 170 172 174 176 178 180	162-180	164-182
MCW0078	4	134 138 140 142	134-142	114-126
Total	74			

Study of Table 25 reveals that a total of 74 alleles were observed across all chicken populations under study. The number of alleles per loci ranged from 4 (MCW0078 and MCW0222) to 14 (LEI0094). Within a marker, observed base pairs range (allele size) varied from a difference of 6 base pairs (215 – 221bp) for locus MCW0222 to 36 base pairs (244-280bp) for LEI0094.

The individual allele frequencies estimated for all loci and population are shown in appendix 1. The observed numbers of alleles for the different microsatellite markers by population are shown in Table 26.

Table 26. Observed number of alleles for different microsatellite markers within and across population

Marker	Dawo (N=37)	Sedan Sodo (N=30)	Mehal Amba (N=29)	Mhurena Aklile (N=26)	Fayomi (N=10)	Swedish (N=17)	Mean Alleles across population
ADL0268	5	5	5	6	4	3	4.67
LEI0094	8	10	11	6	4	4	7.17
MCW0034	6	7	6	8	5	5	6.17
MCW0069	6	6	6	5	4	4	5.17
MCW0081	5	6	4	4	2	3	4.00
MCW0222	4	3	4	4	3	3	3.50
MCW0295	6	6	6	6	5	6	5.83
ADL0112	4	4	5	4	4	5	4.33
MCW0014	5	3	4	4	1	4	3.50
MCW0078	4	3	4	4	4	0	3.17
Mean	5.3	5.3	5.5	5.1	3.6	3.7	4.80

Among four indigenous ecotypes, the highest number of 11 alleles per marker was observed for the Mehal Amaba chicken population at LEI0094 marker, while the lowest number of 3 alleles per locus was recorded for Seden Sodo at MCW0014 and MCW0078 markers. In Fayomi

chicken the lowest number of allele (1) at MCW0014 and highest (5) at MCW0034 and MCW0295 markers were observed. In Swedish chicken lowest (0) allele at MCW0078 marker and highest (6) alleles were detected at MCW0295 marker. The mean number of alleles within population varied from 3.6 (Fayomi) to 5.5 (Mehal Ameba). From the Ethiopian chicken population, Mehal Ameba chickens showed the highest mean number of alleles within population (5.5), followed by Dawo and Seden Sodo (5.3) and Mehurena Aklile (5.1). The average number of alleles across all populations in all loci was 4.80. All these results showed a more diversity among the indigenous ecotypes than exotic pure breed chicken.

4.3.2. Polymorphic information content and hetrozygosity

The Polymorphic information content (PIC) of the markers in the studied population are presented in Table 27. The average PIC value of the markers across population varied from 0.25 for MCW0014 (smaller number of alleles) to 0.73 for LEI0094 (larger number of alleles).

Table 27. Polymorphic information content of microsatellite markers in tested populations

Microsatellite Markers	Populations						Overall Mean*
	Mehurena Aklile	Mehale Amba	Seden		Fayomi	Swedish	
			Dawo	Sodo			
ADL0112	0.54	0.50	0.52	0.48	0.22	0.59	0.48
ADL0268	0.75	0.70	0.67	0.67	0.55	0.59	0.67
LEI0094	0.77	0.82	0.76	0.71	0.78	0.54	0.73
MCW0014	0.28	0.17	0.16	0.29	0	0.57	0.25
MCW0034	0.74	0.61	0.68	0.71	0.62	0.69	0.68
MCW0069	0.51	0.53	0.59	0.54	0.60	0.66	0.57
MCW0078	0.59	0.49	0.54	0.47	0.35	0	0.49
MCW0081	0.21	0.35	0.21	0.23	0.63	0.39	0.34
MCW0222	0.52	0.52	0.56	0.49	0.16	0.12	0.40
MCW0295	0.51	0.70	0.61	0.57	0.58	0.73	0.62
Mean**	0.54	0.54	0.53	0.52	0.45	0.54	

*Average PIC/ microsatellite marker; ** Average PIC/population

The heterozygosity was calculated to determine the genetic variation in the four chicken ecotypes / populations under study and presented in Table 28. The mean expected heterozygosity (H_e) values per markers ranged from as low as 53% for the Swedish local chicken to as high as 61% for Seden Sodo ecotype. For Ethiopian local chicken the mean expected heterozygosity were 58%, 56% and 61% for Mehurena Aklile and Mehale Amba, Dawo and Seden Sodo ecotypes, respectively. The mean observed Heterozygosity (H_o) were ranged from 19 to 55% in overall population and from 50 to 55% in Ethiopian ecotypes.

Table 28. Observed (H_o) and expected heterozygosity (H_e) values in different chicken populations for different microsatellite markers

Markers/locus	Chicken population											
	Aklile		Ameba		Dawo		Seden Sodo		Fayomi		Swedish	
	H_o	H_e	H_o	H_e	H_o	H_e	H_o	H_e	H_o	H_e	H_o	H_e
ADL0112	0.75	0.60	0.46	0.54	0.55	0.60	0.43	0.49	0.60	0.58	0.12	0.63
ADL0268	0.95	0.79	0.84	0.74	0.83	0.74	0.79	0.69	1.00	0.70	0.13	0.66
LEI0094	0.85	0.80	0.89	0.84	0.86	0.80	0.81	0.81	1.00	0.72	0.21	0.58
MCW0014	0.22	0.30	0.10	0.18	0.10	0.26	0.70	0.19	0.00	0.00	0.12	0.64
MCW0034	0.76	0.77	0.73	0.65	0.78	0.69	0.76	0.81	0.63	0.71	0.38	0.73
MCW0069	0.43	0.58	0.69	0.60	0.70	0.69	0.52	0.63	0.50	0.56	0.31	0.71
MCW0078	0.57	0.63	0.50	0.55	0.44	0.48	0.38	0.64	0.67	0.71	0.00	0.00
MCW0081	0.14	0.22	0.25	0.37	0.17	0.20	0.48	0.66	0.13	0.12	0.19	0.47
MCW0222	0.38	0.60	0.56	0.59	0.61	0.61	0.48	0.51	0.50	0.59	0.13	0.12
MCW0295	0.33	0.55	0.50	0.74	0.48	0.55	0.30	0.67	0.50	0.68	0.31	0.76
Mean	0.54	0.58	0.55	0.58	0.55	0.56	0.50	0.61	0.55	0.54	0.19	0.53
SD	0.09	0.06	0.08	0.06	0.08	0.06	0.07	0.05	0.10	0.08	0.04	0.08

4.3.3. Genetic distance and relatedness

The Analysis of Molecular Variance (AMOVA) of six chicken populations is presented in Table 29. The analysis of molecular variance revealed that there was only 8 percent genetic variation

between different chicken populations while within population variation was 92% of the total variation in the studied chicken population.

Table 29. Analysis of Molecular Variance of the six chicken populations tested at seven marker loci

Source of variance	d.f.	Sum of Squares	Mean Squares	Est.Var	Variance (%)
Among population	5	106.459	21.292	0.592	8%
Within population	143	996.333	6.967	6.967	92%
Total	148	1102.792		7.559	100%

The estimates of unbiased genetic distance values are presented in Table 30. It is evident from these results that among four local ecotypes the lowest genetic distance of 0.034 was between Mehurena Ameba and Dawo ecotypes while the largest genetic distance of 0.074 was found between Mehurena Aklile and Seden Sodo ecotypes. Swedish chicken had the greatest genetic distance to all four Ethiopian chicken ecotypes under this study. Seden Sodo was most distant (0.106) to Fayomi while Mehurena Aklile was the closest (0.083) to Fayomi. Mehale Amba ecotype was the most distant (0.47) to Swedish chicken while Dawo ecotype was found closest (0.40).

Table 30. Genetic distance of the six chicken populations

Population	Mehurena Aklile	Mehale Amba	Dawo	Seden Sodo	Fayomi	Swedish
Aklile	0.000					
Amba	0.042	0.000				
Dawo	0.041	0.034	0.000			
Seden	0.074	0.061	0.072	0.000		
Fayomi	0.083	0.087	0.087	0.106	0.000	
Swedish	0.440	0.471	0.398	0.405	0.441	0.000

*Unbiased genetic distance (Nei, 1978)

Using Nei's standard genetic distance and the UPMGA method (Nei, 1978), a phylogenetic tree was reconstructed (Figure 5). This tree reflected three patterns of relatedness between the chicken populations studied. The Swedish chicken formed a separate branch, Fayomi breed was grouped in a second branch, while the third group embraced the Ethiopian local chicken ecotypes.

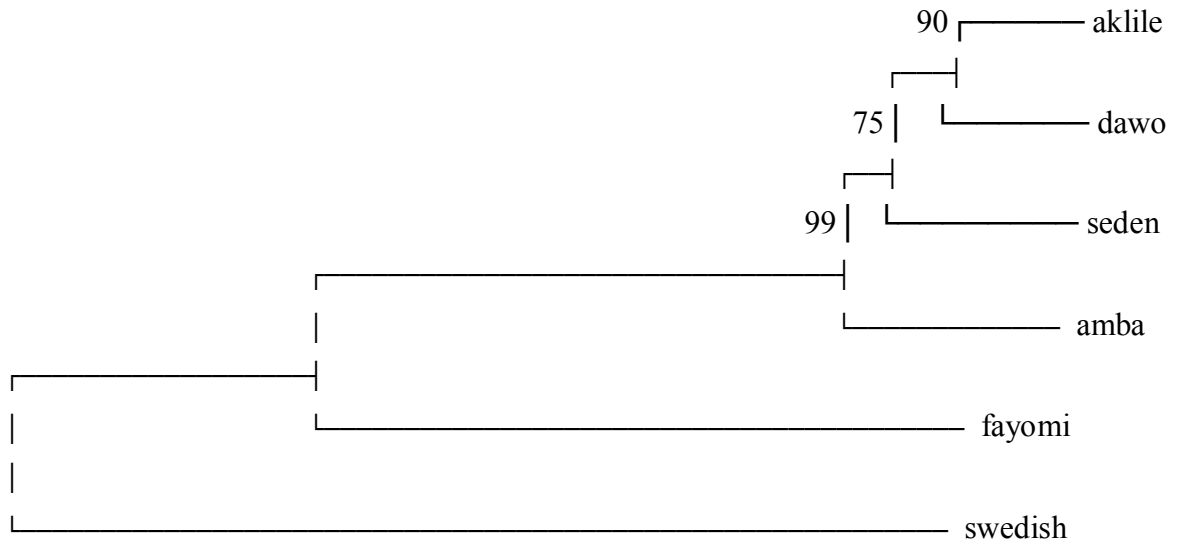


Fig.5. Phylogenetic tree with Nei's standard genetic distance using UPMGA Method for four local chicken ecotypes and two reference breeds fayomi and Swedish

Although Ethiopian ecotypes formed one large cluster, within this cluster it seems that there are two sub-clusters. One ecotype Mehale Amba was separated as a single cluster and the other three ecotypes, Seden Sodo, Dawo and Mehurena Aklile were grouped in another cluster.

5. DISCUSSION

5.1. Characterization of Village Chicken Production System

The observations on household characteristics and respondents profile (Table 5) shows that there is higher proportion of female respondents (79.1%) than males in all districts under this study. It was observed from personal discussions with both female and male respondents that females are responsible for managing the chicken in all study districts while males are responsible for crop farming. This clearly reflected to the fact that village poultry rearing is mainly managed by females. This is in agreement with the observations reported by Muchadeyi *et al.* (2007), Khandait *et al.* (2011) and Desalew *et al.* (2013). Gueye (1998) found that approximately 80 % of the chicken flocks in a number of African countries were owned and largely controlled by women. The average age of respondents 40.9 years both for Dawo and Seden Sodo and 36.3 years and 42.6 years for Mehale Amba and Mehurena Aklile, respectively were almost similar to those reported by Moges *et al.* (2010a) in North West Ethiopia and Dessalew *et al.* (2013) in Ada's and Lume district . Education level of respondents in the study area was similar to those reported by Halima (2007) and Moges *et al.* (2010a) but was lower than those reported by Desalew *et al.* (2013) in Ada'a and Lume districts. The average land holding per household in Dawo (2.17 ha), Seden Sodo (1.73ha), Mehale Amba (0.89ha) and Mehurena Aklile (1.11ha) with an overall average of 1.47ha per family in the study area was higher than those reported by Moges *et al.* (2010a) and Desalew *et al.* (2013). The difference in per family land holdings recorded for the districts of Southwest Showa Zone (2 ha) and for the districts of Gurage Zone (1 ha) may be attributed to the presence of low available arable land and relatively high population pressure in Gurege zone and therefore most people in this zone are engaged in trade while crop production was the main occupation for farmers in the district of Southwest Showa Zone. The overall mean family size of sample households (6.4) in the study area is higher than the national average of 5.2 persons (CSA 2003). However, this is similar to the findings of Moges *et al.* (2010b) who reported 6.2 and 6.9 persons per household for Bure and Dale districts of North West and Southern Nations Nationalities and peoples Regional State, respectively.

The observations on livestock holdings in the study area (Table 6) revealed that among livestock cattle dominated in all the four districts under study and the average flock size per household varied between seasons mainly due to availability of feed and the occurrence of diseases and predators. However, village chicken production seems to be an important activity in all study areas because sale of animals and animal products is an important source of household cash income. In addition, livestock are vital sources of food (animal protein), prestige (determination of wealth status of households) and organic manure for soil fertility.

Study of Table 7 revealed the average chicken holding per household to be 5.41, 4.11, 5.13 and 4.75 for Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively. This is in line with the report of Gueye (1997), who has reported that the flock size generally ranged from 5 to 20 fowls per African village household. An average flock size of 4.73 and 2.40 for cocks and for hens, respectively with a total flock size of 7.13 per household was also reported in North West Ethiopia (Halima *et al.*, 2007a). An average flock size of 6.23 birds per house hold was also reported in Gomma Wereda of Jimma Zone (Meseret, 2010). However, a relatively higher flock size of 18.8 birds/ household was reported by Khalafalla *et al.* (2001) in Sudan. Similarly, 16 birds/ household were reported in the central highlands of Ethiopia and South coast Kenya by Tadelle *et al.* (2003) and Njenga (2005), respectively. Ownership of relatively higher proportion of hens, (41.90% in Mehurena Aklile to 62.66% in Dawo) and young chicks (14.84 % in Seden Sodo to 21.90% in Mehurena Aklile) in all the study districts indicates that this is purposely done by farmers to ensure production of replacement flock in a sustainable manner (about 64% of the replacement is from own stock) and also to produce adequate number of eggs for sale and household consumption.

Observations recorded for chicken management practices in Southwest Showa and Gurege zones of Ethiopia (Table8) revealed that a majority of farmers ranging from 58.7% in Mehale Amba to 97.3% in Dawo districts with an overall average of 71.55% respondents practice extensive system of chicken production and remaining 28.45 % respondents practice semi-intensive poultry production in the study area. Similarly in Northwest Ethiopia majority of indigenous chicken producer's practice extensive system and very few farmers practice semi-intensive system (Halima, 2007).

It is revealed from Table 8 that almost all (96.3%) farmers in the study area provided supplementary feeding to their chickens and chickens of different age groups were fed together and 88.8% of the farmers provide the feed with containers and the rest throw on the ground. These observations are in agreement with the reports of Mapiye and Sibanda (2005), who reported that 96.8 % of the farmers in Zimbabwe, supplied partial supplementation of feeds and 95.5 % of the feed was produced locally. However, Halima (2007) reported that 99.28 % of the farmers in Northwest Ethiopia provided supplementary feeding to their chickens. Moges *et al.* (2010b) also reported that About 98, 93 and 98% of respondents in Bure, Fogera and Dale, respectively, offer supplementary feeds to their chicken. Desalew *et al* (2013) also reported that 97.8% of the respondents provided additional feed supplements to their chicken in both Lume and Ada'a districts. Mengesha *et al.*, (2011) observed that 98% of respondents provided supplementary feed to their chicken. In India, 97.25% backyard chicken owners provide additional supplement (Khandait *et al.*, 2011). Further, it is revealed from table 8 that about 44.6% of respondents were giving supplement two times a day, 31.7 % once in a day and 23.6% three times a day. As scavenging laying hen can find approximately 60 to 70% of their feed requirement (Rahman *et al.*, 1997); providing supplementary feeds three times per day could help to express the laying potential of chickens at village level.

From Table 8, it can be seen that majority of the village chicken owners kept birds on perches inside the house (90.9%) while small number of respondents (9.1%) uses various night sheltering places like part of the kitchen (0.4 %), the main house (4.7 %), and bamboo cages (3.7 %) and in separate sheds purpose-made for chickens (0.3%). This is an indication that the owners are aware of the importance of housing. This finding is similar to what was reported in North West part of Ethiopia by Halima *et al.*, (2007) and Moges *et al.*, (2010a). Desalew *et al.* (2013) observed that about 91.11% in Ada'a and 95.6% in Lume districts constructed a separate house entirely for poultry. Similarly, Khandait *et al.* (2011) in Bhandara district of India, reported 90% of backyard chicken owners provided separate poultry house. While Moges *et al.*, (2010a) reported that 22.1% village chicken owners provided separate poultry house in Bure district, North West Ethiopia. Also in Botswana 35.8 % of the indigenous chicken farmers provided housing of some kind (Badubi *et al.*, 2006). This significant variation in different areas of within country and

outside the country might be due to difference in farmers' awareness to the importance of poultry housing.

Further, it was observed (Table 8) that 17.2% respondents were cleaning the poultry shelters daily, 31.8% respondents were practicing cleaning once in a week, 30.1% once in a month, 11.1% once in a year and 9.8% of the poultry keepers in the study region were not practicing cleaning of the poultry shelters at all. Therefore, mostly respondents are not aware of significance of hygiene in poultry production.

The observations on watering practices (Table 9) revealed that almost all of the respondents in four districts provide water *ad libitum* for their chicken with an overall average of 99.7% in the study area. Indicating that in all the four districts, farmers well understood the importance of providing water for productivity of their chicken. The majority of chicken owners (76.4%) provide water in plastic container followed by clay pots (20.3%) and a very small number of respondents use wooden (2.7%) or metallic (0.7%) containers. It can also be seen from Table 9 that 55.4 % of the respondents cleaned the waterer daily followed by once per week (10.8%), twice per month (7.1%) and sometimes (4.1%) while on an average 22.6% of the respondents in the study area do not clean the chicken water drinkers at all. Similar, watering practices were reported by Moges *et al.* (2010a) and Mengesha *et al.* (2011).

From the observations recorded for culling and disposal of birds (Table10) it can be seen that majority of respondents (72.3%) cull their birds for income purpose/money requirement followed by 16.9% respondents cull for both consumption and income, 9.1% cull for home consumption while a very small proportion of respondents (1.7%) sacrifices their birds for religious ceremonies. Similar trends were reported in other African countries. For example, in the western middle-belt region of Nigeria, Atteh (1989) reported that village fowls were kept for income (11%), consumption (28%), income and consumption (45%), ceremonies (3%), income and ceremonies (11%), consumption and ceremonies (3%). In the Keita region of Niger, 47%, 38% and 16% of the chickens reared were used for home consumption, trade and gifts, respectively (Bell and Abdou, 1995). A study done in the central part of Ethiopia has also shown that 26.6% of the birds were reared to be sold, while 25% were used for sacrifice or healing, 20.3% for

replacement, and 19.5 % for home consumption (Tadelle & Ogle, 2001). Similarly in Northwest part of Ethiopia chickens were mainly culled for home consumption, religious sacrifices and as a source of income (53.3 %); 19.22 % of the chickens were sold because of fear of disease and 21.81 % were sold solely to generate income (Halima *et al.*, 2007a). The major reason/ factors of culling and reducing the number of chickens were cited as poor productivity (31.85%), old age (26.7%), diseases outbreak problem (19.6%), rainy season problems (13.5%) and lack of capacity to manage large number of birds (8.4%). Moges *et al.* (2010a) also reported that Culling was practiced by all respondents due to poor productivity, old age and disease problems. These results do not agree with Desalew *et al.* (2013) who has observed old age (45%) as the major reason of culling followed by poor productivity (37.2%) and diseases (17.8%) for Isa Brown (IB), Bovan Brown (BB) and Potchefstroom Koekoek (PK), which were improved breeds while the present results are from indigenous local birds. The difference in observations may be attributed to the difference in the type of birds studied in two different areas. Further there may be a difference in awareness of disease control programmes in different areas studied by different researchers.

The average number of eggs per clutch per hen reported from overall study area was 12 (with a range of 6-18 eggs) with a maximum of 3 clutches/hen/year, as a result the estimated total number of eggs produced were 54 eggs/year/ hen, which is very low (Table 11). Average number of eggs used for hatching was 11 and out of these on average 76.6% eggs were hatched, however only 65.5% chicks survived to adulthood. Similarly, Halima (2007) reported that 9-19 eggs were laid by indigenous hens and 7-15 and 6-12 chicks were hatched and survive to adulthood, respectively. It was also reported that eggs per clutch, clutches per year and eggs laid per hen per year varied between 12-13, 3 and 36 in Tanzania (Katule, 1992), 8.8, 2.1 and 35 in Mali (Wilson *et al.*, 1987), 10.9, 4.5 and 50 in Sudan (Wilson, 1979) and 8-15, 4-5 and 40-50 in Senegal (Sall, 1990), respectively.

Study of Table 12 revealed that mean egg weight, shell weight, albumin weight, yolk weight, egg shell thickness, albumin thickens and yolk colour of Southwest zone were $42.59g \pm 2.64$, $7.08g \pm 2.35$, $18.58g \pm 3.23$, $16.93g \pm 2.22$, $0.32mm \pm 0.049$, $3.43mm \pm 0.79$ and 9.23 ± 0.99 and respectively and for Gurage zone were $42.36g \pm 5.55$, $8.34g \pm 1.89$, $17.24g \pm 4.61$, $16.77g \pm 2.72$,

0.30mm±0.047, 3.5mm±1.08 and 8.86±0.66 respectively. These findings agreed with Fayeye *et al.* (2005) as they have reported mean egg weight, shell weight, albumin weight, yolk weight, shell thickness and albumin height were 40.73±4.07g, 5.04±0.89g, 20.33±3.06g, 13.03±3.51g, 0.58±0.10mm and 4.92±0.79 mm, respectively for Fulani ecotype chicken. Similar findings are also reported by Halima (2007).

The fertility, hatchability (TES) and hatchability (FES) of Southwest zone were observed as 86.13%, 46.79% and 51.85%, respectively and for Gurege zone were 85.67%, 46.53% and 51.57%, respectively (Table 13). The egg fertility and hatchability based on fertile eggs from chickens managed under intensive conditions ranged from 85.1 to 100 % and 50 to 80.3%, respectively were reported by Halima (2007). However, the present results agreed with reports of Hoque *et al.* (1975) who have reported a fertility of 83 % and hatchability of 52 % for eggs of Deshi/local chickens under scavenging systems.

Pullet and cockerels reached sexual maturity at the average age of 5.5, 6.5 and 7.5 months as it was reported by 70.35, 20.6 and 9.1% of the respondents respectively. An average age for sexual maturity at age of 7.5 months indicates late maturity in indigenous chicken (Table 14). Similar results were also reported by Moges (2010a) who observed the average age of local cockerels at first mating and pullets at first egg were 24.6 and 27.5 weeks, respectively. These results agreed with, Halima (2007) who has reported that 77.4% of local cocks in Northwest Ethiopia reach sexual maturity at 20–24 weeks of age, which is similar with reported value of 6.33 to 7.07 months (Meseret, 2010; Mekonene, 2007). It was also reported that sexual maturity of indigenous female chickens to be 28 weeks in Tanzania (Katule, 1992), 24 weeks in Mali (Kassambara, 1989) and Nigeria (Sonaiya & Olori, 1989), 32 weeks in Sudan (Wilson, 1979), 28 to 36 weeks in Benin (Assan, 1990). Variation among observations reported by different workers could be attributed to genetic reasons and difference in management and feeding practices followed in the area of study.

The average sexually mature body weight of indigenous female chicken in the study area at the age of 6 months were observed as 750±222.2, 587±116.1, 925±162.9 and 670±382.3g, in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively (Table 15). The observed

significant differences in body weights of indigenous female chicken of Seden Sodo and Mehale ecotypes could be attributed to genetic reasons. Similar mature body weights of indigenous layer chickens were reported by Duguma (2006). He showed that body weight of indigenous layers at the beginning of layer phase were 876, 822 and 663g for Horro, Tepi and Jarso, respectively.

The information collected for initial source of chick's, flock replacement and finance (Table 16) revealed that most of the respondents in study area get their initial chicken stock by purchase (91.9%) while a very small proportion get through hatching (4.4%) and as inherited or gifts (3.7%). While important source of replacement stock was recorded as hatching (63.9%) of chicks followed by purchase (31.1%) and a small proportion as inherited or gifts (5.15). These observations agreed with the reports of Halima (2007) and Tadle (2003) as they have also observed purchase of chicks as the initial source of chick's to start the chicken production in rural area, and own hatching of eggs as source of replacement stock afterward using the self-replacing and brooding/mothering ability of indigenous chicken layers. The major source of finance for purchase of chicks was sells of crop (46.36%) followed by sells of egg (20.50%), off farm income (16.5%), sells of poultry (6.65%), sells of eggs (5.55%) and sells of cash crops (4.45%).

Results in Table 17 indicated that 100, 95.8, 94.7 and 100% of the respondents in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively, reported the prevalence of diseases in their chicken. Newcastle Disease (NCD) is the most prevalent and economically important disease that devastates village chicken production. Similarly 97.5, 100 and 62.9% of the respondents in Bure, Fogera and Dale districts, respectively, confirmed that occasional and serious disease outbreak results in complete devastation of the flock when occurred (Moges, *et al.*, 2010b). Halima (2007) also reported that the major cause of death in local chicken in Northwest Amhara is seasonal outbreak of diseases, specifically Newcastle Disease. Desalew (2013) has also reported that diseases were the first major problem, where NCD was number one constraint of village chicken productivity in Ada'a and Lume districts; Respondents also confirmed that the prevalence of Newcastle Disease (NCD) and chicken mortality are higher at the start of the main rainy season, mainly from April to June. They also reported that although

NCD affects chicken of different age, sex and ecotypes indiscriminately, layers and brooding hens being the most vulnerable and affected groups.

Accesses to veterinary services are limited in all the study areas and on an average only 8.1% of the respondents get advisory services (Table 17). Limited veterinary services for village chickens were also reported by Moges *et al.* (2010a) and Mengesha *et al.* (2011) in different parts of Ethiopia. Traditional (ethno-veterinary) treatment is used by the majority of chicken owners (92.0, 63.9, 77.3 and 58.1% in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile respectively) with an overall average of 73% in the study area against NCD and other killer diseases while 18.9% respondents do not use any treatment against any disease. None of the farmers in the study area had any experience of getting their chicken vaccinated against diseases. Similarly, the level of awareness about getting treatment to sick chicken is low. And they never took sick chicken to veterinary offices for veterinary treatment. Lacks of awareness about availability of the service, lack of attention to village chicken and poor service are some of the reasons.

It was observed from personal discussions with the respondents that sick birds are sold immediately or slaughtered for home consumption. There is no practice of isolating sick birds from the household flocks and dead birds could sometimes be offered or left for either domestic or wild predators. These observations are in agreement with that of Solomon (2007) who reported that the bio-security of the backyard poultry production system is very poor and risky, since scavenging birds live together with people and other species of livestock.

Regarding marketing of eggs and live birds (Table18), 58.9% respondents in the study area reported that unstable price is the most important factor influencing the marketing of chicken and eggs. Disease outbreak (9.6%), poor infrastructure (6.0%) and seasonal demand (0.7%) were considered other problems influencing the marketing of chicken and eggs in the study area. Similar observations have also been reported by Halima (2007), Tadelle (2003) and (Mesert, 2010). These workers have reported that price of eggs was directly related to supply and demand as well as the orthodox Christian fasting months and the price of live chickens is affected by seasonal demand (holidays and fasting seasons), lack of infrastructure, plumage colour, size, age,

sex, market site and the health status of the birds. A study in Nigeria also reported that the price of live birds of indigenous chicken is often lower during the periodical outbreak of Newcastle and other chicken diseases (Sonaiya *et al.*, 1992).

The study of Table 18 also revealed that 74.7% of the respondents were females (mothers) who were responsible for selling the chicken and eggs in the study area and the income derived from the sale of chickens and eggs is also used by female (76%) to purchase consumable food items, for school fees, grain milling services, purchasing of improved seeds of maize, wheat and other expenses. This was in agreement with the reports of Halima (2007), (Mesert, 2010) and (Moges, *et al.*, 2010b).

It is revealed from Table 19 that 48, 59.7, 46.7 and 86.5 % respondents in Dawo, Mehale Ambe, Mehurena Akilile and Seden Sodo districts, respectively with an overall average of 60.1% respondents in the study area reported that they have used extension services in their poultry production. While 52, 43.3, 53.3 and 13.5% respondents in four districts, respectively with an overall average of 39.9% respondents did not use any extension service. These results indicated that still quite a good proportion of poultry farmers are not aware about the extension services available in the field of rural poultry production. In terms of place of contact with extension agents, the most common meeting place is farmers' homes (48.5%), followed by extension agent's office (23.6%), association meetings (17.6%) demonstration sites (8.5%) and by chance (1.8%). About 84.1 % of the farmers obtained chicken related information and 95.1% of the sources of information were agricultural extension agents and the rest sources (8.5%) were neighbors, relatives, market and radio. In the study area almost all farmers (98%) had an interest of expanding their poultry production. This was in agreement with a report from Northwest Ethiopia by Halima (2007). However, the proportion of farmers (60.1%) used extension services in this study was higher than a report by Halima (2007) who reported 52.5% of farmers using extension services. This is may be due to a result of appointing of a number of development agents from newly opened agricultural universities and this indicates that the attention is being given by the government for the farmers.

5.2. Phenotypic characterization

In this study indigenous chickens showed heterogeneity and have diverse plumage colour like black, black with white tips, brown with white and black strips, red and white which accounted for 9.2, 2.1, 11.8, 5.1 and 10.3 % respectively that aid for camouflage against predators (Table 20). This is in agreement with previous studies in Nigeria (Daikwo *et al.*, 2011) and Halima (2007) in North West Ethiopia. Duguma (2006) also found similar variations in plumage colour of Horro, Tepi and Jarso indigenous chickens. According to Ensminger (1992), plumage colors such as white or light colored feathers have become an important factor in breeding particularly in broilers because they are easier to pick clean and preferred for appearance of carcass and cut-up parts, thus, have market implications. Variations were also observed in shank colour (Table 20) and the overall mean indicated that about 32.48, 33.73, 11.4 and 7.75 % of the chickens had yellow, white, brown and black shank colour, respectively. Almost all chicken in the study area (98.48%) had no shank feathers. Similar variations in shank colour were reported in North West Ethiopia (Halima, 2007) and also Duguma (2006) reported similar result.

Study of Morphological characteristics of head region of indigenous chicken (Table 21) revealed the variations in comb type, head shape and ear lobe colour of four indigenous chicken ecotype of four districts of two zones under study area. The observations on comb type indicates single comb were predominant in Dawo (59.2%) and Seden Sodo (46.8%) districts of Southwest Showa zone while Rose comb type was predominant in Mehale Amba (46.7%) and Mehurena Aklile (56.3%) districts of Gurege zone. These observed variations in comb type of indigenous chicken ecotypes of two different zones and similarities in comb types of two ecotypes within a zones reflects genetic closeness of two ecotypes of a zone for comb type. Other comb types observed with varying proportions in indigenous chicken were double comb and strawberry comb. Similar observations were also reported by Halima (2007) for indigenous chicken of North West Ethiopia.

The observations on head shape (Table 21) revealed that frequencies of plain head shape were higher in all the four indigenous ecotypes with an overall average of 72.8% than crest head shape (27.2 %) in the study area. The study of Table 21 also revealed variations in ear lobe colour of

four indigenous chicken ecotypes of four districts of two zones of study area. Red ear lobe colour was predominant in Dawo (45.8%) and in Mehurena Aklile (38.5%) while red & white ear lobes were predominant in Seden Sodo (39.3%) and Mehale Amba (43.3%) chicken population. However, on overall basis in the study area the predominant ear lob colour was red & white (34.9%) followed by red (32.2%) and white (31.7%). Yellow and black ear lobe colours were also recorded with a very low frequency of 0.8 and 0.1% respectively. Similar results were reported in other countries (Mcainsh *et al.*, 2004; Bhuiyan *et al.*, 2005; Badubi *et al.*, 2006). Halima (2007) also reported similar results.

Morphological characteristics of leg region (Table 22) of indigenous chicken under study area revealed that almost all chicken in the study area (98.4%) had no shank feathers. However, variations were observed in shank colour and the overall mean indicated that about 32.48, 33.73, 26.30 and 7.75 % of the chickens had Yellow, White, Brown and Black shank colour, respectively. Similar variations were reported in the indigenous chickens of Tanzania (Msoffe *et al.*, 2001), Zimbabwe (Mcainsh *et al.*, 2004), Botswana (Badubi *et al.*, 2006) and Halima (2007).

Study of Table 23 showed that wattle length in male chicken varied significantly ($p < 0.05$) between different indigenous chicken ecotypes found in four different study districts. In male the wattle length varied between 2.05 cm in Dawo chicken ecotype to 1.22cm in Mehale Amba ecotype while wattle lengths in females varied between 1.84cm in Dawo ecotype to 1.02 cm in Mehale Amba chicken ecotype. There was no significant difference in wattle length of female chicken found in four districts under study. Similar results were reported by Aklilu *et al.*, (2013)..

The overall mean shank length for male and female indigenous chicken in the study area was in a range by other reports and was 12.14cm and 8.8cm respectively (Table 23). In Tanzania, five local chicken ecotypes were identified with shank length of 13.3 cm for Kuchi, 13.9 cm for Singamagazi, 12.4 cm for Mbeya, 12 cm for Morogoro medium and 10 cm for Ching'wekwe adult local cocks. Shank lengths of 11.2 cm for Kuchi, 10.9 cm for Singamagazi, 10.2 cm for Mbeya, 9.7 cm for Morogoro medium and 8.2 cm for Ching'wekwe adult local hens were also reported (Msoffe *et al.*, 2001). Badubi *et al.* (2006) reported the shank length of the Tswana indigenous females and males as 7 cm and 8.5 cm, respectively. The report from North West

Ethiopia by Halima (2007) showed mean shank length of 10.31 and 8.14cm for male and female local chickens, respectively. Nigussie (2010) also reported an average shank length of adult males 8.2cm for Farta, 8.4cm for Mandura, 10.1cm for both Horro and Konso and 9.4cm for Sheka and that of females 6.6cm for Farta, 7.1cm for Mandura, Horro and Konso and 7.8cm for Sheka population of chicken in Ethiopia. A report by Eskinder (2013) also showed mean shank length of 11.32cm and 9.99cm for male and 9.22cm and 8.51cm for female of Horo and Jareso local chickens, respectively.

The body lengths (Table 23) of male indigenous chicken found in Mehale Amba were significantly ($p < 0.05$) longer than male chicken of Seden Sodo districts while body lengths of female indigenous chicken from Seden sodo district was not significantly different than female indigenous chicken of Mehale Amba district. The overall mean body weight for female chicken in the study area was 1.3kg which is higher than the reported values for the central highlands of Ethiopia (1.04kg) by Alemu and Tadelle (1997), 847.77g by Halima (2007) in northwest Ethiopia, 1kg by Nigussie (2010) for Farta, Horro and Konso chickens, 1.29kg and 1.12kg by Aklilu *et al.*, (2013) who reported for two districts of Ethiopia (Horro and Jarso) respectively. But it was lower than what was reported by Nigussie (2010) 1.4 and 1.5kg for Mandura and Sheka chickens respectively. The corresponding values for male chicken were 1.6 kg which were closer to the values reported for central highlands of Ethiopian chicken (1.5 kg) by Alemu and Tadelle (1997), 1.6kg for Farta and 1.7kg for both Mandura and sheka chickens by Nigussie (2010), 1.69kg for Horro ecotype by Aklilu *et al.*, (2013). But it was higher than a report by Nigussie (2010) that was 1.4kg both for Horro and Konso chicken and lower than the average weight of indigenous chicken in North-west Ethiopia (2.05 kg) by Halima (2007). The body weight variation in the present study compared to the literature could be attributed to the ecotype differences among various indigenous chicken populations of Ethiopia.

Table 23 also showed that there is positive correlations between shank length, body length and body weight. Similar findings of positive correlations of body weight with other linear body measurements were reported by Getu *et al.*, (2013) from a study in North Gondar Zone, Ethiopia. Alabi *et al.* (2012) also observed a positive relationship between body weight and other linear body measurements in indigenous chickens

5.3. Measurement of genetic diversity

Study of Table 25 revealed that a total of 74 alleles were observed across all chicken populations under study. The number of alleles per loci ranged from 4 (MCW0078 and MCW0222) to 14 (LEI0094). Within a marker, observed base pairs range (allele size) varied from a difference of 6 base pairs (215 – 221bp) for locus MCW0222 to 36 base pairs (244-280bp) for locus LEI0094.

Microsatellite markers tested in this study showed variation in number of alleles within population which ranged from 3 to 11 in four Ethiopian chicken ecotypes (Table 26). According to reports by Crooijmans *et al.* (1996), Ponsuksili *et al.* (1996), Vanhala *et al.* (1998) and Wimmers *et al.* (2000), the different number of alleles per marker varied between 1 and 9 (commercial lines), 4 to 13 (inbred lines and hybrid), 2 to 11 (native lines), 3 to 14 (native South African) and 2 to 11 (for different breeds of Africa and Asia), respectively. Studies by Tadelle (2003) and Halima (2009) characterized different local chicken ecotypes reported 2 to 9 and 2 to 11 number of alleles per loci, respectively.

The average PIC value (Table27) of the markers across population (0.25 to 0.73) in this study are in agreement with PIC values reported for other chicken populations 0.25 to 0.83 (Ponsuksili *et al.*, 1996), 0.33 to 0.66 (Köster, 2001) and 0.27 to 0.73 (Tadelle,2003). Halima (2009) reported PIC value of 0.58 to 0.78 in Northwestern chicken ecotypes of Ethiopia. PIC values for all tested markers within population showed a much smaller variation of 0.45 to 0.54, which are in a similar range as PIC values of 0.46 to 0.57 reported for native South African chicken populations tested at 23 microsatellite markers (Köster, 2001) and 0.47 to 0.55 reported by Tadelle (2003). Markers which had the highest number of alleles (close to five or more) showed the highest PIC value. Even though MCW0078 had the smallest number of alleles, its PIC value is greater than the PIC value of MCW0081 which had more number of alleles as compared to MCW0078. The reason for low PIC value for MCW0081 is one of the alleles (111) was main (dominant). For example, in Amba and Dawo population, the dominant allele represented 90 and 91%.

Results in Table 28 showed the mean observed heterozygosity (H_o) value of 50 to 55% obtained in Ethiopian ecotypes is much higher than the previous results reported by Vanhala *et al.* (1998); Zhou & Lamont (1999) and Wimmers *et al.* (2000), who reported mean heterozygosity values ranging from 0.29 to 0.67, 0.0 to 0.1 and 0.45 to 0.71 using microsatellite markers, respectively. However, it is in agreement with the range (55 to 63%) by Tadle (2003) Halima (2009) also reported heterozygosity values above 50% in other local chicken ecotypes.

Results (Table 29) obtained from the Analysis of Molecular Variance (about 92% of the total in the studied chicken population was due to within populations and the rest 8% among populations) are consistent with population variation analyses in other works (Tadelle, 2003; Shahbazi *et al.*, 2007). The observed patterns in genetic diversity where there is high variation within populations than among populations may be due to a high rate of genetic recombination within populations and a relatively high degree of gene flow between them, preventing genetic differentiation. The F_{st} distances generated support that explanation, since they did not exceed 0.12 ($P < 0.01$). Although, the genetic distance among the local ecotypes (0.034 to 0.074) obtained in this study is lower than values reported by Tadelle (2003), there is a considerable genetic distance of the local ecotypes from Fayomi breed and Swedish chicken population.

Although Ethiopian ecotypes formed one large cluster, within this cluster it seems that there are two sub-clusters. One ecotype Amba was separated as a single cluster and the other three ecotypes, Seden, Dawo and Aklile were grouped in another cluster. The grouping of Dawo and Seden was not surprising since they are from the same zones (Southwest Showa) but the grouping of Aklile with Dawo and Seden was not expected as its geographical location is not the same with Dawo and Seden. The reason for clustering of Aklile with Dawo and Seden might be due to the fact that this district is a newly established district, and the two study zones (Southwest Showa and Gurage) are adjacent to it. So, the source of initial stock for Aklile district could be Dawo and Seden ecotypes and this is in agreement with the information obtained from the result of the first part of this study (section 4.1) that is characterization of village chicken production system which reports 83.8% of the initial stock in Aklile district is obtained by purchasing. Still Seden formed a distinct group from Dawo and Aklile and this makes sense because Dawo is situated in the westernmost area of Ethiopia relative to the other three districts.

6. Conclusion and recommendation

6.1 Conclusions

This study was conducted on “phenotypic and genetic characterization of local chicken in Southwest Showa and Gurage zones of Ethiopia” to generate information on village based chicken production system and characterize and describe the genetic diversity and phenotypic variation of four indigenous chicken ecotypes of Southwest Showa and Gurage zones of Ethiopia. The production and reproductive performances and egg quality traits of indigenous chickens were evaluated under extensive management system. Two districts from each study zones and three kebeles from each district and 25 households from each kebele were selected using multistage random sampling. A survey was conducted on the selected 295 households to describe the village-based poultry production systems.

In majority of the households women (79.1%) were responsible for village chicken rearing. Almost all farmers provide night shelters to their chicken, either in a part of kitchen (0.4%) or in main house (4.7%), on perch (90.9%), in bamboo cages (3.7%) or in a separate shed made for chickens (0.3%). Along with full day scavenging about 96.3% of the respondents provides additional feed supplement to their full time scavenging chicken and almost all respondents (99.7%) in the four districts of two study zones provide water to their chicken. The majority of chicken owners provide water in plastic container (76.4%) followed by clay pots (20.3%, wooden (2.7%) or metallic (0.7%) containers.

Most of the respondents (72.3%) in the study area cull their bird for income purpose followed by consumption and income (16.9%) and only for consumption (9.1%) while a small number of respondents cull their birds to sacrifice for religious rituals.

Age at sexual maturity was 5.96, 5.76, 5.81 and 6.01 months and mature females weight at 6 month was 750, 587, 925 and 670g in Dawo, Seden Sodo, Mehale Amba and Mehurena Aklile districts, respectively.

The average number of eggs per clutch per hen in study area was 6-18 with a maximum of 2 to 3 clutches/hen/year. Average number of eggs incubated per hen ranged from 6-16 eggs. Average hatchability and chick survivability to adulthood were 76.6% and 65.5% respectively.

The mean egg weight, shell weight, albumin weight, yolk weight, egg shell thickness, albumin thickness and yolk colour in south west zone were 42.59g, 7.08g, 18.58g, 16.93g, 0.32mm, 3.43mm, and 9.23 respectively and for Gurage zone were 42.36g, 8.34g, 17.24g, 16.77g, 0.30mm, 3.5mm and 8.86 respectively.

Average fertility, hatchability (TES) and hatchability (FES) of South West zone were 86.13, 46.79 and 51.85% and for Gurage zone were 85.67, 46.53 and 51.57%, respectively.

About 91.9% respondents in the study area obtained their initial chicks stock by purchasing, 4.4% by hatching and the rest 3.7% as gift from parents or relatives. About 63.9% of respondents in the study area obtained their replacement stock by hatching, 31.1% by purchasing and the rest 5.1% as inherited or gifts from parents and relatives.

The major source of money to replace and to start chicken production was sells of crops (46.36 %) followed by sells of egg (20.50%), off farm income (16.50%), sells of poultry (6.65%), sells of other animal(5.55% and sells of cash crop (4.43%) in the study area. Almost all respondents (97.6%) reported Newcastle disease outbreak as a major disease problem.

Unstable price, disease outbreaks, poor infrastructure and seasonal demand were the most important factors influencing the marketing of chicken and eggs as reported by 58.9, 9.6, 6.0 and 0.7% of the respondents in the study area, respectively. About 60.1% respondents in the study area have used extension services in their poultry production.

Study of qualitative characteristics showed a considerable heterogeneity in chicken's plumage colours, which were recorded as brown (32.8%), grey mixture (14.4%), red brownish (14.4%), white (10.3%), black (9.2%) and red (5.1%). Other major qualitative characteristics were rose comb (41.5%) and single comb(43.6%); plain (54.9 %) and crest (45.1%) head shapes;

unfeathered shanks (98.48%); white (33.73 %), and yellow (32.48%) shank colours and red (30.6%), white (26.7%) and red and white (30.6%) ear lobe colours.

The Mehale Amba male indigenous chicken had shank length of 12.2 cm, which was significantly longer compared to the other chicken in this study. The correlations of shank length with body length was positive and significant, while shank length with body weight and body length with body weight were all positive but non-significant. The four indigenous chicken ecotypes showed distinct physical variations for both qualitative and quantitative morphological traits under traditional management system.

The genetic diversity of four indigenous chicken ecotypes were studied using ten microsatellite markers. Fayomi and Swedish breeds were included for comparison. The number of alleles in Ethiopian ecotypes ranged from 3 to 11 per locus. The mean observed heterozygosity (H_o) values ranged from 19 to 55% in overall population and from 50 to 55% in Ethiopian ecotypes. In the phylogenetic tree the Swedish, Fayomi and the Ethiopian chicken could be grouped separately in three different groups. Ethiopian local chickens were different from exotic breeds and there is a tendency of sub-clustering within Ethiopian ecotypes which needs further investigation.

From the above conclusions the following may be drawn:

1. Indigenous village chicken production is usually managed by females.
2. Along with full time scavenging almost all farmers provide supplementary feed and water to their birds.
3. Almost all of the farmers provide night shelters to their birds.
4. Unstable price, disease outbreaks, poor infrastructure and seasonal demand were the most important factors influencing the marketing of chicken and eggs.
5. Most of the farmers get their initial chick stock by purchasing but replacement stock by hatching.
6. The major source of money to replace and to start chicken production was sells of crops, eggs, off farm income, poultry, other animal and cash crops.

7. Qualitative traits like plumage colour, comb type, shank colour and ear lobe colours showed a considerable heterogeneity.
8. Genetically indigenous Ethiopian ecotypes were more divergent and variable and hence selection can be practiced to improve the productivity of indigenous chicken.
9. Ethiopian ecotypes are different from the reference populations and have a tendency of sub-clustering. At least two sub-clustering might exist in Ethiopian ecotypes but this needs further investigation using more number of informative markers and advanced clustering tools such as structure programme. Furthermore, studies need to be made to characterize the two sub-clusters of Ethiopian ecotypes for performance traits such as growth and egg production.

6.2 Recommendations

In view of the above, the following recommendations are suggested:

1. Government, research and developmental organizations should have appropriate intervention in disease and predator control activities so as to reduce mortality and improve productivity of birds.
2. Sound veterinary extension programmes, imparting training to poultry farmers on use of latest technologies in chicken production and management practices should be formulated and implemented.
3. Provision of credit facilities to chicken owners to create infrastructure for suitable chicken house construction, purchase of chicks, supplementary feeds, medicines, vaccines and linking the production with marketing should be made for the overall improvement of the sector.
4. There is a need to improve indigenous chicken using scientific breeding practices; hence further research is needed to explore full genetic potentiality of indigenous chicken.
5. Further cataloging and genetic characterization of Ethiopian indigenous chicken populations in other provinces including the present chicken ecotypes should be carried out to have a national picture of the genetic diversity of Ethiopian chickens. Indigenous chicken ecotypes with specific characteristics may be identified and conserved.

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APPENDICES

Appendix 1. Checklist For survey work

1. General information of the study area

- Region----- • zone: ----- • District: -----
- PA/Village:----- • Agricultural institutes involving on research-----
- Extension services----- • Human population density-----
- Estimated average family size----- • Population distribution of male and female -----
- Occupation----- • Source of money -----
- Religion ----- • Ethnic groups -----

Land use patterns

- Arable land _____ ha • Forest land _____ ha • Grazing land _____ ha
- Un-utilized land _____ ha • Other types of land _____ ha

Availability of infrastructure

- Road----- • School----- • Clinic -----
- Accessibility of the study areas with other districts -----

Mobility

- Transhumance • Romadism • Sedentary • Others, specify

2. Physical environment-----

3. Farm resources-----

4 Source of cash income-----

5. Flock characteristics -----

6. Housing -----

7. Production & productivity potentials

8 Management and feeding-----

9. Disease occurrence & health management-----

10. Role of poultry farming-----

11. Role of extension system-----

12. Major constraints: -----

13. Potential of poultry farming for development-----

14. Research & development interventions for Q.10-----

Appendix 2 Questionnaire for the characterization, identification of poultry types and rural poultry production systems in South west and South part of Ethiopia

Farmer's Name-----Region-----
 District----- Peasant Association-----
 Enumerator's Name-----Date of interview-----
 Agro ecology a. Lowland b. Mid-altitude c. Highland

A. Socio-economic characteristics

1. Sex and age of the respondent 1. Male ----- 2. Female----- 3. Age-----
2. Major occupation-----
3. Educational level of the respondent
 1. Illiterate 2. Read & write 3.1st –4th 4. 5th –8th 5. 9th-12th
5. Religion (%)
 1. - Orthodox Christian ----- 2 Muslim ----- 3.others-----.
6. Status of the family
 1. Poor 2.Medium 3. Rich
7. Land size/ha-----
8. Family size

	Male	Female
a) Ages 14 years	-----	-----
b) Ages between 15 and 60 years	-----	-----
c) Ages 60 years	-----	-----
10. Animal ownership, sale and consumption by the house hold (last year)

Type	No. per family	Purpose		
		Owned	Consumed (by 2003 E.C)	Sold (by 2003E.C)
Cattle				
Sheep				
Goat				
Donkey				
Hourse				
Mule				
Chicken				

11. The extent of exotic chickens distribution in the area

B. Production system/Husbandry practices

12. State the number or members who care of Poultry?

- 1. Father 2. Mother 3. Children/ boys 4. Children/girls 5. Mother and boys 6. Mother and girls
- 7. All family

13. How long has poultry been kept in the household? -----

14. What Chicken types do you raise? -----

Chicken types	No. of chicks	Age group of the owner				Source of foundation stock	Source of replacement stock
		father	mother	boys	girls		
Starter (0-4wks)							
Finisher(5-8wks)							
Grower							
Layer/hen							
Breeder							

Foundation and replacement stock

- 1. Purchase 2. Inherited 3. Custody 4. Hatched 5. Other, specify-----

15. For which of the following purposes you spend money?

- 1. Purchase of birds 2. Purchase of feeds
- 3. Purchase of veterinary products 4. Others (specify) -----

16. Source of money to finance your poultry farming?

- 1. Poultry sales 2. Egg sales 3. Crop sales 4. Livestock sales
- 5. Money lender 6. Family or friends 7. Bank 8. Cooperatives
- 9. Off-farm work 10. Others, specify-----

17. On average how many days per week do you & your family spend to take care of the birds?

18. Do you feel the need to improve your poultry production?

- 1. Yes 2. No

19. Is there any taboo/regulation concerning the raising, consumption and sale of poultry which has special feature?

1. Yes 2.No

1. What type of taboo/regulation is this-----
 2. To which type of birds this taboo/regulation applies-----
 3. To which category of people this taboo/regulation applies-----

C. Biological data

I. Housing

1. What type of management system do you practice for your poultry rising
 1. Extensive 2. Semi-intensive 3.intensive 4.Others, specify-----
 2. Where do your birds rest at night?
 1. In the kitchen 2. A room inside the house 3. Perch on trees 4. Hand woven basket
 5. Bamboo cages 6. I don't know where they rest 7. In the house purposely made for chicken
 3. If they rest in basket or cage (4, 5 and 7), how frequently do you clean?
 (How many days in week) -----
 4. Specify any special care given/associated with birds in the area-----

II. Feeding

1. Do you give supplementary feed to your birds? 1. Yes 2. No
 2. If yes, what type of feed resources do you give to your poultry?

Feed	Specific name of the feed
Grains	
Vegetation	
Oil seeds	
Concentrated	
Minerals	
Vitamins	
Others by-products,	

3. If you give feed how frequently do you feed your birds daily?
 Morning :- 1. None 2. Once 3. Twice 4.Thrice or more
 Afternoon :- 1. None 2. Once 3. Twice 4.Thrice or more
 Evening 1. None 2. Once 3. Twice 4.Thrice or more
 4. If you give feed how do you feed your birds?

1. Put feed in containers 2. Throw on the ground for collective feeding
3. Others, specify-----
5. If you do not give feed, reasons for not giving supplementary feeding
 1. Lack of awareness about feed 2. Unavailable 3. Expensive
 4. Time shortage 5. Lack of cash/credit 6. Others, specify-----
 6. Do your birds scavenge? 1. Yes 2. No
 7. Do you give water to your birds? 1. Yes 2. No (Why?)
 8. If you give water for the chickens, where do you get the water
 1. Bore hole 2. Well 3. Rain water
 4. River 5. Tap water 6. Other, specify-----
 9. If you give water for the chickens, what type of container do you use to supply water-----
 10. If you give water for the chickens, how frequently do you wash the container? -----

III. Culling

1. Do you purposely cull your birds at any time? 1. Yes 2. No
2. For what purpose do you cull the poultry?
 1. For consumption 2. For sale 3. For sacrifice 4. Other specify-----
3. What factors determine which bird you will cull?
 1. Poor productivity 2. Old age 3. Sickness 4. Other, specify-----
4. If you culled OLD AGE BIRDS, at what age of the bird do you decide to cull it? -----

IV. Productivity

1. State the productivity of your birds in the following table

Productivity interms of	Chicken	
	Hen	Cock
Age at sexual maturity (month)		
No. of times the hen hatches in a year		
Average No of eggs per clutch		
Average No of days per clutch		
Average No of eggs per set		
No of chicks hatched per clutch		
No. chicks surviving to adulthood		

2. What do you think about the trend of the clutch period as the age of the bird increases?

1. Increase 2. Decrease 3.No change

3. After which clutch period the hen is supposed to set eggs for hatching chicks-----

4. Egg characteristics

1. Colour ----- 1. White-----2. Pale white-----3.Pale-----

4. Pale brown----- 5. Dark brown-----6. Others, specify-----

2. Weight (grams) -----

3. Length (long circum. (cms)) -----

4. Width (short circum. (cms)) -----

5. Method of incubation

1. Mud containers----- 2.Clay-----3. Wooden containers 4. Others, specify-----

6.What kind of materials are used during the incubation of eggs?-----

6. Potential threat/ Production constraints to chicken production and productivity (Specify in order of their economical importance) -----

V. Health and disease control

1. Do you experience serious disease outbreaks? 1. Yes 2.No

2. What do you do when birds fall to sick?

1. Treat them myself 2. Call in the vet. Doctor 3.Kill them immediately

4. Consume them immediately 5.Sell them immediately 6. Other, specify-----

3. Describe the common diseases you have experienced in your flock.

Name of diseases	Symptoms	Susceptible species (age)	Favorable seasons	Severity death(age)	Resistance	Local treatment

D. Marketing

1. What are the problems relating to poultry marketing in your experience?
 1. Instable bird price
 2. Poor sales (demand seasonality)
 3. Lack of market place
 4. Availability of substitute
 5. Poor infrastructure (road, market...)
 6. Others, specify
2. How far the market place from the residence area?
3. State the average unit price of any of the following products that you sell

E. Extension contact and services

1. Have you ever discussed your poultry production & related problems with extension agents?
 1. Yes
 - 2.No
2. If yes, where do you meet the extension agents?
 1. At agent office
 2. At farm house
 3. At fortnightly meetings
 4. At co-operative meetings
 5. At the demonstration station
 - 6.Others, specify-----
3. If yes how frequently do you contact the agent (days in a month) -----
4. If no, state the reasons for not contacting the extension agent
 1. Have not heard about the extension in poultry
 - 2.Can not easily reach them
 3. There is no need to contact the agent
 4. Other, specify-----
5. Have you ever heard about improved poultry production practices
 - 1.Yes
 - 2.No
6. If you heard, what is your major source of information on improved poultry production practices?
 1. Extension agents
 - 2.Market
 - 3.Relatives
 4. Neighbors'
 - 5.Other farmers
 6. Co-operative leader
 - 7 Radio
 8. Newspaper
 - 9 Television
 - 10.Others, specify

F. Morphometry

1. Age (Months/weeks/days) -----
2. Sex (M/F)
 - 1.Male-----
 - 2.Fimale-----
3. Feather characteristics
 - a. Body colour
 1. Completely white-----
 - 2.Completly black-----
 3. Completly red-----
 4. Grayish/Gebsema-----
 5. Multicolour/Ambesma-----
 6. Black with white tips/Teterma-

7. Red brownish/Kokima----- 8. White with red stripes/Seram 9. Others/Specify-----

b. Breast colour

1. Black----- 2. Red-----

3. White----- 4. Others/specify-----

c.. Neck colour

1. Completely white----- 2. Completely black-----3. Completely red-----

4. Grayish/Gebsema----- 5. Multicolour/Ambesma----- 6. Black with white tips/Teterma-

7. Red brownish/Kokima----- 8. White with red stripes/Seram - 9. Others/Specify-----

d. Back colour

1. Completely white----- 2. Completely black-----3. Completely red-----

4. Grayish/Gebsema----- 5. Multicolour/Ambesma----- 6. Black with white tips/Teterma----

7. Red brownish/Kokima----- 8. White with red stripes/Seram- 9. Others/Specify-----

4. Shank colour

1. Yellow----- 2. Black----- 3. White-----

4. Blue ----- 5. Green----- 6. Others /specify-----

5. Wing span (arrested) /cm-----

6. Shank length (cm) -----

7. Shank circumference (cm) -----

8. Comb type

1. Rose----- 2. Pea ----- 3. Walnut/strawberry-----

4. Single-----5. Duplex/V-shape, Double/----- 6. Others, specify -----

9. Comb length (cm) -----

10. Wattle length (cm) -----

11. Head shape

1. Plain/Ebab-ras----- 2. Crest/Gutya-----3. Others, specify -----

12. Ear lobe/presence (P/A) 1. Present-----2. Absent-----

13. Ear lobe colour

1. White-----2. Red-----3. Black----- 4. White and red 5. Others, specify-----

14. Ear mark presence (P//a) 1. Present-----2. Absent-----

15. Shank feather (P/A) 1. Present-----2. Absent-----

16. Body weight (kgs/g) -----

G. Other General Issues

1. Do you intend to expand poultry production? 1. Yes 2. No

2. If yes, to what size? -----

3. What are your barriers to future expansion of poultry production? -----

4. What do you think the government should do to improve poultry keeping, particularly in rural areas ?

Appendix 3. Allele frequency for four chicken populations using ten microsatellite markers

Allele frequency for four chickens population using ten microsatellite markers						
Microsatellites	Chicken population					
ADL0112	Aklile	Ameba	Dawo	Seden	Control	Swedish
120	2.50	3.85	4.41	1.72	0	5.88
122	27.50	7.69	25.00	6.90	0	26.47
124	0	3.85	0	0	0	5.88
126	55.00	63.46	58.82	53.45	85.00	52.94
128	15.00	21.15	11.76	37.93	15.00	8.82
ADLO268						
100	5.00	0	3.45	4.00	0	33.33
106	30.00	34.00	41.38	34.00	42.86	40.00
108	20.00	20.00	10.34	32.00	42.86	0
110	20.00	26.00	20.69	24.00	7.14	26.67
112	20.00	18.00	24.14	6.00	7.14	0
114	5.00	2.00	0	0	0	0
LEI0094						
244	3.85	11.11	2.38	6.25	37.50	14.29
245	11.54	8.33	11.90	6.25	6.25	0

246	0	0	2.38	0	0	0
252	0	5.56	0	0	6.25	0
258	23.08	27.78	23.81	37.50	12.50	10.71
260	26.92	22.22	33.33	28.13	12.50	60.71
262	15.38	8.33	9.52	15.63	0	0
264	19.23	5.56	11.90	0	12.50	0
266	0	2.78	0	0		0
268	0	0	0	3.13	6.25	0
274	0	0	0	0	6.25	0
276	0	2.78	0	0	0	0
278	0	2.78	4.76	0	0	0
280	0	2.78	0	3.13	0	14.29
MCW0014						
162	5.56		1.47	3.85		41.18
168	0	2.38	0	0	0	0
170	5.56	0	1.47	7.69	0	0
172	0	2.38	0	0	0	11.76
174	0	0	1.47	3.85	0	0
176	83.33	90.48	91.18	82.69	100.00	41.18
178	0	0	0	0	0	5.88
180	5.56	4.76	4.41	1.92	0	0
MCW0034						
221	19.05	13.33	20.00	2.78	44.44	0
222	0	0	0	0	0	37.50
224	33.33	53.33	30.00	38.89	11.11	15.63
226	2.38	3.33	0	8.33	0	0
228	0	0	2.50	0	0	0
230	26.19	20.00	37.50	27.78	5.56	3.13
232	4.76	6.67	0	11.11	33.33	28.13
234	4.76	0	5.00	8.33	5.56	15.63

242	2.38	0	0	0	0	0
244	7.14	3.33	5.00	2.78	0	0
MCW0069						
153	54.76	53.13	54.76	58.70	35.00	37.50
155	2.38	0	2.38	6.52	0	0
157	33.33	34.38	23.81	23.91	5.00	0
160	7.14	3.13	9.52	4.35	45.00	31.25
162	0	0	0	0	5.00	18.75
164	0	3.13	4.76	2.17	10.00	0
166	2.38	0	4.76	4.35	0	0
170	0	3.13	0	0	0	12.50
172	0	3.13		0	0	0
MCW0078						
134	15.22	25.00	24.07	32.14	5.00	0
138	54.35	61.54	57.41	58.93	20.00	0
140	10.87	5.77	12.96	5.36	75.00	0
142	19.57	7.69	5.56	3.57	0	0
MCW0081						
109	0	0	2.38	2.17	0	3.13
111	88.10	78.13	88.10	86.96	15.00	65.63
117	2.38	9.38	2.38	2.17	5.00	0
119	0	0	0	0	50.00	0
125	7.14	9.38	2.38	4.35	10.00	0
131	2.38	3.13	4.76	4.35	20.00	31.25
MCW0222						
215	4.76	6.25	2.38	2.17	0	0
217	42.86	34.38	42.86	43.48	90.00	93.75
219	45.24	53.13	40.48	47.83	10.00	3.13
221	7.14	6.25	14.29	6.52	0	3.13
MCW0295						

83	0	6.25	0	0	10.00	6.25
85	63.89	37.50	57.14	58.70	55.00	34.38
87	2.78	9.38	9.52	15.22	0	12.50
89	2.78	3.13	7.14	2.17	0	0
93	16.67	28.13	11.90	10.87	15.00	18.75
95	11.11	15.63	9.52	10.87	20.00	0
97	2.78	0	4.76	2.17	0	3.13
100	0	0	0	0	0	25.00

List of publications

1. Emebet, M., Singh, H., Johansson, A.M., Tesefaye, S., and Zemelak, S., 2013. Characteristics of Indigenous Chicken Production System in South west and South part of Ethiopia. *British Journal of Poultry Sciences* 2 (3): 25-32, 2013.
2. Emebet, M., Singh, H., Tesefaye, S., and Johansson, A.M., 2014. Phenotypic Characterization of Indigenous Chicken Population in South West and South Part of Ethiopia. *British Journal of Poultry Sciences* 3 (1): 15-19, 2014.
3. Emebet, M., Zemelak, S., Johansson, A.M., and Singh, H., 2014. Genetic diversity and population structure of four Indigenous chicken ecotypes representing South and South western Ethiopia. (on review)